**Is late bedtime an overlooked sleep behavior? Investigating associations between sleep timing, sleep duration, and dietary choices in adolescence and adulthood.**

**Online Supplemental Materials**

**Supplemental Figure 1.** Flow chart of participants included in cross-sectional analyses of sleep, bedtime, and body mass index, National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 1, United States, 1994-1995

**Supplemental Figure 2.** Flow chart of participants included in cross-sectional analyses of sleep, bedtime, and body mass index, National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 2, United States, 1996

**Supplemental Figure 3.** Flow chart of participants included in cross-sectional analyses of sleep, bedtime, and body mass index, National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 3, United States, 2001-2002

**Supplemental Figure 4.** Flow chart of participants included in cross-sectional analyses of sleep, bedtime, and body mass index, National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 4, United States, 2008

**Supplemental Table 1.** Key exposure and outcome variables measured

**Supplemental Table 2**. Characteristics of participants with and without missing data

**Supplemental Figure 1.** Flow chart of participants included in cross-sectional analyses of sleep, bedtime, and body mass index, National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 1, United States, 1994-1995

N = 20,237

N = 19,624

N = 19,264

N = 17,578

N = 20,774 participants National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 1

N = 13,048 included in analyses

Excluded 4,530 participants with missing data on key variables (e.g., sex, race/ethnicity, screen time, dietary choices)

Excluded 1,686 participants without valid sampling weights

Excluded 65 participants with missing data for bedtime and 295 participants with extreme values for bedtime (more than 2 standard deviations from the sample mean, i.e., bedtime 6:00 PM or earlier or 3:30 AM or later)

Excluded 46 participants with missing data for sleep duration and 567 with extreme values for sleep duration (more than 2 standard deviations from the sample mean, i.e., ≤ 4 hours per night or ≥12 hours per night)

Excluded 13 participants younger than 12 years, 478 participants older than 18 years, and 46 with missing age data

**Supplemental Figure 2.** Flow chart of participants included in cross-sectional analyses of sleep, bedtime, and body mass index, National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 2, United States, 1996

N = 13,659

N = 13,418

N = 13,260

N = 12,268

N = 14,738 participants National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 2

Excluded 20 participants with missing data for sleep duration and 221 with extreme values for sleep duration (more than 2 standard deviations from the sample mean, i.e., ≤ 3 hours per night or ≥12 hours per night)

Excluded 18 participants with missing data for bedtime and 140 participants with extreme values for bedtime (more than 2 standard deviations from the sample mean, i.e., bedtime 6:00 PM or earlier or 3:00 AM or later)

N = 9,438 included in analyses

Excluded 2,830 participants with missing data on key variables (e.g., sex, race/ethnicity, screen time, dietary choices)

Excluded 992 participants without valid sampling weights

Excluded 5 participants younger than 12 years and 1,074 participants older than 18 years

**Supplemental Figure 3.** Flow chart of participants included in cross-sectional analyses of sleep, bedtime, and body mass index, National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 3, United States, 2001-2002

N = 14,134

N = 13,381

N = 13,216

N = 12,487

N = 15,197 participants National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 3

Excluded 157 participants with missing data for sleep duration and 596 with extreme values for sleep duration (more than 2 standard deviations from the sample mean, i.e., ≤ 1.5 hours per night or ≥15.07 hours per night)

N = 9,427 included in analyses

Excluded 3,060 participants with missing data on key variables (e.g., sex, race/ethnicity, screen time, dietary choices)

Excluded 729 participants without valid sampling weights

Excluded 165 participants with extreme values for bedtime (more than 2 standard deviations from the sample mean, i.e., bedtime 5:17 PM or earlier or 6:47 AM or later)

Excluded 149 participants 18 years or young and 914 participants older than 24 years

**Supplemental Figure 4.** Flow chart of participants included in cross-sectional analyses of sleep, bedtime, and body mass index, National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 4, United States, 2008

