Supplemental Table 1. Covariate data completeness in the Bogotá School Children Cohort.

|  |  |  |
| --- | --- | --- |
| Characteristics | *n* | % missing1 |
|  |  |  |
| Children |  |  |
| Sex | 889 | 0 |
| Age | 889 | 0 |
| Height-for-age Z score | 835 | 6 |
| Body mass index-for-age Z score | 833 | 6 |
| Anemia | 790 | 11 |
| Iron deficiency | 790 | 11 |
| Low vitamin B-12 serostatus | 774 | 13 |
| Screen time | 886 | 0 |
| Time playing outdoors | 883 | 1 |
| Asthma | 869 | 2 |
| Allergies | 864 | 3 |
|  |  |  |
| Mothers |  |  |
| Age at child’s birth | 862 | 3 |
| Height | 870 | 2 |
| Body mass index | 870 | 2 |
| Parity | 866 | 3 |
| Single parent | 864 | 3 |
| Education level | 861 | 3 |
|  |  |  |
| Household |  |  |
| Home ownership | 887 | 0 |
| Number of household assets | 871 | 2 |
| Severe food insecurity | 888 | 0 |
| Socioeconomic status | 889 | 0 |
|  |  |  |

1 Out of a total of 889 children.

Supplemental Table 2. Sociodemographic characteristics and nighttime sleep duration in middle childhood in the Bogotá School Children Cohort

| Characteristics1 | Sleep duration per recommendations2 | | | *P*3 |
| --- | --- | --- | --- | --- |
| Under  *n* = 370 | Within  *n* = 495 | Above  *n* = 24 |
|  |  |  |  |  |
| Children |  |  |  |  |
| Sex, % girls | 57.6 | 54.6 | 54.2 | 0.67 |
| Age (y) | 10.5 ± 1.6 | 10.4 ± 1.9 | 11.8 ± 2.1 | 0.005 |
| Height-for-age Z score4 | -0.64 ± 0.97 | -0.81 ± 0.98 | -0.66 ± -1.25 | 0.02 |
| Body mass index-for-age Z score4 | 0.29 ± 1.03 | 0.20 ± 1.01 | 0.11 ± 1.22 | 0.58 |
| Anemia5, % | 2.1 | 3.3 | 4.6 | 0.53 |
| Iron deficiency6, % | 4.0 | 1.8 | 4.6 | 0.18 |
| Low vitamin B-12 serostatus7, % | 20.4 | 27.2 | 42.9 | 0.02 |
| Screen time (hours/week)8 | 17.3 ± 13.2 | 17.2 ± 13.3 | 20.8 ± 18.4 | 0.90 |
| Time playing outdoors (hours/week) | 7.2 ± 8.4 | 8.0 ± 9.1 | 9.8 ± 13.6 | 0.34 |
| Asthma, % | 6.9 | 6.2 | 8.7 | 0.83 |
| Allergies, % | 27.4 | 25.0 | 4.6 | 0.05 |
| Weekday sleep, % | 47.8 | 50.2 | 2.0 | <0.0001 |
| Weekend sleep, % | 18.3 | 73.9 | 7.8 | <0.0001 |
|  |  |  |  |  |
| Mothers |  |  |  |  |
| Age at child’s birth (y) | 27.3 ± 6.7 | 27.4 ± 6.5 | 26.7 ± 6.0 | 0.91 |
| Height (cm) | 158 ± 6.0 | 158 ± 6.6 | 159 ± 4.8 | 0.29 |
| Body mass index (kg/m2) | 24.1 ± 3.6 | 24.2 ± 3.8 | 24.4 ± 3.0 | 0.86 |
| Parity | 2.5 ± 1.0 | 2.7 ± 1.1 | 3.4 ± 1.1 | 0.0004 |
| Single parent, % | 25.8 | 23.0 | 20.8 | 0.60 |
| Education level (y) | 9.3 ± 3.1 | 8.9 ± 3.2 | 7.4 ± 3.5 | 0.02 |
|  |  |  |  |  |
| Household |  |  |  |  |
| Home ownership, % | 34.2 | 38.8 | 47.8 | 0.21 |
| Number of household assets9 | 4.3 ± 1.5 | 4.3 ± 1.5 | 3.8 ± 1.7 | 0.39 |
| Severe food insecurity, % | 8.7 | 9.1 | 25.0 | 0.03 |
| Socioeconomic status10 | 2.7 ± 0.7 | 2.7 ± 0.7 | 2.5 ± 0.7 | 0.32 |
|  |  |  |  |  |

1 Data are means ± SD unless noted otherwise.

2 <9, 9 to 12, or ≥12 h per 24 h, respectively, in children aged 6 to <13 y and <8, 8 to 10, or ≥10 h per 24 h in children aged ≥13 y.

