Depressive Symptoms and Cigarette Smoking Predict Development and Persistence of Sleep Problems in US Adolescents

Christi A. Patten, PhD*; Won S. Choi, PhD‡; J. Christian Gillin, MD‡§; and John P. Pierce, PhD‡

ABSTRACT. Objective. To evaluate factors related to the development and persistence of adolescent sleep problems.

Methods. In this longitudinal, population-based study, the Teenage Attitudes and Practices Survey was administered by telephone to 7960 adolescents (3921 girls and 4039 boys) 12 to 18 years old in 1989 and at follow-up in 1993. Sleep problems at both time points were assessed using a single item on the Teenage Attitudes and Practices Survey. Those who responded that they "often or sometimes" had trouble going to sleep or staying asleep during the past 12 months were categorized as reporting sleep problems, whereas those who responded "often" were categorized as having frequent sleep problems. Multiple logistic regression analyses were used to identify baseline characteristics predictive of the development and persistence of sleep problems or frequent sleep problems, respectively, from baseline to follow-up.

Results. Of the 4866 adolescents without sleep problems at baseline, 28% developed sleep problems by 1993, and 9% developed frequent sleep problems. Of the 3094 adolescents who reported sleep problems at baseline, 52% reported sleep problems in 1993, and 21% reported frequent sleep problems. Female sex and notable depressive symptoms were associated with the development and persistence of sleep problems and frequent sleep problems at follow-up. Cigarette smoking status showed a dose–response relationship with development of sleep problems and frequent sleep problems at follow-up. Cigarette smoking status showed a dose–response relationship with development of sleep problems and frequent sleep problems, and with persistence of frequent sleep problems at follow-up.

Conclusion. The reduction of depressive symptoms and cigarette smoking among adolescents are important factors to consider in prevention and treatment efforts focused on adolescent sleep problems. Pediatrics 2000; 106(2). URL: http://www.pediatrics.org/cgi/content/full/106/2/e23; adolescence, sleep, sleep problems, depression, cigarette smoking.

ABBREVIATIONS. EEG, electroencephalogram; MDD, major depressive disorder; TAPS, Teenage Attitudes and Practices Survey; NHIS, National Health Interview Survey; NN, adolescents who remained noncurrent established smokers from baseline to follow-up; NY, adolescents who were noncurrent established smokers at baseline who became current established smokers by follow-up; YN, adolescents who were current established smokers at baseline but quit by follow-up; YY, adolescents who remained current established smokers for both years. Similar coding was used for depressive symptom status.

Adolescence is associated with marked changes in normal sleep–wake patterns. The most salient developmental trend is the reduction of sleep duration and a phase delay in the timing of sleep.1–3 Objective measures of sleep, analyzing polysomnogram recordings (ie, electroencephalogram, electromyogram, and electrooculogram), show changes from preadolescence to adolescence, including a decrement in δ or slow-wave sleep and reduced rapid-eye-movement latency.4 Adolescents are also vulnerable to daytime sleepiness,5,6 reflecting an endogenous-based maturation increase in physiologic sleep tendency in the absence of changes in total sleep time.7,8 Moreover, several environmental and lifestyle factors contribute to changes in sleep during adolescence, including academic demands, curfews and school schedules, altered parent–child relationships, expanding social opportunities, employment, and increased access to drugs and alcohol.7,9

Sleep problems in adolescents have been commonly defined in the literature as insomnia; perceived difficulty initiating or maintaining sleep; or early morning waking. Cross-sectional epidemiologic studies indicate that between 6% and 13.9% of adolescents report sleep problems.6,10–13 Moreover, school-based surveys have found that during the previous 6 to 12 months, between 11% and 16.5% of adolescents report frequent sleep problems,14–18 and 23% to 37.6% report occasional sleep problems.14,17,19 It is important to note that sleep disorders other than insomnia, including circadian rhythm disorders and hypersomnias, have also been reported in adolescents.2,7