N = 15,669

N = 15,064

N = 14,801

N = 13,963

N = 15,701 participants National Longitudinal Study of Adolescent to Adult Health (Add Health), Wave 4

Excluded 838 participants without valid sampling weights

N = 10,410 included in analyses

Excluded 3,553 participants with missing data on key variables (e.g., sex, race/ethnicity, screen time, dietary choices)

Excluded 66 participants with missing data for sleep duration and 539 with extreme values for sleep duration (more than 2 standard deviations from the sample mean, i.e., ≤ 1.5 hours per night or ≥15.07 hours per night)

Excluded 263 participants with extreme values for bedtime (more than 2 standard deviations from the sample mean, i.e., bedtime 5:17 PM or earlier or 2:17 AM or later)

Excluded 32 participants 24 years or younger

**Supplemental Table 1.** Key exposure and outcome variables measured

| **Variable** | **Definition or survey item** | **Notes** |
| --- | --- | --- |
| **Wave 1** |  |  |
| Sleep duration | Participants indicated, “How many hours of sleep do you usually get?” |  |
| Bedtime | Participants indicated “What time do you usually go to bed on week nights?” | Because participants often confuse “12:00 PM” to mean midnight (12:00 AM) rather than noon(1), we corrected reported bedtimes of “12:00 PM” to indicate “12:00 AM,” following previous studies(1) |
| Eating behaviors |  |  |
| Fruit yesterday | Participants who indicated “1” or “2 or more” in response to the question,“How often did you eat fruit or drink fruit juice yesterday?” |  |
| Vegetables yesterday | Participants who indicated “1” or “2 or more” in response to the question, “How often did you eat vegetables yesterday?” |  |
| Sweets yesterday | Participants who indicated “1” or “2 or more” in response to the question, “How often did you eat cookies, doughnuts, pie, or cake yesterday?” |  |
|  |  |  |
| **Wave 2** |  |  |
| Sleep duration | Participants indicated, “How many hours of sleep do you usually get?” |  |
| Bedtime | Participants indicated, “During the school year, what time do you usually go to bed on week nights?”  | Because participants often confuse “12:00 PM” to mean midnight (12:00 AM) rather than noon(1), we corrected reported bedtimes of “12:00 PM” to indicate “12:00 AM,” following previous studies(1) |
| Eating behaviors |  |  |
| Fruit yesterday | Participants who indicated they ate any of the following “yesterday”:* apples, applesauce, pears, or pineapple
* bananas, plantains, grapes, berries, or cherries
* cantaloupes, melons, mangoes, or papayas
* oranges, grapefruit, tangerines, or kiwis
* peaches, plums, nectarines, or apricot
* raisins or dried fruit
 | Following categorizations used in by the Behavioral Risk Factor Surveillance System (BRFSS)(2) |
| Vegetables yesterday | Participants who indicated they ate any of the following “yesterday”:* mixed vegetables, or acorn, hubbard, or winter squash
* avocados
* string beans, green beans, peas, or snow peas
* cabbage or bok choy
* broccoli
* carrots
* dried beans, peas, lentils, black beans, or soybeans
* field peas, chick peas, or lima beans
* kale, beet greens, mustard greens, turnip greens, or collard greens
* lettuce or tossed salad
* spinach
* tomatoes
* yams or sweet potatoes
* zucchini, summer squash, eggplants, bell peppers, or asparagus
 | Following categorizations used in by BRFSS(2) |
| Soda yesterday | Participants who indicated they drank “soft drinks or mixers, such as tonic water or club soda, etc.” “yesterday”, excluding those who indicated the drinks were all “diet or sugar free.”  |  |
| Fruit drink yesterday | Participants who indicated they drank “Koolaid, fruit-flavored drinks, Gatoraid [*sic*], or other sport drinks” “yesterday,” excluding those who indicated the drinks were all “diet or sugar free.”  |  |
| Pizza yesterday | Participants who indicated they ate “pizza” “yesterday.” |  |
| Desserts and sweets yesterday | Participants who indicated they ate any of the following “yesterday”:* doughnuts, sweet rolls, muffins, or pastries
* cookies, brownies, cake, or pie
* ice cream
* chocolate bars or candy