3 χ2 test for categorical variables, Kruskal-Wallis test for continuous variables.

4 According to the World Health Organization growth reference for children and adolescents.

5 Hemoglobin <12.7 g/dL.

6 Plasma ferritin <15 μg/L among children with C-reactive protein <10 mg/L.

7 Plasma vitamin B-12 (pmol/L) <25th percentile of the population (261.5 and 247.5 in girls and boys, respectively).

8 Time spent watching television or playing video games.

9 From a list that included refrigerator, bicycle, blender, television, stereo, and washing machine.

10 Per the local government’s classification for tax and public services fees.

Supplemental Table 3. Nighttime sleep duration in middle childhood and externalizing problems in adolescence further adjusting for nutrition factors and history of asthma and allergies.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Externalizing problems | Youth Self-Report | | | |  | Child Behavior Checklist | | | |
| Sleep duration per recommendations1 | | | *P*2 |  | Sleep duration per recommendations | | | *P* |
| Under  *n* = 363 | Within  *n* = 485 | Above  *n* = 24 |  | Under  *n* = 319 | Within  *n* = 395 | Above  *n* = 15 |
|  |  |  |  |  |  |  |  |  |  |
| Total |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 52.9 ± 9.6 | 51.7 ± 9.8 | 57.7 ± 8.2 | 0.003 |  | 55.7 ± 9.1 | 55.2 ± 9.3 | 61.1 ± 8.5 | 0.08 |
| Adjusted difference (95% CI)3 | 1.2 (-0.1, 2.5) | Reference | 4.0 (0.1, 7.9) | 0.02 |  | 0.5 (-0.9, 1.8) | Reference | 5.1 (0.4, 9.8) | 0.10 |
| Adjusted difference (95% CI)4 | 1.2 (-0.1, 2.5) | Reference | 4.0 (0.1, 8.0) | 0.01 |  | 0.5 (-0.9, 1.8) | Reference | 5.2 (0.5, 10.0) | 0.10 |
|  |  |  |  |  |  |  |  |  |  |
| Aggressive behavior |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 56.4 ± 7.3 | 55.7 ± 7.1 | 60.3 ± 8.7 | 0.002 |  | 58.6 ± 7.5 | 58.6 ± 8.1 | 64.4 ± 11.5 | 0.09 |
| Adjusted difference (95% CI) | 0.7 (-0.3, 1.7) | Reference | 3.9 (0.9, 6.8) | 0.05 |  | 0.1 (-1.1, 1.3) | Reference | 5.3 (1.2, 9.3) | 0.20 |
| Adjusted difference (95% CI) | 0.7 (-0.3, 1.7) | Reference | 3.9 (0.9, 6.9) | 0.04 |  | 0.1 (-1.0, 1.3) | Reference | 5.4 (1.3, 9.4) | 0.19 |
|  |  |  |  |  |  |  |  |  |  |
| Rule breaking behavior |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 54.6 ± 4.9 | 54.0 ± 4.8 | 55.4 ± 5.3 | 0.10 |  | 55.1 ± 5.4 | 54.6 ± 5.1 | 57.5 ± 6.4 | 0.13 |
| Adjusted difference (95% CI) | 0.5 (-0.2, 1.1) | Reference | 0.6 (-1.4, 2.6) | 0.36 |  | 0.5 (-0.3, 1.2) | Reference | 2.6 (-0.1, 5.3) | 0.16 |
| Adjusted difference (95% CI) | 0.5 (-0.2, 1.1) | Reference | 0.6 (-1.4, 2.6) | 0.39 |  | 0.5 (-0.3, 1.2) | Reference | 2.7 (0.0, 5.4) | 0.10 |
|  |  |  |  |  |  |  |  |  |  |

1 <9, 9 to 12, or ≥12 h per 24 h, respectively, in children aged 6 to <13 y and <8, 8 to 10, or ≥10 h per 24 h in children aged ≥13 y.

2 Kruskal-Wallis tests for unadjusted means and χ2 Score test for adjusted estimates.

3  From linear generalized estimating equation models with each behavior problems score as the continuous outcome. Adjustment variables included child’s sex, age, screen time, mother’s education, parity, food insecurity, anemia, iron deficiency, low vitamin B-12 serostatus, child height, and body mass index-for-age Z. Robust variances were specified in all models and accounted for within family correlations among children with siblings in the sample. Multiple Imputation analysis.