There are few epidemiologic data on the development or persistence of self-reported sleep problems in adolescents. In 1 study, 1710 adolescents 14 to 18 years old were administered structured diagnostic interviews to assess current major depressive disorder (MDD) at baseline and at 12-month follow-up.12 The 12-month incidence rate for insomnia was 12.5%. Adolescents with a diagnosis of MDD at baseline were more likely to develop insomnia at follow-up than were those without MDD (75.7% vs 8.7%). In a sample of young adults 18 to 25 years old, the 12-month incidence of insomnia based on structured interview was 5.7%.11 Only 1 study examined the persistence of sleep problems over time in adoles-
cents. Among 704 New Zealand adolescents, 36 reported sleep problems at 13 years old. Of these, 41.6% continued to report sleep problems at 15 years old. Similarly, a study of 979 young adults 21 to 30 years old found that of those with a lifetime history of insomnia at baseline, 45% reported insomnia during the 3-year follow-up. With the exception of 1 article, no previous work has evaluated factors related to the development and/or persistence of sleep problems in adolescents.

The relationship between depressive symptoms and cigarette smoking in adolescents is well-documented, and both of these factors may contribute to incipient and/or persistent sleep problems. Previous studies in adolescents indicate cross-sectional relationships among sleep problems, depressive disorders, and depressive symptoms. Studies using objective measures of sleep indicate that adolescents with MDD have longer sleep latencies but do not consistently show the electroencephalogram sleep abnormalities associated with adult depression.

Similar to their adult counterparts, however, most adolescents with MDD report sleep disturbance. In young adults and adult samples, insomnia has been found to be a precursor of development of MDD. Alternatively, a study of older community adults found that depressive symptoms were associated with development of sleep problems over a 3-year period.

Cross-sectional studies further indicate that adolescents who smoke cigarettes sleep less than non-smokers and report more sleep problems, although some exceptions have been reported. These observations are similar to those found in young adults and adult samples. For example, Gillin et al determined that transdermal nicotine had a dose-dependent effect on rapid-eye-movement sleep and increased waking in normal adult nonsmoker volunteers. Studies in adults examining the effects of abstinence from smoking on sleep are mixed; some show an increase in sleep disturbance while others indicate improvement in sleep.

In addition to depressive symptoms and cigarette smoking, several correlates of adolescent sleep problems have been observed, including negative mood, family problems, poorer school performance, cognitive impairments, behavior problems, physical illness, psychiatric morbidity, alcohol and other drug use, and accidents. Girls report more frequent occasional sleep problems than boys, although some studies found no sex differences. Sleep problems in adolescents have not been related to age, race/ethnicity, or socioeconomic status. The elucidation of the causal nature between various predictor variables and adolescent sleep problems would be important for designing prevention and treatment programs focused on perceived sleep problems in adolescents.

In this study, we examine factors associated with the development and persistence of sleep problems in a longitudinal sample of 7960 US adolescents.

METHODS

Survey Sample

The Teenage Attitudes and Practices Survey (TAPS) was designed to provide information on adolescent smoking behavior and was developed under the direction of the National Center for Health Statistics and the Office on Smoking and Health, Centers for Disease Control and Prevention. TAPS interviewed adolescents who had responded to the 1989 National Health Interview Survey (NHIS), an annual household interview survey of the civilian, noninstitutionalized population of the United States. The first TAPS (TAPS I) was conducted in 1989 and the follow-up (TAPS II) was conducted in 1993.

Adolescents (n = 9965) 12 to 18 years old were interviewed in 1989 by telephone or mail questionnaire (TAPS I). This represented a response rate of 82% of the original sample of 12,097 adolescents who had responded to the NHIS in 1989. Of the 9965 adolescents in TAPS I, only those reached by telephone (n = 9135) were eligible for follow-up in 1993. The 830 who were not reached by telephone responded through mail questionnaire and were not eligible for the follow-up in 1993. The follow-up telephone survey (TAPS II) was completed in 1993 by 87% of the eligible TAPS I respondents (n = 7960) who by that time were 15 to 22 years old.

Demographic Variables

Sociodemographic predictors assessed in 1989 included age, sex, and race/ethnicity (categorized as non-Hispanic white, Hispanic, black, Asian, and other). The TAPS sample was drawn from households that had recently completed the NHIS, making adult-provided NHIS data available on family income and the educational attainment of the responsible adult who gave permission for the adolescent to be interviewed. For the purposes of this analysis, family income was reduced to 4 categories (< $16,000, $16,000–$29,999, $30,000–$49,999, and ≥$50,000). Academic achievement was measured by asking all adolescents how they thought they were performing at school, compared with the average student.

