# Sociodemographic and Behavioral Predictors of Bed Time and Wake Time among US Adolescents Aged 15 to 17 Years

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**Objective**   To examine bed times and wake times in US adolescents aged 15 to 17 years using time diaries to determine whether adolescent sleep has changed in recent years and what factors determine bed times and wake times.

**Study design**   Time diary analysis using 2 national probability samples: 1981 Time Use Longitudinal Panel Study (n = 130) and 2003-2006 American Time Use Survey (n = 2978).

**Results**   Average time in bed on school days was about 8 hours and was 1 to 2 hours longer on non-school days. Bed times and wake times were similar in 1981 and 2003-2006. Sociodemographic factors and daytime activities, specifically computer use and social activities, predicted bed time. On school days, school start time was the strongest predictor of wake time. Every hour earlier that school started, wake time was about 25 minutes earlier.

**Conclusions**   Adolescents spent less than the recommended 9 hours in bed on school days. There is no evidence that this is a recent change in bed times and wake times, however. Although many factors influence bed time, school start time is the strongest determinant of wake time on school days. Increased computer use and earlier school days may be contributing to insufficient sleep in adolescents. *(J Pediatr 2009;154:426-30)*

A national survey of adolescents conducted by the National Sleep Foundation found that adolescents in high school reported spending an average of 7.5 hours in bed and getting an average of 7.2 hours of sleep per night.[1] However, a 6-year longitudinal study among adolescents given a 10-hour sleep opportunity suggested that adolescents need 9 hours of sleep on average.[2,3] Both experimental and observational studies have found deleterious health and behavioral consequences of shorter sleep duration in adolescents and young adults. Adequate sleep appears to be critical for improved school performance and cognitive performance.[4,5] Furthermore, one study found increased risk-taking behavior in adolescents who experienced more sleep problems.[6] Studies in young adults have found that sleep loss also can lead to impaired neurobehavioral performance, mental health, immune function, appetite regulation, and glucose metabolism.[7-10] Population-based studies also have found an association between sleep duration and obesity in adolescents.[11-13] Finally, sleep loss increased the risk of motor vehicle accidents in young adults,[14] and sleep-related crashes are more common in adults under age 25 years.[15] Traffic accidents are the leading cause of death in adolescents.[16] Thus, it is of concern if adolescents are sleeping only 7 to 7.5 hours per night.

In this study, we used a different type of national survey data—24-hour time diaries—to answer key questions about adolescent sleep, based on time spent in bed. Time diaries allow researchers to examine time spent in different daily activities. We used these data to address 2 questions about adolescent sleep behavior: (1) whether adolescent bed times and wake times have changed in recent years, and (2) what factors determine adolescent bed times and wake times.

## METHODS

### Samples

These data come from 2 different population-based studies in the United States. The American Time Use Survey (ATUS) is an annual Bureau of Labor Statistics survey; data are available for 2003, 2004, 2005, and 2006.[17] The ATUS sample is drawn from households included in the Current Population Survey (CPS), which measures labor force participation of the civilian noninstitutionalized population. One household member aged 15 or older was randomly selected from CPS households to participate in the ATUS. Only 1 time diary was collected from each participant. Time diaries were collected using

| ATUS | American Time Use Survey | | CPS | Current Population Survey |
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computer-assisted telephone interviewing. Our analyses were restricted to the adolescents in the sample, respondents age 15 to 17 years.

The second sample is the Time Use Longitudinal Panel Study 1975-1981, a national 2-wave panel survey.[18] The 1975 data included only adults, but in 1981, up to 3 children from each household were eligible to participate. Each child participant was asked to complete 2 time diaries, for 1 school day and 1 non-school day. The time diaries were collected during personal interviews. Our analyses included children aged 15 to 17 years, for comparability with the ATUS sample.