4 Further adjusted for a history of asthma and allergies.

Supplemental Table 4. Nighttime sleep duration in middle childhood and externalizing problems in adolescence per the YSR stratified by sex.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Externalizing problems | Boys | | | |  | Girls | | | | *P3* |
| Sleep duration per recommendations1 | | | *P*2 |  | Sleep duration per recommendations | | | *P* |
| Under  *n* = 157 | Within  *n* = 221 | Above  *n* = 11 |  | Under  *n* = 206 | Within  *n* = 264 | Above  *n* = 13 |
|  |  |  |  |  |  |  |  |  |  |  |
| Total |  |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 52.2 ± 9.0 | 50.6 ± 9.8 | 59.0 ± 8.0 | 0.006 |  | 53.5 ± 9.9 | 52.6 ± 9.7 | 56.6 ± 8.5 | 0.23 | 0.43 |
| Adjusted difference (95% CI)4 | 1.3 (-0.6, 3.2) | Reference | 6.8 (1.0, 12.6) | 0.03 |  | 1.0 (-0.8, 2.7) | Reference | 2.1 (-3.2, 7.5) | 0.40 | 0.35 |
|  |  |  |  |  |  |  |  |  |  |  |
| Aggressive behavior |  |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 55.6 ± 6.8 | 54.8 ± 6.8 | 61.6 ± 8.9 | 0.005 |  | 57.0 ± 7.6 | 56.4 ± 7.4 | 59.2 ± 8.6 | 0.23 | 0.53 |
| Adjusted difference (95% CI) | 0.7 (-0.7, 2.0) | Reference | 6.7 (2.5, 10.9) | 0.07 |  | 0.6 (-0.8, 2.0) | Reference | 2.0 (-2.2, 6.2) | 0.51 | 0.43 |
|  |  |  |  |  |  |  |  |  |  |  |
| Rule breaking behavior |  |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 54.3 ± 5.1 | 53.8 ± 5.0 | 56.2 ± 5.7 | 0.19 |  | 54.8 ± 4.7 | 54.2 ± 4.6 | 54.7 ± 5.0 | 0.45 | 0.67 |
| Adjusted difference (95% CI) | 0.3 (-0.7, 1.4) | Reference | 1.6 (-1.5, 4.7) | 0.52 |  | 0.6 (-0.3, 1.4) | Reference | -0.5 (-3.0, 2.1) | 0.37 | 0.53 |
|  |  |  |  |  |  |  |  |  |  |  |

1 <9, 9 to 12, or ≥12 h per 24 h, respectively, in children aged 6 to <13 y and <8, 8 to 10, or ≥10 h per 24 h in children aged ≥13 y.

2 Kruskal-Wallis tests for unadjusted means and χ2 Score test for adjusted estimates.

3  χ2 Score test for interaction by sex for unadjusted and adjusted models.

4 From linear generalized estimating equation models with each behavior problems score as the continuous outcome. Adjustment variables included child’s sex, age, screen time, mother’s education, parity, food insecurity, anemia, iron deficiency, low vitamin B-12 serostatus, child height, and body mass index-for-age Z. Robust variances were specified in all models and accounted for within family correlations among children with siblings in the sample. Multiple Imputation analysis.

Supplemental Table 5. Nighttime sleep duration in middle childhood and externalizing problems in adolescence per the YSR stratified by weekday and weekend.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Externalizing problems | Weekday Sleep | | | |  | Weekend Sleep | | | |
| Sleep duration per recommendations1 | | | *P*2 |  | Sleep duration per recommendations | | | *P* |
| Under  *n* = 417 | Within  *n* = 437 | Above  *n* = 18 |  | Under  *n* = 161 | Within  *n* = 643 | Above  *n* = 68 |
|  |  |  |  |  |  |  |  |  |  |
| Total |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 52.7 ± 9.6 | 51.9 ± 9.9 | 55.4 ± 8.5 | 0.11 |  | 52.7 ± 9.7 | 52.0 ± 9.7 | 54.6 ± 9.1 | 0.11 |
| Adjusted difference (95% CI)3 | 0.8 (-0.5, 2.1) | Reference | 2.0 (-2.5, 6.5) | 0.34 |  | 0.4 (-1.3, 2.0) | Reference | 1.7 (-0.7, 4.0) | 0.30 |
|  |  |  |  |  |  |  |  |  |  |
| Aggressive behavior |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 56.2 ± 7.2 | 55.9 ± 7.4 | 58.6 ± 7.8 | 0.07 |  | 56.2 ± 7.5 | 55.9 ± 7.2 | 57.8 ± 7.8 | 0.10 |
| Adjusted difference (95% CI) | 0.3 (-0.6, 1.3) | Reference | 2.0 (-1.4, 5.4) | 0.49 |  | 0.2 (-1.1, 1.4) | Reference | 1.5 (-0.4, 3.3) | 0.30 |
|  |  |  |  |  |  |  |  |  |  |
| Rule breaking behavior |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 54.5 ± 4.9 | 54.1 ± 4.8 | 54.1 ± 4.7 | 0.36 |  | 54.5 ± 5.2 | 54.2 ± 4.8 | 54.7 ± 4.5 | 0.19 |
| Adjusted difference (95% CI) | 0.4 (-0.3, 1.0) | Reference | -0.8 (-3.1, 1.5) | 0.35 |  | 0.2 (-0.6, 1.0) | Reference | 0.2 (-1.0, 1.4) | 0.88 |
|  |  |  |  |  |  |  |  |  |  |

1 <9, 9 to 12, or ≥12 h per 24 h, respectively, in children aged 6 to <13 y and <8, 8 to 10, or ≥10 h per 24 h in children aged ≥13 y.