Measure of Sleep Problems

A single item from the TAPS questionnaire was used to determine the presence or absence of sleep problems in 1989 and 1993. All respondents were asked, “During the past 12 months, how often have you had trouble going to sleep or staying asleep?” with the corresponding response categories, “often,” “sometimes,” “rarely,” and “never.” In 1989 and 1993, respondents who answered “rarely” or “never” to the above question were classified as not having sleep problems. Respondents who answered, “often” or “sometimes” were classified as having sleep problems. Those who responded “often” were categorized as frequent sleep problems.

Measure of Depressive Symptoms

A 5-item modified version of a previously validated scale was used to assess depressive symptoms in 1989 and 1993. The scale was modified to exclude the item on sleep (described above), so that the effect of depressive symptoms on sleep problems did not rely on information about sleep problems. All adolescents were asked, “During the past 12 months, how often have you felt too tired to do things?; felt unhappy, sad, or depressed?; felt hopeless about the future?; felt nervous or tense?; and worried too much about things?” Respondents were provided with 4 response categories including, “never,” “rarely,” “sometimes,” or “often.” These 4 responses were assigned scores of 1, 2, 3, and 4, respectively, and then summed to produce an overall depressive symptom score, which ranged from 5 to 20 points. In addition, these scores were increased by 10 to produce a new range of 15 to 30 points.

Adolescents who achieved a score ≥ 21 were defined as having notable depressive symptoms. Using a cutoff score of 21, 15% of the adolescent baseline sample were classified as having notable depressive symptoms, which corresponds with the percentage obtained by Kandel and Davies. This cutoff score also produced the largest magnitude of association between the self-reported scores and Diagnostic and Statistical Manual of Mental Disorders III diagnoses of MDD in a clinical adolescent sample. The difference in magnitude of the cutoff score (21 vs 13) in this study, compared with our previous study, is attributable to the omission of the
sleep item in this study. The internal consistency of the depressive symptom scale for this sample was .72, as measured by the Cronbach’s coefficient $a$-statistic.

**Measure of Smoking Status**

In both the 1989 and 1993 surveys, we identified current smokers using the standard question: “On how many of these days did you smoke?” Experimentation with cigarettes was defined as a positive response to either of 2 questions: “Have you ever smoked a cigarette?” and “Have you ever tried or experimented with cigarette smoking, even a few puffs?” Two negative responses required classifying a respondent as a never smoker. A positive response to the first question led to an additional question: “Have you ever smoked 100 cigarettes?” Current established smokers were defined as adolescents who had smoked at least 100 cigarettes in their lifetime and had smoked in the past 30 days. Experimenters were defined as adolescents who had either puffed or smoked cigarettes but who had smoked <100 cigarettes in their lifetime. Never smokers were adolescents who had never smoked a cigarette, not even a puff.

**Other Psychosocial Predictors**

Psychosocial variables assessed in 1989 included the adolescents’ participation in any type of competitive and organized physical activity, such as team sports. Adolescents who answered “yes” to the following 2 questions were defined as having rebellious characteristics: “I get a kick out of doing things every now and then that are a little risky or dangerous,” and “During the past year have you been in a physical fight that involved hitting, pushing, shoving, or any other kind of physical contact not including family fights, such as fights with brothers and sisters?” Finally, the availability of social support from the adolescent’s family, friends, and other adults was assessed by the question, “If you had a serious problem, is there someone you could talk to or go to for help?”

**Statistical Analysis**

The NHIS uses a multistage sample design to provide national estimates of the civilian, noninstitutionalized population. It is a complex sample design involving both clustering and stratification. The stratification variables were race (black and non-black), sex, and age categories (10–14, 15–17, 18–19, and 20–22 years old). The multistage NHIS sample design requires a Taylor series approximation to estimate variance, based on the NHIS weighting procedures. We used the SUDAAN program for all statistical analyses. All percentages were weighted and adjusted for sampling design and nonresponse.

We used 2 logistic regressions to identify which specified variables predicted the development of sleep problems or persistence of sleep problems from baseline to follow-up. The first logistic regression included only adolescents who reported no sleep problems at baseline, and the second logistic regression examined only those who reported sleep problems at baseline. Separate analyses were conducted with frequent sleep problems as the dependent variable. The first logistic regression included only adolescents who reported no sleep problems at baseline, and the second logistic regression included only those with sleep problems at baseline.

