

# 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, 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.*

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.<sup>1-3</sup> Objective measures of sleep, analyzing polysomnogram recordings (ie, electroencephalogram, electromyogram, and electrooculogram), show changes from preadolescence to adolescence, including a decrement in  $\delta$  or slow-wave sleep and reduced rapid-eye-movement latency.<sup>4</sup> Adolescents are also vulnerable to daytime sleepiness,<sup>5,6</sup> reflecting an endogenous-based maturational increase in physiologic sleep tendency in the absence of changes in total sleep time.<sup>7,8</sup> 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.<sup>7,9</sup>

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.<sup>6,10-13</sup> 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,<sup>14-18</sup> and 23% to 37.6% report occasional sleep problems.<sup>14,17,19</sup> It is important to note that sleep disorders other than insomnia, including circadian rhythm disorders and hypersomnias, have also been reported in adolescents.<sup>2,7</sup>

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.<sup>12</sup> 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%.<sup>11</sup> Only 1 study examined the persistence of sleep problems over time in adoles-

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

From the Nicotine Research Center and Department of Psychiatry and Psychology, \*Mayo Clinic, Rochester, Minnesota; †University of California, San Diego, San Diego, California; and ‡Veterans Affairs Medical Center, San Diego, California.

Received for publication Nov 29, 1999; accepted Mar 2, 2000.

Reprint requests to (C.A.P.) Mayo Clinic, Nicotine Research Center, Colonial 3, 200 First Street SW, Rochester, MN 55905. E-mail: [patten.christi@mayo.edu](mailto:patten.christi@mayo.edu)

PEDIATRICS (ISSN 0031 4005). Copyright © 2000 by the American Academy of Pediatrics.

cents.<sup>6</sup> 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.<sup>6</sup> Similarly, a study of 979 young adults 21 to 30 years old<sup>20</sup> 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,<sup>12</sup> 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,<sup>21–27</sup> 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.<sup>12,14</sup> 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.<sup>28–32</sup> Similar to their adult counterparts, however, most adolescents with MDD report sleep disturbance.<sup>33</sup> In young adult<sup>20</sup> and adult samples,<sup>11,34,35</sup> insomnia has been found to be a precursor of development of MDD. Alternatively, 1 study of older community adults<sup>36</sup> 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 nonsmokers<sup>37,38</sup> and report more sleep problems,<sup>39–43</sup> although some exceptions have been reported.<sup>16,44</sup> These observations are similar to those found in young adult<sup>20</sup> and adult samples.<sup>17,36,40,45–48</sup> For example, Gillin et al<sup>49</sup> 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<sup>50–52</sup> while others indicate improvement in sleep.<sup>48,53</sup>

In addition to depressive symptoms and cigarette smoking, several correlates of adolescent sleep problems have been observed, including negative mood,<sup>14,16,54</sup> family problems,<sup>55</sup> poorer school performance,<sup>56,57</sup> cognitive impairments,<sup>58–60</sup> behavior problems,<sup>12,54,61</sup> physical illness,<sup>55,62</sup> psychiatric morbidity,<sup>6,12,54,63</sup> alcohol and other drug use,<sup>8</sup> and accidents.<sup>8,59,64,65</sup> Girls report more frequent<sup>16–18,40</sup> and occasional sleep problems<sup>14,16,17</sup> than boys, although some studies found no sex differences.<sup>3,6,66</sup> Sleep problems in adolescents have not been related to age, race/ethnicity, or socioeconomic status.<sup>3,17,18</sup> 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.

## 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.<sup>67</sup> 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.<sup>68</sup>

## 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<sup>69</sup> 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  $\geq 21$  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.<sup>69</sup> 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.<sup>69</sup> The difference in magnitude of the cutoff score (21 vs 13) in this study, compared with our previous study,<sup>21</sup> 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<sup>70</sup> coefficient  $\alpha$ -statistic.