2 Kruskal-Wallis tests for unadjusted means and χ2 Score test for adjusted estimates.

3  From linear generalized estimating equation models with each behavior problems score as the continuous outcome. Adjustment variables included child’s sex, age, screen time, mother’s education, parity, food insecurity, anemia, iron deficiency, low vitamin B-12 serostatus, child height, and body mass index-for-age Z. Robust variances were specified in all models and accounted for within family correlations among children with siblings in the sample. Multiple Imputation analysis.

Supplemental Table 6. Likelihood ratio test for the interaction between nighttime sleep duration (hours) and age at sleep assessment for different age cut points on the association between sleep duration in middle childhood and behavior problems in adolescence per the YSR.

| Age cut point (years) | *n* above cut point1 | Total externalizing behavior2 | Total internalizing behavior2 | Attention problems2 | Social problems2 | Thought problems2 |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
| 10.0 | 545 | 4.5 | 0.8 | 2.0 | 1.8 | 3.2 |
| 10.5 | 446 | 6.7 | 2.2 | 2.2 | 4.0 | 4.6 |
| 11.0 | 369 | 7.5 | 1.6 | 2.2 | 3.4 | 4.1 |
| 11.5 | 274 | 5.1 | 5.2 | 3.5 | 5.1 | 1.2 |
| 12.0 | 177 | 5.8 | 3.3 | 1.5 | 4.1 | 1.4 |
| 12.5 | 102 | 2.7 | 3.5 | 1.3 | 4.1 | 2.3 |
| 13.0 | 49 | 4.0 | 3.5 | 0.4 | 3.1 | 1.9 |
|  |  |  |  |  |  |  |

1 Total *n* = 872.

2 χ2 values with three degrees of freedom from -2 log-likelihood comparisons of main effects (including linear and 2 spline terms for sleep duration and the age-at-assessment cut point plus adjustment covariates) and saturated linear regression models (additionally including interaction terms between sleep duration terms and age-at-assessment).

Supplemental Table 7. Nighttime sleep duration in middle childhood and behavior problems in adolescence per the YSR.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Behavior problem | Mean ± SE behavior problem score at sleep duration1 | | |  | Model 12 | | | |  | Model 23 | | | |
|  | 7 hours vs. 8 hours | | 12 hours vs. 8 hours | |  | 7 hours vs. 8 hours | | 12 hours vs. 8 hours | |
| 7 hours | 8 hours | 12 hours |  | Adjusted difference  (95% CI) | *P* | Adjusted difference  (95% CI) | *P* |  | Adjusted difference  (95% CI) | *P* | Adjusted difference  (95% CI) | *P* |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Total externalizing |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <11 years-old | 52.1 ± 1.3 | 51.5 ± 0.8 | 50.0 ± 1.2 |  | 0.7 (-1.3, 2.7) | 0.48 | -1.3 (-4.1, 1.5) | 0.35 |  | 0.8 (-1.1, 2.9) | 0.50 | -1.0 (-4.0, 2.1) | 0.53 |
| ≥11 years-old | 53.0 ± 1.1 | 54.8 ± 0.7 | 58.5 ± 1.4 |  | -2.1 (-4.1, -0.1) | 0.04 | 3.6 (0.6, 6.5) | 0.02 |  | -2.2 (-4.2, -0.2) | 0.03 | 3.8 (0.8, 6.9) | 0.01 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Total internalizing | 53.8 ± 1.1 | 53.2 ± 0.6 | 53.4 ± 1.1 |  | 0.2 (-1.5, 1.9) | 0.80 | 0.5 (-1.8, 2.9) | 0.65 |  | 0.1 (-1.6, 1.8) | 0.90 | 1.1 (-1.4, 3.6) | 0.38 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Attention problems | 51.7 ± 0.2 | 52.1 ± 0.2 | 52.3 ± 0.4 |  | -0.4 (-0.8, 0.1) | 0.09 | 0.3 (-0.5, 1.0) | 0.51 |  | -0.5 (-0.9, 0.0) | 0.04 | 0.4 (-0.4, 1.1) | 0.32 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Social problems | 56.1 ± 0.6 | 55.9 ± 0.4 | 57.2 ± 0.7 |  | 0.1 (-1.0, 1.1) | 0.89 | 1.1 (-0.4, 2.6) | 0.13 |  | 0.0 (-1.0, 1.1) | 0.93 | 1.4 (-0.2, 2.9) | 0.09 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Thought problems | 54.3 ± 0.6 | 54.2 ± 0.3 | 54.6 ± 0.5 |  | -0.2 (-1.1, 0.7) | 0.66 | 0.4 (-0.8, 1.6) | 0.51 |  | -0.2 (-1.2, 0.8) | 0.71 | 0.5 (-0.7, 1.8) | 0.41 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |

1 Estimates are from linear generalized estimating equation models with externalizing behavior score as the continuous outcome; predictors include linear and spline terms for sleep duration (hours).