**RESULTS**

**Baseline Characteristics**

Of the 7960 adolescents (3921 girls and 4039 boys) surveyed in 1989, 3094 (38.8%) reported sleep problems and 1146 (14.4%) reported frequent sleep problems. Notable depressive symptoms were reported by 14.9% of the adolescents. Moreover, 56.1% were never smokers, 34% were experimenters, and 9.9% were current established smokers.

**Development of Sleep Problems in 1993 Among Those Without Sleep Problems in 1989**

Table 1 shows the baseline distribution of adolescents developing sleep problems or frequent sleep problems in 1993 among the 4866 adolescents without sleep problems at baseline. Approximately 28% developed sleep problems and 9% developed frequent sleep problems. Consequently, the estimated average annual incidence rate of developing sleep problems and frequent sleep problems in this study is 7% and 2.3%, respectively. Marked differences were observed in development of sleep problems between girls and boys. There were no significant differences across age group or race/ethnicity subgroups and development of sleep problems or frequent sleep problems.

Table 2 shows the results from the multiple logistic regression analysis that examined baseline characteristics measured in 1989 that were predictive of development of sleep problems or frequent sleep problems in 1993. Boys were ~30% less likely to develop sleep problems and 40% less likely to develop fre-

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**Table 1. Baseline Distribution of Adolescents Reporting No Sleep Problems in 1989 and Proportion Developing Sleep Problems or Frequent Sleep Problems by 1993**

<table>
<thead>
<tr>
<th>Baseline Demographics</th>
<th>n</th>
<th>Sleep Problems % (95% Confidence Interval)</th>
<th>Frequent Sleep Problems % (95% Confidence Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>4866</td>
<td>28.5 ± 1.3</td>
<td>9.0 ± 0.8</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2633</td>
<td>24.9 ± 1.8</td>
<td>7.4 ± 1.0</td>
</tr>
<tr>
<td>Female</td>
<td>2233</td>
<td>32.6 ± 2.0</td>
<td>10.8 ± 1.3</td>
</tr>
<tr>
<td>Age group (y)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12–14</td>
<td>2144</td>
<td>29.8 ± 2.0</td>
<td>8.6 ± 1.2</td>
</tr>
<tr>
<td>15–16</td>
<td>1333</td>
<td>27.7 ± 2.4</td>
<td>9.3 ± 1.7</td>
</tr>
<tr>
<td>17–18</td>
<td>1389</td>
<td>27.2 ± 2.5</td>
<td>9.2 ± 1.5</td>
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<tr>
<td>Race/ethnicity</td>
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<td></td>
</tr>
<tr>
<td>White</td>
<td>2638</td>
<td>27.7 ± 1.5</td>
<td>8.7 ± 0.9</td>
</tr>
<tr>
<td>Black</td>
<td>707</td>
<td>29.8 ± 3.4</td>
<td>10.7 ± 2.6</td>
</tr>
<tr>
<td>Hispanic</td>
<td>367</td>
<td>31.2 ± 4.8</td>
<td>9.4 ± 2.9</td>
</tr>
<tr>
<td>Asian/other</td>
<td>154</td>
<td>31.8 ± 8.6</td>
<td>5.0 ± 3.3</td>
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<tr>
<td>Perceived school performance</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Much better</td>
<td>868</td>
<td>27.6 ± 3.1</td>
<td>7.3 ± 1.9</td>
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<tr>
<td>Better</td>
<td>1851</td>
<td>27.1 ± 2.2</td>
<td>7.9 ± 1.4</td>
</tr>
<tr>
<td>Average/below</td>
<td>2147</td>
<td>30.1 ± 1.9</td>
<td>10.6 ± 1.3</td>
</tr>
</tbody>
</table>

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quent sleep problems than girls. After adjusting for age, sex, race/ethnicity, and family income, there were 3 significant predictors of development of sleep problems and/or frequent sleep problems: rebelliousness, depressive symptoms, and cigarette smoking status. Respondents who were rebellious were \( \sim 30\% \) more likely to develop frequent sleep problems, compared with those who were not rebellious. Those who reported notable depressive symptoms were \( \sim 50\% \) more likely to develop sleep problems and frequent sleep problems by follow-up than those without notable depressive symptoms. Smoking status showed a dose–response relationship with development of sleep problems and frequent sleep problems, respectively; current established smokers had the highest risk, compared with never smokers, with experimenters having an intermediate risk. The interaction between notable depressive symptoms and smoking status was examined in the logistic regression, and it was not statistically significant.