### Measure of Smoking Status

In both the 1989 and 1993 surveys, we identified current smokers using this standard question<sup>67</sup>: "Think about the last 30 days. 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.<sup>67</sup> We used the SUDAAN program for all statistical analyses.<sup>71</sup> 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-

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

Baseline Demographics	n	Follow-Up	
		Sleep Problems % (95% Confidence Interval)	Frequent Sleep Problems % (95% Confidence Interval)
Overall	4866	28.5 ± 1.3	9.0 ± .8
Sex			
Male	2633	24.9 ± 1.8	7.4 ± 1.0
Female	2233	32.6 ± 2.0	10.8 ± 1.3
Age group (y)			
12–14	2144	29.8 ± 2.0	8.6 ± 1.2
15–16	1333	27.7 ± 2.4	9.3 ± 1.7
17–18	1389	27.2 ± 2.5	9.2 ± 1.5
Race/ethnicity			
White	3638	27.7 ± 1.5	8.7 ± .9
Black	707	29.8 ± 3.4	10.7 ± 2.6
Hispanic	367	31.2 ± 4.8	9.4 ± 2.9
Asian/other	154	31.8 ± 8.6	5.0 ± 3.3
Perceived school performance			
Much better	868	27.6 ± 3.1	7.3 ± 1.9
Better	1851	27.1 ± 2.2	7.9 ± 1.4
Average/below	2147	30.1 ± 1.9	10.6 ± 1.3

**TABLE 2.** Multivariate Predictors of Sleep Problems or Frequent Sleep Problems in 1993 Among Adolescents Without Sleep Problems in 1989

Baseline Predictors	Follow-Up	
	Sleep Problems Odds Ratio (95% Confidence Interval)	Frequent Sleep Problems Odds Ratio (95% Confidence Interval)
Sex		
Females	1.00	1.00
Males	.67 (.58-.77)	.60 (.49-.75)
Age group (y)		
17-18	1.00	1.00
15-16	1.07 (.89-1.28)	1.09 (.82-1.45)
12-14	1.30 (1.09-1.54)	1.21 (.94-1.56)
Race/ethnicity		
White	1.00	1.00
Black	1.12 (.93-1.34)	1.31 (.94-1.81)
Hispanic	1.16 (.91-1.49)	1.05 (.71-1.53)
Asian/other	1.27 (.83-1.95)	.60 (.29-1.26)
Family income		
<\$16 000	1.00	1.00
\$16 000-\$29 999	1.00 (.82-1.22)	1.15 (.83-1.61)
\$30 000-\$49 999	.98 (.81-1.20)	1.00 (.71-1.41)
\$50 000+	.83 (.67-1.02)	.67 (.46-.97)
Perceived school performance		
Much better	1.00	1.00
Better	.97 (.80-1.17)	1.04 (.73-1.47)
Average/below	1.06 (.88-1.29)	1.27 (.92-1.75)
Rebelliousness		
Not rebellious	1.00	1.00
Rebellious	1.12 (.97-1.30)	1.29 (1.03-1.61)
Notable depressive symptoms		
Not depressed	1.00	1.00
Depressed	1.54 (1.21-1.97)	1.47 (1.03-2.04)
Smoking status		
Never smoker	1.00	1.00
Experimenter	1.20 (1.03-1.40)	1.56 (1.21-2.00)
Established smoker	1.47 (1.16-1.87)	2.10 (1.47-3.01)

Note:  $n = 4866$ .

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: rebel-

liousness, depressive symptoms, and cigarette smoking status. Respondents who were rebellious were ~30% more likely to develop frequent sleep problems, compared with those who were not rebellious. Those who reported notable depressive symptoms were ~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, ~60% for sleep problems and 31% for frequent sleep problems.

Table 4 shows the results from the multiple logistic regression analysis for those with sleep problems at baseline who reported sleep problems or frequent sleep problems at follow-up. Boys were less likely than girls to report sleep problems. Among the ethnic groups, Asians had the highest risk of frequent sleep problems. They were 80% more likely than whites to report frequent sleep problems at follow-up. Respondents who reported notable depressive

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

Baseline Demographics	$n$	Follow-Up	
		Sleep Problems % (95% Confidence Interval)	Frequent Sleep Problems % (95% Confidence Interval)
Overall	3094	51.6 ± 2.0	21.1 ± 1.5
Sex			
Male	1406	47.1 ± 2.8	19.8 ± 2.1
Female	1688	55.3 ± 2.5	22.1 ± 2.1
Age group (y)			
12-14	1332	50.5 ± 2.9	20.0 ± 2.4
15-16	913	51.8 ± 3.3	21.4 ± 2.8
17-18	849	53.1 ± 3.5	22.3 ± 2.9
Race/ethnicity			
White	2312	51.7 ± 2.2	21.1 ± 1.7
Black	431	47.4 ± 5.5	16.4 ± 3.5
Hispanic	244	54.8 ± 6.9	24.4 ± 5.4
Asian/other	107	59.9 ± 10.2	31.4 ± 8.4
Perceived school performance			
Much better	428	49.3 ± 5.4	15.6 ± 3.5
Better	1073	52.7 ± 3.2	20.8 ± 2.5
Average/below	1593	51.6 ± 2.6	22.8 ± 2.2