2 Adjusted for child’s sex, age, screen time, mother’s education, parity, and food insecurity. In all models, the robust sandwich estimate of the variance was used to account for intra-family correlations. *P* from χ2 Score test. Complete case analysis (n= 843).

3 Additionally adjusted for adolescence nighttime sleep duration (continuous). Complete case analysis (n= 800).

Supplemental Table 8. Nighttime sleep duration in middle childhood and internalizing problems in adolescence further adjusting for nutrition factors and a history of asthma and allergies.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Internalizing problems | Youth Self-Report | | | |  | Child Behavior Checklist | | | |
| Sleep duration per recommendations1 | | | *P*2 |  | Sleep duration per recommendations | | | *P* |
| Under  *n* = 363 | Within  *n* = 485 | Above  *n* = 24 |  | Under  *n* = 319 | Within  *n* = 395 | Above  *n* = 15 |
|  |  |  |  |  |  |  |  |  |  |
| Total |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 53.7 ± 9.8 | 53.3 ± 9.8 | 57.8 ± 10.6 | 0.06 |  | 56.3 ± 9.7 | 57.2 ± 9.7 | 62.7 ± 8.9 | 0.07 |
| Adjusted difference (95% CI)3 | 0.4 (-1.0, 1.7) | Reference | 3.8 (-0.2, 7.9) | 0.22 |  | -0.9 (-2.3, 0.5) | Reference | 5.9 (0.9, 10.8) | 0.02 |
| Adjusted difference (95% CI)4 | 0.3 (-1.0, 1.6) | Reference | 3.7 (-0.3, 7.8) | 0.21 |  | -0.9 (-2.3, 0.5) | Reference | 6.0 (1.0, 10.9) | 0.02 |
|  |  |  |  |  |  |  |  |  |  |
| Anxious/depressed |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 55.6 ± 6.4 | 55.2 ± 6.3 | 58.7 ±9.3 | 0.16 |  | 56.3 ± 7.0 | 56.4 ± 7.3 | 61.3 ± 10.8 | 0.16 |
| Adjusted difference (95% CI) | 0.3 (-0.6, 1.2) | Reference | 3.3 (0.6, 6.0) | 0.19 |  | -0.1 (-1.2, 0.9) | Reference | 5.2 (1.5, 9.0) | 0.15 |
| Adjusted difference (95% CI) | 0.3 (-0.6, 1.2) | Reference | 3.2 (0.6, 5.9) | 0.18 |  | -0.1 (-1.2, 0.9) | Reference | 5.2 (1.5, 9.0) | 0.07 |
|  |  |  |  |  |  |  |  |  |  |
| Withdrawn/depressed |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 55.6 ± 6.4 | 55.3 ± 6.1 | 57.0 ± 6.4 | 0.39 |  | 55.9 ± 6.1 | 56.2 ± 6.5 | 58.9 ± 8.5 | 0.33 |
| Adjusted difference (95% CI) | 0.3 (-0.5, 1.2) | Reference | 1.7 (-0.9, 4.3) | 0.40 |  | -0.4 (-1.3, 0.6) | Reference | 2.9 (-0.4, 6.2) | 0.28 |
| Adjusted difference (95% CI) | 0.3 (-0.6, 1.1) | Reference | 1.6 (-1.0, 4.2) | 0.39 |  | -0.4 (-1.3, 0.6) | Reference | 2.8 (-0.5, 6.1) | 0.27 |
|  |  |  |  |  |  |  |  |  |  |
| Somatic complaints |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 56.9 ± 7.1 | 56.8 ± 7.6 | 60.3 ± 7 | 0.02 |  | 60.8 ± 8.0 | 61.7 ± 8.5 | 65.8 ± 7.7 | 0.06 |
| Adjusted difference (95% CI) | 0.0 (-1.0, 1.0) | Reference | 3.2 (0.2, 6.2) | 0.10 |  | -1.0 (-2.2, 0.2) | Reference | 4.6 (0.4, 8.8) | 0.02 |
| Adjusted difference (95% CI) | 0.0 (-1.0, 1.0) | Reference | 3.4 (0.3, 6.4) | 0.06 |  | -1.0 (-2.2, 0.1) | Reference | 4.8 (0.6, 9.0) | 0.02 |
|  |  |  |  |  |  |  |  |  |  |

1 <9, 9 to 12, or ≥12 h per 24 h, respectively, in children aged 6 to <13 y and <8, 8 to 10, or ≥10 h per 24 h in children aged ≥13 y.