### Persistence of Sleep Problems in 1993 Among Those With Sleep Problems in 1989

Table 3 presents the baseline distribution of adolescents reporting sleep problems or frequent sleep problems in 1993 among the 3094 reporting sleep problems in 1989. Of those who reported sleep problems at baseline, 52% reported sleep problems and 21% reported frequent sleep problems at follow-up. Girls were more likely than boys to report sleep problems, but not frequent sleep problems, at follow-up. There were large racial/ethnic differences, with blacks reporting the lowest rate of sleep problems and frequent sleep problems and with Asians reporting the highest rates, \( \sim 60\% \) for sleep problems and \( 31\% \) for frequent sleep problems.

### Table 3. Baseline Distribution of Adolescents Reporting Sleep Problems in 1989 and Proportion With Sleep Problems or Frequent Sleep Problems in 1993

<table>
<thead>
<tr>
<th>Baseline Demographics</th>
<th>n</th>
<th>Sleep Problems % (95% Confidence Interval)</th>
<th>Frequent Sleep Problems % (95% Confidence Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>3094</td>
<td>51.6 ± 2.0</td>
<td>21.1 ± 1.5</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1406</td>
<td>47.1 ± 2.8</td>
<td>19.8 ± 2.1</td>
</tr>
<tr>
<td>Female</td>
<td>1688</td>
<td>55.3 ± 2.5</td>
<td>22.1 ± 2.1</td>
</tr>
<tr>
<td>Age group (y)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12–14</td>
<td>1332</td>
<td>50.5 ± 2.9</td>
<td>20.0 ± 2.4</td>
</tr>
<tr>
<td>15–16</td>
<td>913</td>
<td>51.8 ± 3.3</td>
<td>21.4 ± 2.8</td>
</tr>
<tr>
<td>17–18</td>
<td>849</td>
<td>53.1 ± 3.5</td>
<td>22.3 ± 2.9</td>
</tr>
<tr>
<td>Race/ethnicity</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>2312</td>
<td>51.7 ± 2.2</td>
<td>21.1 ± 1.7</td>
</tr>
<tr>
<td>Black</td>
<td>431</td>
<td>47.4 ± 5.5</td>
<td>16.4 ± 3.5</td>
</tr>
<tr>
<td>Hispanic</td>
<td>244</td>
<td>54.8 ± 6.9</td>
<td>24.4 ± 5.4</td>
</tr>
<tr>
<td>Asian/other</td>
<td>107</td>
<td>59.9 ± 10.2</td>
<td>31.4 ± 8.4</td>
</tr>
<tr>
<td>Perceived school performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Much better</td>
<td>428</td>
<td>49.3 ± 5.4</td>
<td>15.6 ± 3.5</td>
</tr>
<tr>
<td>Better</td>
<td>1073</td>
<td>52.7 ± 3.2</td>
<td>20.8 ± 2.5</td>
</tr>
<tr>
<td>Average/below</td>
<td>1593</td>
<td>51.6 ± 2.6</td>
<td>22.8 ± 2.2</td>
</tr>
</tbody>
</table>
symptoms were ~25% more likely to report sleep problems and 60% more likely to have frequent sleep problems, compared with those with notable depressive symptoms. Smoking status was only significant in predicting frequent sleep problems. Current established smokers had the highest risk, compared with never smokers, with the experimenters having an intermediate risk. We examined the interaction between depressive symptoms and smoking status in the logistic regression, and it was not significant. Therefore, we examined the rates of frequent sleep problems in 1993 by both baseline depressive symptoms and smoking status among those reporting sleep problems at baseline. Figure 1 illustrates the results showing that depressive symptoms are an effect modifier; for each level of smoking status, having notable depressive symptoms at baseline increases the risk of frequent sleep problems at follow-up.