**TABLE 4.** Multivariate Predictors of Sleep Problems or Frequent Sleep Problems in 1993 Among Those Reporting Sleep Problems in 1989

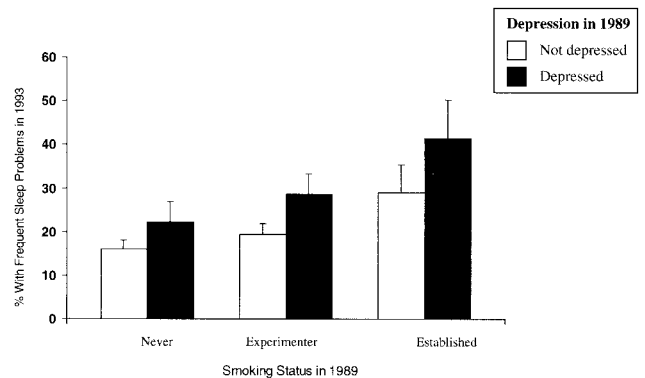
Baseline Predictors	Follow-Up	
	Sleep Problems Odds Ratio (95% Confidence Interval)	Frequent Sleep Problems Odds Ratio (95% Confidence Interval)
Sex		
Females	1.00	1.00
Males	.73 (.63–.85)	.90 (.75–1.08)
Age group (y)		
17–18	1.00	1.00
15–16	.96 (.79–1.18)	1.01 (.78–1.30)
12–14	.97 (.81–1.18)	1.11 (.87–1.41)
Race/ethnicity		
White	1.00	1.00
Black	.87 (.68–1.12)	0.79 (.58–1.08)
Hispanic	1.16 (.85–1.59)	1.22 (.88–1.70)
Asian/other	1.40 (.90–2.17)	1.80 (1.21–2.68)
Family income		
<\$16 000	1.00	1.00
\$16 000–\$29 999	.95 (.75–1.21)	.89 (.66–1.22)
\$30 000–\$49 999	.95 (.74–1.21)	.82 (.61–1.12)
\$50 000+	.99 (.75–1.31)	.82 (.59–1.15)
Perceived school performance		
Much better	1.00	1.00
Better	1.15 (.89–1.48)	1.39 (1.00–1.92)
Average/below	1.07 (.83–1.37)	1.33 (.98–1.79)
Rebelliousness		
Not rebellious	1.00	1.00
Rebellious	1.10 (.93–1.31)	1.14 (.92–1.41)
Depressive symptoms		
Not depressed	1.00	1.00
Depressed	1.24 (1.04–1.48)	1.57 (1.30–1.89)
Smoking status		
Never smoker	1.00	1.00
Experimenter	.95 (.80–1.13)	1.29 (1.04–1.54)
Established smoker	1.26 (.95–1.66)	2.18 (1.63–2.91)

Note:  $n = 3094$ .

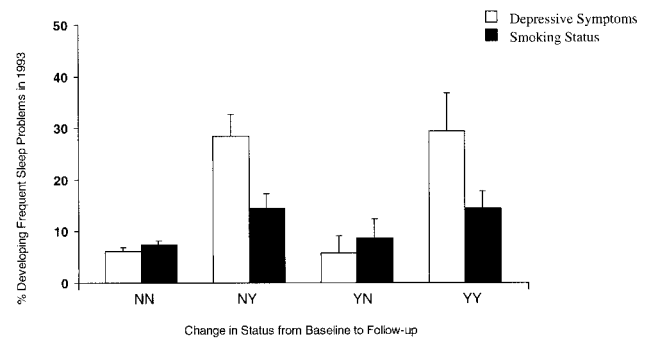
symptoms were ~25% more likely to report sleep problems and 60% more likely to have frequent sleep problems, compared with those without notable depressive symptoms. Smoking status was only significant in predicting frequent sleep problems. Current established smokers had the highest risk, compared with 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,



**Fig 1.** Frequent sleep problems in 1993 by baseline smoking status and depressive symptom status among the 3094 adolescents with sleep problems at baseline.