2 Kruskal-Wallis tests for unadjusted means and χ2 Score test for adjusted estimates.

3  From linear generalized estimating equation models with each behavior problems score as the continuous outcome. Adjustment variables included child’s sex, age, screen time, mother’s education, parity, food insecurity, anemia, iron deficiency, low vitamin B-12 serostatus, child height, and body mass index-for-age Z. Robust variances were specified in all models and accounted for within family correlations among children with siblings in the sample. Multiple Imputation analysis.

4 Further adjusted for a history of asthma and allergies.

Supplemental Table 9. Nighttime sleep duration in middle childhood and internalizing problems in adolescence per the YSR stratified by sex.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Internalizing problems | Boys | | | |  | Girls | | | | *P3* |
| Sleep duration per recommendations1 | | | *P*2 |  | Sleep duration per recommendations | | | *P* |
| Under  *n* = 157 | Within  *n* = 221 | Above  *n* = 11 |  | Under  *n* = 206 | Within  *n* = 264 | Above  *n* = 13 |
|  |  |  |  |  |  |  |  |  |  |  |
| Total |  |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 53.7 ± 9.5 | 52.3 ± 9.4 | 57.2 ± 8.6 | 0.13 |  | 53.8 ± 10.0 | 54.0 ± 10.0 | 58.2 ± 12.4 | 0.24 | 0.46 |
| Adjusted difference (95% CI)4 | 1.2 (-0.8, 3.1) | Reference | 5.6 (-0.3, 11.4) | 0.12 |  | -0.2 (-2.0, 1.7) | Reference | 3.1 (-2.5, 8.7) | 0.62 | 0.61 |
|  |  |  |  |  |  |  |  |  |  |  |
| Anxious/depressed |  |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 55.9 ± 6.5 | 54.8 ± 5.5 | 56.1 ± 6.6 | 0.41 |  | 55.3 ± 6.5 | 55.6 ± 6.8 | 60.9 ± 10.8 | 0.17 | 0.15 |
| Adjusted difference (95% CI) | 1.0 (-0.2, 2.2) | Reference | 1.8 (-1.9, 5.4) | 0.22 |  | -0.2 (-1.5, 1.0) | Reference | 5.2 (1.4, 9.1) | 0.20 | 0.18 |
|  |  |  |  |  |  |  |  |  |  |  |
| Withdrawn/depressed |  |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 55.7 ± 6.3 | 54.8 ± 5.6 | 56.4 ± 6.7 | 0.35 |  | 55.6 ± 6.6 | 55.7 ± 6.5 | 57.6 ± 6.3 | 0.44 | 0.49 |
| Adjusted difference (95% CI) | 1.0 (-0.3, 2.2) | Reference | 2.2 (-1.4, 5.9) | 0.21 |  | -0.0 (-1.2, 1.2) | Reference | 1.5 (-2.1, 5.1) | 0.70 | 0.47 |
|  |  |  |  |  |  |  |  |  |  |  |
| Somatic complaints |  |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 56.0 ± 5.9 | 55.8 ± 6.8 | 60.5 ± 6.4 | 0.02 |  | 57.6 ± 7.8 | 57.6 ± 8.1 | 60.2 ± 7.8 | 0.41 | 0.77 |
| Adjusted difference (95% CI) | -0.1 (-1.4, 1.2) | Reference | 5.2 (1.3, 9.2) | 0.10 |  | 0.0 (-1.4, 1.5) | Reference | 1.9 (-2.6, 6.3) | 0.61 | 0.61 |
|  |  |  |  |  |  |  |  |  |  |  |

1 <9, 9 to 12, or ≥12 h per 24 h, respectively, in children aged 6 to <13 y and <8, 8 to 10, or ≥10 h per 24 h in children aged ≥13 y.

2 Kruskal-Wallis tests for unadjusted means and χ2 Score test for adjusted estimates.

3  χ2 Score test for interaction by sex for unadjusted and adjusted models.

4 From linear generalized estimating equation models with each behavior problems score as the continuous outcome. Adjustment variables included child’s sex, age, screen time, mother’s education, parity, food insecurity, anemia, iron deficiency, low vitamin B-12 serostatus, child height, and body mass index-for-age Z. Robust variances were specified in all models and accounted for within family correlations among children with siblings in the sample. Multiple Imputation analysis.