Excluding participants who indicated that these items were all “low fat or fat-free.” |  |
| French fries yesterday | Participants who indicated they ate “French fries” “yesterday.” |  |
| Fast food (days/week) | Response to the question, “In the last seven days, on how many days did you eat at a fast food type place – McDonalds, Kentucky Fried Chicken, Pizza Hut, Taco Bell, etc.?” |  |
|  |  |  |
| **Wave 3** |  |  |
| Sleep duration | Participants indicated “On days when you go to work, school, or similar activities, what time do you usually wake up?” and “What time do you usually go to sleep the night (or day) before?” A parallel set of questions were asked regarding “days you don’t have to get up at a certain time.” Responses were used to calculate sleep duration for weekdays and weekends; average sleep duration was calculated as a weighted average of these variables.  | Following previous studies(1,3) |
| Bedtime | Participants indicated “On days when you go to work, school, or similar activities, what time do you usually wake up?” and “What time do you usually go to sleep the night (or day) before?” A parallel set of questions were asked regarding “days you don’t have to get up at a certain time.” Responses were used to calculate weighted average bedtime in decimal hours after 12:00 noon, such that large values indicate later bedtimes. |  |
| Eating behaviors |  |  |
| Fast food (days/week) | Response to the question, “On how many of the past seven days did you eat food from a fast food place McDonalds, Kentucky Fried Chicken, Pizza Hut, Taco Bell, or a local fast food restaurant?” |  |
|  |  |  |
| **Wave 4** |  |  |
| Sleep duration | Participants indicated “On days when you go to work, school, or similar activities, what time do you usually wake up?” and “On those days, what time do you usually go to sleep the night or day before?” A parallel set of questions were asked regarding “days you don’t have to get up at a certain time.” Responses were used to calculate sleep duration for weekdays and weekends; average sleep duration was calculated as a weighted average of these variables.  | Following previous studies(1,3) |
| Bedtime | Participants indicated “On days when you go to work, school, or similar activities, what time do you usually wake up?” and “On those days, what time do you usually go to sleep the night or day before?” A parallel set of questions were asked regarding “days you don’t have to get up at a certain time.” Responses were used to calculate weighted average bedtime in decimal hours after 12:00 noon, such that large values indicate later bedtimes. |  |
| Eating behaviors |  |  |
| Fast food (times/week) | Response to the question, “How many times in the past seven days did you eat food from a fast food restaurant, such as McDonald’s, Burger King, Wendy’s, Arby’s, Pizza Hut, Taco Bell, or Kentucky Fried Chicken or a local fast food restaurant?” |  |
| Sugary drinks (drinks/week) | Response to the question, “In the past 7 days, how many regular (non-diet) sweetened drinks did you have? Include regular soda, juice drinks, sweetened tea or coffee, energy drinks, flavored water, or other sweetened drinks.” |  |

*Note*. Additional details on survey items can be found via the Add Health Codebook Explorer tool: <https://www.cpc.unc.edu/projects/addhealth/documentation/ace/tool>.

**Supplemental Table 2.** Characteristics of participants excluded from analyses due to missing or extreme data, by developmental stage, National Longitudinal Study of Adolescent to Adult Health