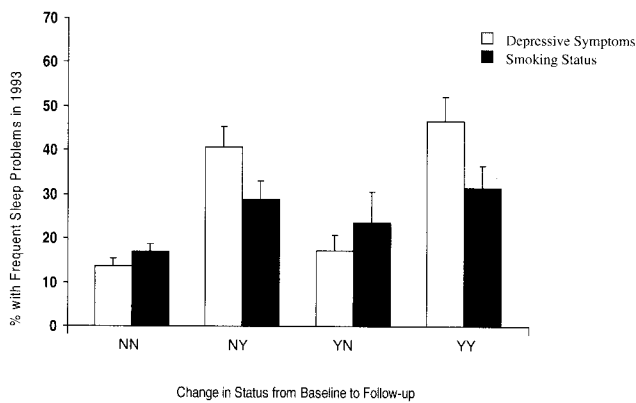


**Fig 2.** The percentage of adolescents with frequent sleep problems in 1993 by changes in smoking status and depressive symptom status among all 4866 adolescents without sleep problems in 1989 (see text for coding).

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 by change in smoking status and depressive symptom status among those with sleep problems at baseline. The pattern of frequent sleep problems is similar as that found in Fig 2. Those with depressive symptoms at both years (YY) had the highest rates of



**Fig 3.** The percentage of adolescents with frequent sleep problems in 1993 by changes in smoking status and depressive symptom status among all 3094 respondents with sleep problems in 1989 (coding similar as in Fig 2).

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.<sup>12,14</sup> Longitudinal work in adults suggests that insomnia is a precursor of the development of MDD,<sup>11,20,34,35</sup> although 1 study found that depressive symptoms predicted later insomnia.<sup>36</sup> It may be that adults with insomnia are more likely to develop MDD, but depressive symptoms in adolescence might be an 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.<sup>62</sup> 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.<sup>72</sup> 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.<sup>12</sup> 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.<sup>37-43</sup> 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.<sup>52</sup> The prevalence of adolescent smoking has recently increased among all racial and ethnic subgroups.<sup>73</sup> More than 3000 adolescents in the United States begin to use tobacco every day.<sup>74</sup> If the current smoking patterns persist among adolescents, the public health burden of smoking will become even greater.<sup>75</sup> 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.<sup>76</sup> Moreover, cigarette smoking typically

results in a precipitous nocturnal drop in blood nicotine levels that may contribute to sleep problems.<sup>52,77–81</sup> 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 use<sup>82–84</sup>; lack of physical exercise<sup>38</sup>; obesity<sup>40</sup>; health problems<sup>85</sup>; medical disorders<sup>63</sup>; and personality traits, such as anger, introversion, and somatic concerns.<sup>42,86</sup>

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.<sup>87</sup> Research has also shown that stressing the assurance of confidentiality increases the validity of self-reported smoking status in adolescents,<sup>88</sup> 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.<sup>6,10–18</sup> Consistent with previous results,<sup>14–18</sup> 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%),<sup>12</sup> but comparable to a study of young adults (5.7%).<sup>11</sup> Moreover, 52% of adolescents reported persistent sleep problems, compared with the rate of 42% found among adolescents over a 2-year period<sup>6</sup> and with the rate of 45% among young adults over a 3-year period.<sup>20</sup> 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.<sup>20,89</sup> 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 adolescents<sup>12</sup> and young adults<sup>11</sup> used structured interviews to assess the *Diagnostic and Statistical Manual*<sup>90</sup> 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 adolescents<sup>12</sup> assessed for current insomnia, whereas the study in young adults<sup>11</sup> 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,<sup>14,16–18,40</sup> but not all,<sup>3,6,54</sup> cross-sectional studies. Similar to the results of previous studies,<sup>3,17,18</sup> 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,<sup>57,58</sup> 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.<sup>56–58</sup> 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.<sup>91,92</sup>

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.<sup>93</sup> 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.<sup>72,94</sup> 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.

### ACKNOWLEDGMENTS

This study was supported in part by the California Tobacco Related Disease Research Program Grants 7KT-0091 and 4RT-0301; National Institutes of Health Grant MH30914 to the University of California, San Diego Mental Health Clinical Research Center; and the National Cancer Institute Grant R01 CA80323.