Supplemental Table 10. Nighttime sleep duration in middle childhood and internalizing problems in adolescence per the YSR stratified by weekday and weekend.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Internalizing problems | Weekday Sleep | | | |  | Weekend Sleep | | | |
| Sleep duration per recommendations1 | | | *P*2 |  | Sleep duration per recommendations | | | *P* |
| Under  *n* = 417 | Within  *n* = 437 | Above  *n* = 18 |  | Under  *n* = 161 | Within  *n* = 643 | Above  *n* = 68 |
|  |  |  |  |  |  |  |  |  |  |
| Total |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 53.4 ± 9.9 | 53.7 ± 9.7 | 55.4 ± 12.1 | 0.60 |  | 53.8 ± 9.9 | 53.5 ± 9.8 | 53.8 ± 9.7 | 0.62 |
| Adjusted difference (95% CI)4 | -0.5 (-1.8, 0.8) | Reference | 1.5 (-3.1, 6.2) | 0.61 |  | 0.2 (-1.5, 1.9) | Reference | -0.1 (-2.6, 2.3) | 0.96 |
|  |  |  |  |  |  |  |  |  |  |
| Anxious/depressed |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 55.4 ± 6.3 | 55.4 ± 6.4 | 58.6 ± 9.9 | 0.55 |  | 55.4 ± 6.5 | 55.5 ± 6.6 | 55.2 ± 5.8 | 0.99 |
| Adjusted difference (95% CI) | -0.0 (-0.9, 0.8) | Reference | 3.2 (0.1, 6.3) | 0.36 |  | -0.2 (-1.3, 0.9) | Reference | -0.5 (-2.1, 1.1) | 0.74 |
|  |  |  |  |  |  |  |  |  |  |
| Withdrawn/depressed |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 55.4 ± 6.3 | 55.5 ± 6.2 | 55.7 ± 6.1 | 0.90 |  | 55.6 ±6.1 | 55.4 ± 6.4 | 55.9 ± 5.6 | 0.43 |
| Adjusted difference (95% CI) | -0.2 (-1.1, 0.6) | Reference | 0.2 (-2.8, 3.2) | 0.85 |  | 0.3 (-0.8, 1.4) | Reference | 0.4 (-1.1, 2.0) | 0.77 |
|  |  |  |  |  |  |  |  |  |  |
| Somatic complaints |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 56.8 ± 7.3 | 57.0 ± 7.5 | 58.8 ± 7.3 | 0.51 |  | 57.3 ± 7.7 | 56.8 ± 7.4 | 57.3 ± 6.5 | 0.59 |
| Adjusted difference (95% CI) | -0.3 (-1.3, 0.7) | Reference | 1.7 (-1.8, 5.2) | 0.48 |  | 0.5 (-0.8, 1.8) | Reference | 0.3 (-1.5, 2.1) | 0.72 |
|  |  |  |  |  |  |  |  |  |  |

1 <9, 9 to 12, or ≥12 h per 24 h, respectively, in children aged 6 to <13 y and <8, 8 to 10, or ≥10 h per 24 h in children aged ≥13 y.

2 Kruskal-Wallis tests for unadjusted means and χ2 Score test for adjusted estimates.

3  From linear generalized estimating equation models with each behavior problems score as the continuous outcome. Adjustment variables included child’s sex, age, screen time, mother’s education, parity, food insecurity, anemia, iron deficiency, low vitamin B-12 serostatus, child height, and body mass index-for-age Z. Robust variances were specified in all models and accounted for within family correlations among children with siblings in the sample. Multiple Imputation analysis.

Supplemental Table 11. Likelihood ratio test for the interaction between nighttime sleep duration (hours) and age at sleep assessment for different age cut points on the association between sleep duration in middle childhood and behavior problems in adolescence per the CBCL.

| Age cut point (years) | *n* above cut point1 | Total externalizing behavior2 | Total internalizing behavior2 | Attention problems2 | Social problems2 | Thought problems2 |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
| 10.0 | 470 | 3.7 | 0.9 | 1.3 | 4.1 | 5.9 |
| 10.5 | 390 | 3.5 | 2.9 | 1.5 | 6.3 | 4.3 |
| 11.0 | 325 | 1.4 | 0.9 | 0.9 | 3.2 | 3.2 |
| 11.5 | 239 | 2.7 | 2.8 | 1.9 | 2.5 | 1.2 |
| 12.0 | 155 | 1.5 | 2.3 | 2.2 | 4.5 | 5.4 |
| 12.5 | 89 | 3.8 | 6.5 | 0.7 | 2.7 | 4.5 |
| 13.0 | 45 | 2.6 | 1.0 | 2.1 | 1.8 | 1.0 |
|  |  |  |  |  |  |  |

1 Total *n* = 729.

2 χ2 values with three degrees of freedom from -2 log-likelihood comparisons of main effects (including linear and 2 spline terms for sleep duration and the age-at-assessment cut point plus adjustment covariates) and saturated linear regression models (additionally including interaction terms between sleep duration terms and age-at-assessment).