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | **Adolescents****≥ 12 and ≤ 18 years** |  | **Emerging Adults** **> 18 and ≤ 24 years** |  | **Young Adults****> 24 and ≤ 34 years** |
|  |  | **Wave I*****n*=7,726** | **Wave II*****n*=5,300** |  | **Wave III** ***n*=5,770** |  | **Wave IV*****n*=5,291** |
| **Characteristics** |  | **Mean (SD) or %** | **Mean (SD) or %** |  | **Mean (SD) or %** |  | **Mean (SD) or %** |
| Sleep duration, hours |  | 7.7 (1.3) | 7.5 (1.4) |  | 8.1 (1.8) |  | 8.9 (2.4) |
| Bedtime, decimal hours after noon |  | 10.9 (1.5) | 10.7 (1.3) |  | 12.0 (2.1) |  | 10.5 (2.8) |
| Eating behaviorsa |  |  |  |  |  |  |  |
| Ate fruit yesterday |  | 75% | 62% |  | – |  | – |
| Ate vegetables yesterday |  | 65% | 79% |  | – |  | – |
| Ate sweets/desserts yesterday |  | 54% | 65% |  | – |  | – |
| Drank soda yesterday |  | – | 71% |  | – |  | – |
| Ate pizza yesterday |  | – | 25% |  | – |  | – |
| Ate French fries yesterday |  | – | 32% |  | – |  | – |
| Fast food, number of days in last week |  | – | 2.3 (2.0) |  | 2.5 (2.2) |  | – |
| Fast food, number of times in last week |  | – | – |  | – |  | 2.6 (5.1) |
| SSBs, number of drinks in last week |  | – | – |  | – |  | 12.6 (15.8) |
| Age, years |  | 16.0 (2.0) | 16.7 (2.0) |  | 22.4 (2.2) |  | 28.7 (2.0) |
| Female |  | 49% | 49% |  | 49% |  | 49% |
| Race/ethnicity |  |  |  |  |  |  |  |
| White |  | 55% | 55% |  | 58% |  | 58% |
| Hispanic |  | 15% | 15% |  | 14% |  | 14% |
| Black |  | 21% | 20% |  | 20% |  | 21% |
| Other |  | 9% | 9% |  | 8% |  | 8% |
| Born in the U.S. |  | 90% | 90% |  | 92% |  | 94% |
| Parental education |  |  |  |  |  |  |  |
| Less than a high school diploma |  | 19% | 19% |  | 16% |  | 18% |
| High school diploma or GED |  | 31% | 31% |  | 31% |  | 30% |
| Some college |  | 23% | 23% |  | 26% |  | 25% |
| College or more |  | 27% | 27% |  | 27% |  | 27% |
| Parental income, logged |  | 3.20 (1.09) | 3.23 (1.08) |  | 3.38 (0.94) |  | 3.35 (0.98) |
| Usual television viewingb,c |  |  |  |  |  |  |  |
| Low (0-14 hours/week) |  | 51% | 53% |  | 51% |  | 69% |
| Medium (15-28 hours/week) |  | 26% | 26% |  | 30% |  | 22% |
| High (≥ 29 hours/week) |  | 23% | 21% |  | 19% |  | 9% |
| Usual video/computer gamesc,d |  |  |  |  |  |  |  |
| Low (0-14 hours/week) |  | 95% | 95% |  | 91% |  | 94% |
| Medium (15-28 hours/week) |  | 4% | 3% |  | 6% |  | 4% |
| High (≥ 29 hours/week) |  | 2% | 1% |  | 3% |  | 2% |
| Depressive symptomse |  | 7.5 (4.4) | 7.6 (4.3) |  | 6.2 (4.0) |  | 7.2 (4.1) |

*Notes.*Means, SDs, and %s adjust for complex survey features of Add Health. Eating behaviors listed as “– ” were not assessed among this survey wave.

aSee Supplemental Table 1 for information on how eating behaviors were assessed in each wave.

bParticipants reported on the usual number of hours per week they spent watching television during the past 30 days.

cWe trichotomized screen time variables using the categories reported in Kruger et al. (2014)(4).

dParticipants reported on the usual number of hours per week they spent playing video or computer games during the past 30 days.

eSum score on the nine items from Center for Epidemiological Studies Depression Scale(5) that were assessed in all four waves. Score on each item ranged from 0-3 yielding a possible sum scores of 0-27, where higher scores indicate more depressive symptoms.

**References**

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