Changes in Smoking Status and Depressive Symptoms and Development of Frequent Sleep Problems in 1993

Figure 2 shows the rate of frequent sleep problems in 1993 by change in smoking status and depressive symptom status among those without sleep problems at baseline. With respect to smoking status, those who remained noncurrent established smokers from baseline to follow-up reported the lowest rate of frequent sleep problems (NN; Fig 2). Adolescents who were noncurrent established smokers at baseline who became current established smokers by follow-up (NY) had nearly double the rate of frequent sleep problems as those who remained never smokers at both time points. Those who were current established smokers at baseline but quit by follow-up (YN) had lower rates of frequent sleep problems that were comparable to those who were noncurrent established smokers at baseline and at follow-up. Finally, respondents who remained current established smokers for both years (YY) had similar rates of frequent sleep problems as the NY group. The results were similar for change in depressive symptom status from baseline to follow-up. However, for the NY and YY categories of depressive symptom status, the rates of frequent sleep problems were much higher, nearly double the rate reported for smokers.

Changes in Smoking Status and Depressive Symptoms and Frequent Sleep Problems in 1993 Among Those With Sleep Problems in 1989

Figure 3 presents the rate of frequent sleep problems in 1993 by changes in smoking status and depressive symptom status among all 4866 adolescents without sleep problems in 1989 (see text for coding).

<table>
<thead>
<tr>
<th>TABLE 4. Multivariate Predictors of Sleep Problems or Frequent Sleep Problems in 1993 Among Those Reporting Sleep Problems in 1989</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Predictors</td>
</tr>
<tr>
<td>Sleep Problems</td>
</tr>
<tr>
<td>Odds Ratio</td>
</tr>
<tr>
<td>(95% Confidence Interval)</td>
</tr>
<tr>
<td>Sex</td>
</tr>
<tr>
<td>Females</td>
</tr>
<tr>
<td>Males</td>
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<tr>
<td>Age group (y)</td>
</tr>
<tr>
<td>17–18</td>
</tr>
<tr>
<td>15–16</td>
</tr>
<tr>
<td>12–14</td>
</tr>
<tr>
<td>Race/ethnicity</td>
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<tr>
<td>Black</td>
</tr>
<tr>
<td>Hispanic</td>
</tr>
<tr>
<td>Asian/other</td>
</tr>
<tr>
<td>Family income</td>
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<td>$16,000–$29,999</td>
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<td>Perceived school performance</td>
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<tr>
<td>Much better</td>
</tr>
<tr>
<td>Better</td>
</tr>
<tr>
<td>Average/below</td>
</tr>
<tr>
<td>Rebelliousness</td>
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<tr>
<td>Not rebellious</td>
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<tr>
<td>Rebellious</td>
</tr>
<tr>
<td>Depressive symptoms</td>
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<tr>
<td>Not depressed</td>
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<tr>
<td>Depressed</td>
</tr>
<tr>
<td>Smoking status</td>
</tr>
<tr>
<td>Never smoker</td>
</tr>
<tr>
<td>Experimenter</td>
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<tr>
<td>Established smoker</td>
</tr>
</tbody>
</table>

Note: $n = 3094.$
frequent sleep problems, while respondents who did not report notable depressive symptoms both years (NN) had the lowest rates. This was found for change in smoking status from baseline to follow-up. Moreover, in both Figs 2 and 3, for the NY and YY groups, the effect of depressive symptoms was significantly greater than that of smoking status.

DISCUSSION

The major finding of this study is that depressive symptoms and cigarette smoking predicted the development and persistence of frequent sleep problems among adolescents in the United States. Adolescents with notable depressive symptoms at baseline were significantly more likely to develop sleep problems and frequent sleep problems by follow-up than those without notable depressive symptoms. Notable depressive symptoms were also a significant predictor of persistent sleep problems and frequent sleep problems. Moreover, cigarette smoking showed a dose–response relationship with development of sleep problems and frequent sleep problems. The findings for the persistence of frequent sleep problems in adolescents produced a similar dose–response relationship with smoking status.