### REFERENCES

1. Karacan I, Anch M, Thornby JI, Okawa M, Williams RL. Longitudinal sleep patterns during pubertal growth: four-year follow-up. *Pediatr Res*. 1975;9:842-846
2. Wolfson AR. Sleeping patterns of children and adolescents: developmental trends, disruptions and adaptations. *Child Adolesc Psychiatry Clin North Am*. 1996;5:549-568
3. Yarcheski A, Mahon NE. A study of sleep during adolescence. *J Pediatr Nurs*. 1994;9:357-367
4. Carskadon MA. The second decade. In: Guilleminault C, ed. *Sleeping and Waking Disorders: Indications and Techniques*. Menlo Park, CA: Addison-Wesley; 1982:99-125
5. Andrade MM, Benedito-Silva AA, Domenice S, Arnholdt IJ, Menna-Barreto L. Sleep characteristics of adolescents: a longitudinal study. *J Adolesc Health*. 1993;14:401-406
6. Morrison DN, McGee R, Stanton WR. Sleep problems in adolescence. *J Am Acad Child Adolesc Psychiatry*. 1992;31:94-99
7. Carskadon MA. Patterns of sleep and sleepiness in adolescents. *Pediatrician*. 1990;17:5-12
8. Carskadon MA. Adolescent sleepiness: increased risk in a high-risk population. *Alcohol Drugs Driving*. 1990;5/6:317-328
9. Stores G. Practitioner review: assessment and treatment of sleep disorders in children and adolescents. *J Child Psychol Psychiatry*. 1996;37:907-925
10. Bruni O, Fabrizi P, Ottaviano S, Cortesi F, Giannotti F, Guidetti V. Prevalence of sleep disorders in childhood and adolescence with headache: a case-control study. *Cephalalgia*. 1997;17:492-498
11. Ford DE, Kamerow DB. Epidemiologic study of sleep disturbances and psychiatric disorders: an opportunity for prevention? *JAMA*. 1989;262:1479-1484
12. Roberts RE, Lewinsohn PM, Seeley JR. Symptoms of DSM-III-R major depression in adolescence: evidence from an epidemiological survey. *J Am Acad Child Adolesc Psychiatry*. 1995;34:1608-1617
13. Simonds JF, Parraga H. Sleep behaviors and disorders in children and adolescents evaluated at psychiatric clinics. *Dev Behav Pediatr*. 1984;5:6-10
14. Kirmil-Gray K, Eagleston JR, Gibson E, Thoresen CE. Sleep disturbance in adolescents: sleep quality, sleep habits, beliefs about sleep, and daytime functioning. *J Youth Adolesc*. 1984;13:375-384
15. Levy D, Gray-Donald K, Leech J, Zvagulius I, Pless B. Sleep patterns and problems in adolescents. *J Adolesc Health Care*. 1986;7:386-389
16. Manni R, Ratti MT, Marchionni E, et al. Poor sleep in adolescents: a study of 869 17-year-old Italian secondary school students. *J Sleep Res*. 1997;6:44-49
17. Price VA, Coates TJ, Thoresen CE, Grinstead OA. Prevalence and correlates of poor sleep among adolescents. *Am J Dis Child*. 1978;132:583-586
18. Yang L, Zuo C, Eaton LF. Research note: sleep problems of normal Chinese adolescents. *J Child Psychol Psychiatry*. 1987;28:167-172
19. Korlath J, Baizerman M, Williams S. Twin City adolescent health attitudes, knowledge, and behavior. *Center Q Focus*. 1976:1-6
20. Breslau N, Roth T, Rosenthal L, Andreski P. Sleep disturbance and psychiatric disorders: a longitudinal epidemiological study of young adults. *Biol Psychiatry*. 1996;39:411-418
21. Choi WS, Patten CA, Gillin JC, Kaplan RM, Pierce JP. Cigarette smoking predicts development of depressive symptoms among US adolescents. *Ann Behav Med*. 1997;19:42-50
22. Covey LS, Tam D. Depressive mood, the single-parent home, and adolescent cigarette smoking. *Am J Public Health*. 1990;80:1330-1333
23. Escobedo LG, Kirch DG, Anda RF. Depression and smoking initiation among US Latinos. *Addiction*. 1996;91:113-119
24. Fergusson DM, Lynskey MT, Horwood LJ. Comorbidity between depressive disorders and nicotine dependence in a cohort of 16-year-olds. *Arch Gen Psychiatry*. 1996;53:1043-1047