## Time Diaries

Both studies collected 24-hour time diaries. Time diaries provide detailed information about activities over a 24-hour period. The respondents indicated the time at which each activity started and ended.[17,19,20] Unlike a survey question about usual time spent in a particular activity (eg, "How many hours do you spend watching television?"), a time diary does not inquire about specific activities that may be perceived as more or less socially desirable. Studies that ask respondents to estimate time spent doing particular activities are more subject to response bias compared with time diaries.[17,21] Thus, time diaries are considered to measure more accurately daily behavior.

In the ATUS 2003-2006 data, the time diary began at 4 a.m. on the day before the interview and ended at 4 a.m. on the day of the interview. In the 1981 study, the time diary began at midnight on the day before the interview and ended at midnight on the day of the interview. The public-use data for both surveys include the actual times at which each activity started and ended.

## Time Diary Variables

BED TIME. Bed time was defined as the time at which the final evening sleep period began during the 24-hour period. Because more than 1 sleep episode may have occurred over the 24 hours, we considered the last sleep start time after 6:00 p.m. (but before 6 a.m.) to be the bed time. If the respondent indicated that he or she was asleep when the time diary began (4:00 a.m. in the ATUS or midnight in the 1981 Time Use Longitudinal Panel Study data), this was not considered a bed time, because we could not determine the true beginning of the sleep period.

WAKE TIME. Wake time was defined as the first sleep end time that occurred after 4:00 a.m.

INFERRED TIME IN BED. We calculated the interval between average sleep start and average sleep end as the inferred time in bed. Because this includes the end of the previous night and the beginning of the following night, we cannot infer the total time asleep for a single night.

SCHOOL START TIME. School start time was defined as the time at which the educational activity of taking a class began on the diary day. Only those adolescents who went to class on the diary day had a school start time.

ACTIVITIES. We examined the following broad activity categories that were defined in the ATUS: work, child care, education, social entertainment, sports/active leisure, television watching, and computer use.

SCHOOL DAY VERSUS NON-SCHOOL DAY. We identified a diary as being from a school day if it indicated time spent taking a class on that day. If no such time was indicated, then the diary was considered to be from a non-school day.

Additional covariates included age, sex, race (Caucasian, African American, Asian, Hispanic, or other), and total household income. Income responses in the ATUS data were collected in 16 categories ranging from <$5 000/year to ≥$150 000/year. (The top category changed from ≥$75 000 to ≥$150 000 in 2003.) We converted the categorical income data into a single continuous variable by assigning the midpoint of each income category as income; for the top category, we used the Pareto estimate of the mean.[22] Because of inflation, we adjusted income using the Personal Consumption Expenditures Chain-Type Price Index.[23] Because the distribution of income is skewed, we used the natural log of the income in the regression analyses.

## Statistical Analyses

The analysis comprised 2 parts: (1) a comparison of mean bed time, wake time, and time in bed in the 2003-2006 ATUS with the 1981 Time Use Longitudinal Panel Study sample to address our first study question, and (2) an analysis of the predictors of bed times and wake times in the ATUS only to address the second question. We created box plots depicting the median, 25th percentile, and 75th percentile by day of week for bed time, wake time, and time in bed in the 1981 Time Use Longitudinal Panel Study data and the ATUS data. Then we used regression models to predict average bed time, wake time, and time in bed while adjusting for age (centered at 15 years), race, and sex. These adjusted results allowed us to compare average bed time, wake time, and time in bed in the 2 time periods. We calculated separate models for school days and non-school days. For the 1981 Time Use Longitudinal Panel Study data, we also took into account the repeated diaries in some adolescents using the clustered sandwich estimator. Finally, we evaluated whether the bed time, wake time, and inferred time in bed differed between the 1981 Time Use Longitudinal Panel Study data and the 2003-2006 ATUS data using regression models that included a dummy variable identifying the 1981 Time Use Longitudinal Panel Study after adjusting for age, race, and sex.

The second part of our analyses involved separate linear multiple regression models that predicted bed time and wake time using only the 2003-2006 ATUS data. Our findings indicate which factors predict bed time and wake time. The outcome in each model was clock time, from 0