Previous studies suggested cross-sectional associations between sleep problems and depressive symptoms in adolescents.12,14 Longitudinal work in adults suggests that insomnia is a precursor of the development of MDD.11,20,34,35 Although 1 study found that depressive symptoms predicted later insomnia,36 it may be that adults with insomnia are more likely to develop MDD, but depressive symptoms in adolescence might be a early precursor to onset of insomnia. These longitudinal relationships have not been well studied in adolescents. Our results indicate that those with notable depressive symptoms at both years had the highest rates of development and persistence of frequent sleep problems, while respondents without notable depressive symptoms both years had the lowest rates. This study did not explore the mechanisms by which depressive symptoms may lead to sleep disturbance in adolescence. Depressive symptoms, such as poor mood, are associated with lower levels of coping skills and reduced tolerance of difficult situations.62 Thus, 1 hypothesis is that depressive symptoms lead to the development of sleep problems by reducing the adolescent’s coping repertoire. It is notable that although we used a previously validated measure of depressive symptoms, many of the items such as, “felt too tired to do things,” may be confounded with sleep disturbance, thus contributing to the observed relationships between depression and sleep problems. Elevated depressive symptoms in adolescents are associated with adverse health consequences, including suicide.72 Our results further highlight the need to focus prevention and intervention efforts on the reduction of adolescent depressive symptoms.

The phenomenology of depression as it relates to sleep disturbance among adolescents is of interest, given that not all adolescents with notable depressive symptoms reported frequent sleep problems. Inspection of Fig 3 indicates that only ~40% of those with notable depressive symptoms at baseline and at follow-up reported frequent sleep problems at follow-up. These findings are in contrast to studies examining the relationship of sleep problems and MDD, which indicate that perceived sleep disturbance is common in both adults and adolescents with MDD. One study of adolescents suggests low concordance for depressive symptoms across follow-up time points.12 Structured diagnostic interviews were administered to assess for MDD at baseline and at 12-month follow-up. Among those adolescents who had experienced 2 episodes of MDD, there was low concordance across episodes for specific symptoms. For those with MDD at baseline, insomnia was the second most common symptom reported. However, among those who experienced a second MDD episode during follow-up, insomnia was the fourth most frequently reported symptom. The most stable symptoms across depressive episodes were depressed mood and anhedonia.

Results of our investigation indicate that cigarette smoking status is associated with the development and persistence of sleep difficulties in adolescents. These findings are consistent with numerous cross-sectional findings of a relationship between cigarette smoking and sleep disturbance in adolescents.37–43 Importantly, we observed that stopping smoking or not smoking at either time point decreased the risk of development and persistence of frequent sleep problems. This is consistent with some studies in adults that found that stopping smoking improves sleep quality.52 The prevalence of adolescent smoking has recently increased among all racial and ethnic subgroups.73 More than 3000 adolescents in the United States begin to use tobacco every day.24 If the current smoking patterns persist among adolescents, the public health burden of smoking will become even greater.75 Our findings further underscore the need for intensifying intervention efforts to reduce adolescent smoking.

Our study did not address the mechanisms by which cigarette smoking may lead to development or persistence of sleep difficulties. Nicotine is a stimulant, which may increase arousal and difficulty initiating sleep.76 Moreover, cigarette smoking typically
results in a precipitous nocturnal drop in blood nicotine levels that may contribute to sleep problems.52,77–81 However, the relationships between cigarette smoking and sleep problems may be reciprocal. For example, adolescents may take up cigarette smoking to self-medicate sleep disturbance. The lack of interaction between depressive symptoms and cigarette smoking status indicates that the relationship between cigarette smoking and sleep problems does not depend on the level of depressive symptoms and vice versa. However, we recognize that other factors not assessed as part of this study may be a third variable or confounder. In particular, several variables correlate with sleep problems, cigarette smoking, and depressive symptoms in adolescents. These include excessive alcohol use82–84; lack of physical exercise85; obesity40; health problems85; medical disorders83; and personality traits, such as anger, introversion, and somatic concerns.12,86

A limitation of this study is that the occurrence of sleep problems, before the year before the baseline interview, was not determined. Thus, the possibility that sleep problems antedated the onset of depressive symptoms and/or initiation of cigarette smoking cannot be dismissed. Additionally, changes in sleep problems, depressive symptoms, and cigarette smoking were not assessed during the 4-year interval between baseline and follow-up. Furthermore, all information in this study was from self-reported data from telephone interviews of adolescents in their homes. Previous studies of adolescents have shown that there is stability of self-reported substance use in the adolescent population and that questionnaires produce highly reliable data.87 Research has also shown that stressing the assurance of confidentiality increases the validity of self-reported smoking status in adolescents,88 as was done in this study.