25. Kandel DB, Davies M. Adult sequelae of adolescent depressive symptoms. *Arch Gen Psychiatry*. 1986;43:255-262
26. Lewinsohn PM, Roberts RE, Seeley JR, Rohde P, Gotlib IH, Hops H. Adolescent psychopathology. II. Psychosocial risk factors for depression. *J Abnorm Psychol*. 1994;103:302-315
27. Rohde P, Lewinsohn PM, Seeley JR. Are adolescents changed by an episode of major depression? *J Am Acad Child Adolesc Psychiatry*. 1994;33:1289-1298
28. Benca RM, Obermeyer WH, Thisted RA, Gillin JC. Sleep and psychiatric disorders: a meta-analysis. *Arch Gen Psychiatry*. 1992;49:651-668
29. Dahl RE, Puig-Antich J, Ryan ND, et al. EEG sleep in adolescents with major depression: the role of suicidality and inpatient status. *J Affect Disord*. 1990;19:63-75
30. Emslie GJ, Rush AJ, Weinberg WA, Rintelmann J, Roffwarg HP. Sleep EEG features of adolescents with major depression. *Biol Psychiatry*. 1994;36:573-581
31. Giles DE, Roffwarg HP, Rush AJ, Guzik DS. Age-adjusted threshold values for reduced REM latency in unipolar depression using ROC analysis. *Biol Psychiatry*. 1990;27:841-853
32. Gillin JC, Duncan WC, Murphy DL, et al. Age-related changes in sleep in depressed and normal subjects. *Psychiatry Res*. 1981;4:73-78
33. Puig-Antich J. Sleep and neuroendocrine correlates of affective illness in childhood and adolescence. *J Adolesc Health Care*. 1987;8:505-529
34. Dryman A, Eaton WW. Affective symptoms associated with the onset of major depression in the community: findings from the US National Institute of Mental Health Epidemiologic Catchment Area Program. *Acta Psychiatrica Scand*. 1991;84:1-5
35. Livingston G, Blizard B, Mann A. Does sleep disturbance predict depression in elderly people? A study in inner London. *Br J Gen Pract*. 1993;43:445-448
36. Rodin J, McAvay G, Timko C. A longitudinal study of depressed mood and sleep disturbances in elderly adults. *J Gerontol*. 1988;43:P45-53
37. Macgregor IDM, Balding JW. Bedtimes and sleep duration in relation to smoking behaviour in 14-year-old English schoolchildren. *J Biosoc Sci*. 1988;20:371-376
38. Townsend J, Wilkes H, Haines A, Jarvis M. Adolescent smokers seen in general practice: health, lifestyle, physical measurements, and response to antismoking advice. *Br Med J*. 1991;303:947-950
39. Hawkins WE. Problem behaviors and health-enhancing practices of adolescents: a multivariate analysis. *Health Values*. 1992;16:46-54
40. Phillips BA, Danner FJ. Cigarette smoking and sleep disturbance. *Arch Intern Med*. 1995;155:734-737
41. Rimpelä M, Rimpelä A. Sleeping habits and disturbances. In: Rimpelä M, Rimpelä A, Ahlström S, et al, eds. *Health Habits Among Finnish Youth: The Juvenile Health Habits Study 1977-1979*. Helsinki, Finland: National Board of Health; 1983;4:71-81. English summary on page 213
42. Seltzer CC, Oechsli FW. Psychosocial characteristics of adolescent smokers before they started smoking: evidence of self-selection. *J Chron Dis*. 1985;38:17-26
43. Tynjälä J, Kannas L, Välimaa R. How young Europeans sleep. *Health Educ Res*. 1993;7:69-80
44. Pesa JA, Cowdery JE, Wang MQ, Qiang F. Self-reported depressive feelings and cigarette smoking among Mexican-American adolescents. *J Alcohol Drug Educ*. 1997;43:63-75
45. Bale P, White M. The effects of smoking on the health and sleep of sportswomen. *Br J Sports Med*. 1982;16:149-153
46. Lexcen FJ, Hicks RA. Does cigarette smoking increase sleep problems? *Percept Mot Skills*. 1993;7:16-18
47. Janson C, Gislason T, DeBacker W, et al. Prevalence of sleep disturbances among young adults in three European countries. *Sleep*. 1995;18:589-597

48. Soldatos CR, Kales JD, Scharf MB, Bixler EO, Kales A. Cigarette smoking associated with sleep difficulty. *Science*. 1980;207:551–553. Abstract
49. Gillin JC, Lardon M, Ruiz C, Golshan S, Salin-Pascual R. Dose-dependent effects of transdermal nicotine on early morning awakening and rapid eye movement sleep time in nonsmoking normal volunteers. *J Psychopharmacol*. 1994;14:264–267
50. Hajek P, Belcher M. Dream of absent-minded transgression: an empirical study of a cognitive withdrawal symptom. *J Abnorm Psychol*. 1991; 100:487–491
51. Prossise GL, Bonnet MH, Berry RB, Dickel MJ. Effects of abstinence from smoking on sleep and daytime sleepiness. *Chest*. 1994;105:1136–1141
52. Wetter DW, Fiore MC, Baker TB, Young TB. Tobacco withdrawal and nicotine replacement influence objective measures of sleep. *J Consult Clin Psychol*. 1995;63:658–667
53. Wolter TD, Hauri PJ, Schroeder DR, et al. Effects of 24-hr nicotine replacement on sleep and daytime activity during smoking cessation. *Prev Med*. 1996;25:601–610
54. Vignau J, Bailly D, Duhamel A, Vervaecke P, Beuscart R, Collinet C. Epidemiologic study of sleep quality and troubles in French secondary school adolescents. *J Adolesc Health*. 1997;21:343–350
55. Gau SF, Soong WT. Sleep problems of junior high school students in Taipei. *Sleep*. 1995;18:667–673
56. Guilleminault C, Eldridge F, Simmons F, Dement W. Sleep apnea in eight children. *Pediatrics*. 1976;58:23–30
57. Navelet Y, Anders T, Guilleminault C. Narcolepsy in children. In: Guilleminault C, Passouant P, Dement W, eds. *Narcolepsy*. New York, NY: Spectrum Publications; 1976:171–178
58. Anders TS, Carskadon M, Dement WC. Sleep and sleepiness in children and adolescents. *Pediatr Clin North Am*. 1980;27:29–43
59. Carskadon MA, Harvey K, Dement WC. Sleep loss in young adolescents. *Sleep*. 1981;4:299–312
60. Carskadon MA, Harvey K, Dement WC. Acute restriction of nocturnal sleep in children. *Percept Mot Skills*. 1981;53:103–112
61. Coble PA, Taska LS, Kupfer DJ, Kazdin AE, Unis A, French N. EEG sleep 'abnormalities' in preadolescent boys with a diagnosis of conduct disorder. *J Am Acad Child Psychiatry*. 1984;23:438–447
62. McGee R, Williams S, Stanton W. Is mental health in childhood a major predictor of smoking in adolescence? *Addiction*. 1998;93:1869–1874
63. Sadeh A, McGuire JPD, Sachs H, et al. Sleep and psychological characteristics of children on a psychiatric inpatient unit. *J Am Acad Child Psychol Psychiatry*. 1995;34:813–819
64. Copes K, Rosentswieg J. The effects of sleep deprivation on motor performance of ninth-grade students. *J Sports Med*. 1972;12:47–53
65. Leger D. The cost of sleep related accidents: a report for the National Commission on Sleep Disorders Research. *Sleep*. 1994;17:84–93
66. Bearpark HM, Michie PT. Prevalence of sleep/wake disturbances in Sydney adolescents. *Sleep Res*. 1987;16:304. Abstract
67. Allen KF, Moss AJ, Giovino GA, Shopland DR, Pierce JP. *Teenage Tobacco-Use: Data Estimates From the Teenage Attitudes and Practices Survey, United States, 1989*. Hyattsville, MD: National Center for Health Statistics; 1992. Advance data 224
68. Centers for Disease Control and Prevention. Changes in the cigarette brand preferences of adolescent smokers—United States, 1989–1993. *MMWR CDC Surveill Summ*. 1994;43:577–581
69. Kandel DB, Davies M. Epidemiology of depressive mood in adolescents. *Arch Gen Psychiatry*. 1982;39:1205–1212
70. Cronbach LJ. Coefficient alpha and the internal structure of tests. *Psychometrika*. 1951;16:297–334