Sleep difficulties were highly prevalent in our adolescent sample. At baseline, 39% reported sleep problems, which is slightly higher than the estimates reported in cross-sectional studies.6,10–18 Consistent with previous results,14–18 14% of our sample reported frequent sleep problems. The 12-month incidence of sleep problems was 7%, a rate that is lower than that found in a population-based study of adolescents (12.5%),12 but comparable to a study of young adults (5.7%).11 Moreover, 52% of adolescents reported persistent sleep problems, compared with the rate of 42% found among adolescents over a 2-year period6 and with the rate of 45% among young adults over a 3-year period.20 Differences in the estimates of sleep disturbance across studies may be accounted for by variability in the methodology used to elicit adolescent reports of sleep disturbance.20,89 In addition, the frequency and duration used to define a problem is highly variable and often not described, making comparisons across studies difficult. For example, previous investigations examining the incidence of sleep difficulties in adolescents12 and young adults11 used structured interviews to assess the Diagnostic and Statistical Manual criteria of the American Psychiatric Association for insomnia, defined as difficulty initiating or maintaining sleep, or early morning awakening nearly every day for a 2-week period. The study in adolescents12 assessed for current insomnia, whereas the study in young adults determined whether subjects had experienced insomnia during the past 6 months. A limitation of our study is that we used a single item measure of sleep problems, with unknown reliability and validity. In contrast to previous work, our study assessed the frequency of sleep problems occurring over the past 12 months, which may be indicative of a more chronic problem for those reporting “often” or “always.” More consistent measures and definitions of sleep problems are needed, so that results across studies can be compared.

Marked differences were observed in the development and persistence of sleep problems and frequent sleep problems between girls and boys. These results are consistent with some,14,16–18,40 but not all,3,6,54,56 cross-sectional studies. Similar to the results of previous studies,3,17,18 there were no significant differences across age group and development or persistence of sleep difficulties in adolescents. Although race/ethnicity was unrelated to development of sleep problems or frequent sleep problems, there were large differences in the persistence of sleep difficulties, with blacks reporting the lowest rate of sleep problems and frequent sleep problems at follow-up and with Asians reporting the highest rates. These findings may be accounted for by various cultural and environmental factors that were not assessed as part of this study. Further research is needed to explore the mechanisms that account for these racial/ethnic differences. Consistent with previous findings,57,58 the development and persistence of both sleep problems and frequent sleep problems were related to average or below average school performance. Poor school performance is associated with such factors as psychological distress (eg, anxiety and worry) and family problems that may negatively affect sleep.56–58 Moreover, adolescents who were rebellious were more likely to develop frequent sleep problems, compared with those who were not rebellious. Characteristics of rebelliousness are associated with adverse health behaviors, such as later sleep onset, truancy, and alcohol and drug use, which may contribute to the onset of sleep difficulties.

It is possible that many of the adolescents who reported sleep problems in this study may have met diagnostic criteria for insomnia or another sleep disorder. However, our study did not link self-reported sleep problems with a formal diagnosis of insomnia or other sleep disorders. Clinical assessment of adolescents with sleep complaints requires a thorough interview to obtain a wide range of information about sleep and related habits.93 In addition to sleep disorders, other psychiatric disorders may be associated with self-reported sleep disturbance in adolescents, including major depression, bipolar disorder, and alcohol or drug dependence.72,94 A further limitation relates to the validity of independent variables used in this study to assess perceived school performance, rebelliousness, participation in sports, and availability of social support. Because the reliability and validity of these measures are uncertain,
the results related to these measures should be interpreted with caution.

The strengths of this study include the population-based nature of the data and the use of a prospective, longitudinal design. In contrast to previous research, we were able to observe several factors related to the development and persistence of adolescent sleep problems and frequent sleep problems. There is a cogent need for prevention and treatment efforts focused on adolescent sleep problems, because perceived difficulty with sleep has been associated with other health-risk behaviors and future psychiatric morbidity, including major depressive disorder. Our results suggest that the prevention and reduction of adolescent depressive symptoms and cigarette smoking should be an important focus of these interventions.

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