71. Shah BV, Barnwell BG, Bieler GS. *SUDDAN User's Manual, Release 7.5*. Research Triangle Park, NC: Research Triangle Institute; 1997
72. Kazdin AE. Adolescent mental health: prevention and treatment programs. *Am Psychol*. 1993;48:127–141
73. Centers for Disease Control and Prevention. Tobacco use among high school students—United States, 1997. *MMWR CDC Surveill Summ*. 1998; 47:229–233
74. Glynn T, Anderson J, Swartz L. Tobacco-use reduction among high-risk youth: recommendations of a National Cancer Institute Expert Advisory Panel. *Prev Med*. 1993;20:279–291
75. Centers for Disease Control and Prevention. Projected smoking related deaths among youth—United States. *MMWR CDC Surveill Summ*. 1996; 45:971–974
76. Kishimoto T, Domino EF. Effects of tobacco smoking and abstinence on middle latency auditory evoked potentials. *Clin Pharmacol Ther*. 1998; 63:571–579
77. Benowitz NL, Kuyt F, Jacob P. Circadian blood nicotine concentrations during cigarette smoking. *Clin Pharmacol Ther*. 1982;32:758–764
78. Cummings KM, Giovino G, Jaen CR, Emrich LJ. Reports of smoking withdrawal symptoms over a 21-day period of abstinence. *Addict Behav*. 1985;10:373–381
79. Hatsukami DK, Huhges JR, Pickens RW. Blood nicotine, smoke exposure and tobacco withdrawal symptoms. *Addict Behav*. 1985;10:413–417
80. Hughes JR, Hatsukami D. Signs and symptoms of tobacco withdrawal. *Arch Gen Psychiatry*. 1986;43:289–294
81. Myrsten A, Elgerot MA, Edgren B. Effects of abstinence from tobacco smoking in physiological and psychological arousal levels in habitual smokers. *Psychosom Med*. 1977;39:25–38
82. Aubin HJ, Tilikete S, Barrucand D. Alcohol intake, cigarette smoking and sleep disturbance. *Arch Int Med*. 1996;156:1028
83. Gillin JC. Sleep and psychoactive drugs of abuse and dependence. In: Kryger MH, Roth T, Dement WC, eds. *Principles and Practice of Sleep Medicine*. 2nd ed. Philadelphia, PA: WB Saunders Co; 1994:934–942
84. Obermeyer WH, Benca RM. Effects of drugs on sleep. *Neurol Clin*. 1996;14:827–840
85. Mellinger GD, Balter MB, Uhlenhuth EH. Insomnia and its treatment. *Arch Gen Psychiatry*. 1985;42:225–232
86. Marks PA, Monroe LJ. Correlates of adolescent poor sleepers. *J Abnorm Psychol*. 1976;85:243–246
87. Barnea Z, Rahav G, Teichman M. The reliability and consistency of self-reports on substance use in a longitudinal study. *Br J Addict*. 1987; 82:891–898
88. Williams CL, Eng A, Botvin GJ, Hill P, Wynder EL. Validation of students' self-reported cigarette smoking status with plasma cotinine levels. *Am J Public Health*. 1979;69:1271–1274
89. Bixler EO, Kales A, Soldatos CR, Kales JD, Healey S. Prevalence of sleep disorders in the Los Angeles metropolitan area. *Am J Psychiatry*. 1979; 136:1257–1262
90. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders, III-Revised (DSM-III-R)*. Washington, DC: American Psychiatric Association; 1987
91. Clark DC, Sommerfeldt L, Schwartz M, Hedeker D, Watel L. Physical recklessness in adolescence: trait or byproduct of depressive/suicidal states? *J Nerv Ment Dis*. 1990;178:423–433
92. Richardson JL, Radziszewska B, Dent CW, Flay BR. Relationship between after-school care of adolescents and substance use, risk-taking, depressed mood, and academic achievement. *Pediatrics*. 1993;92:32–38
93. Dahl RE, Carskadon MA. Sleep and its disorders in adolescence. In: Ferber R, Kryger M, eds. *Principles and Practice of Sleep Medicine in the Child*. Philadelphia, PA: WB Saunders Co; 1995:19–27
94. Bukstein OG, Brent DA, Kaminer Y. Comorbidity of substance abuse and other psychiatric disorders in adolescents. *Am J Psychiatry*. 1989; 146:1131–1141