Supplemental Table 12. Nighttime sleep duration in middle childhood and behavior problems in adolescence per the CBCL.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Behavior problem | Mean ± SE behavior problem score at sleep duration1 | | |  | Model 12 | | | |  | Model 23 | | | |
|  | 7 hours vs. 8 hours | | 12 hours vs. 8 hours | |  | 7 hours vs. 8 hours | | 12 hours vs. 8 hours | |
| 7 hours | 8 hours | 12 hours |  | Adjusted difference  (95% CI) | *P* | Adjusted difference  (95% CI) | *P* |  | Adjusted difference  (95% CI) | *P* | Adjusted difference  (95% CI) | *P* |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Total externalizing | 56.4 ± 0.9 | 55.5 ± 0.6 | 57.9 ± 1.0 |  | 1.1 (-0.5, 2.6) | 0.18 | 1.7 (-0.4, 3.9) | 0.11 |  | 1.0 (-0.5, 2.6) | 0.19 | 1.8 (-0.4, 4.0) | 0.12 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Total internalizing | 56.9 ± 1.0 | 56.0 ± 0.6 | 60.0 ± 1.1 |  | 1.1 (-0.4, 2.7) | 0.15 | 3.9 (1.7, 6.1) | 0.0004 |  | 1.1 (-0.5, 2.6) | 0.19 | 3.9 (1.7, 6.2) | 0.0006 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Attention problems | 53.9 ± 0.5 | 53.7 ± 0.3 | 55.0 ± 0.6 |  | 0.3 (-0.5, 1.1) | 0.51 | 1.1 (0.0, 2.4) | 0.06 |  | 0.2 (-0.5, 1.0) | 0.54 | 1.3 (0.1, 2.6) | 0.04 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Social problems | 57.4 ± 0.7 | 57.2 ± 0.4 | 59.0 ± 0.9 |  | 0.2 (-0.9, 1.4) | 0.67 | 1.6 (-0.2, 3.4) | 0.09 |  | 0.2 (-0.9, 1.3) | 0.72 | 1.7 (-0.1, 3.6) | 0.06 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Thought problems | 56.2 ± 0.7 | 55.8 ± 0.4 | 56.4 ± 0.8 |  | 0.4 (-0.7, 1.6) | 0.46 | 0.3 (-1.5, 2.2) | 0.73 |  | 0.5 (-0.7, 1.7) | 0.44 | 0.4 (-1.4, 2.3) | 0.64 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |

1 Estimates are from linear generalized estimating equation models with externalizing behavior score as the continuous outcome; predictors include linear and spline terms for sleep duration (hours).

2 Adjusted for child’s sex, age, screen time, mother’s education, parity, and food insecurity. In all models, the robust sandwich estimate of the variance was used to account for intra-family correlations. *P* from χ2 Score test. Complete case analysis (n= 720).

3  Additionally adjusted for adolescence nighttime sleep duration (continuous). Complete case analysis (n= 719).

Supplemental Table 13. Nighttime sleep duration in middle childhood and attention, social, and thought problems in adolescence further adjusting for nutrition factors and a history of asthma and allergies.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Other problems | Youth Self-Report | | | |  | Child Behavior Checklist | | | |
| Sleep duration per recommendations1 | | | *P*2 |  | Sleep duration per recommendations | | | *P* |
| Under  *n* = 363 | Within  *n* = 485 | Above  *n* = 24 |  | Under  *n* = 319 | Within  *n* = 395 | Above  *n* = 15 |
|  |  |  |  |  |  |  |  |  |  |
| Attention problems |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 52.0 ± 3.3 | 52.2 ± 3.4 | 52.8 ± 3.8 | 0.24 |  | 53.7 ± 4.3 | 54.3 ± 5.1 | 55.1 ± 5.6 | 0.39 |
| Adjusted difference (95% CI)3 | -0.3 (-0.7, 0.3) | Reference | 0.3 (-1.1, 1.7) | 0.52 |  | -0.7 (-1.3, 0.02) | Reference | 0.8 (-1.7, 3.2) | 0.11 |
| Adjusted difference (95% CI)4 | -0.3 (-0.7, 0.2) | Reference | 0.3 (-1.1, 1.7) | 0.61 |  | -0.7 (-1.3, 0.03) | Reference | 0.8 (-1.6, 3.2) | 0.14 |
|  |  |  |  |  |  |  |  |  |  |
| Social problems |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 56.3 ± 6.6 | 56.0 ± 6.5 | 60.4 ± 7.1 | 0.008 |  | 57.4 ± 6.6 | 57.7 ± 6.9 | 60.5 ± 8.3 | 0.23 |
| Adjusted difference (95% CI) | 0.3 (-0.6, 1.2) | Reference | 4.1 (1.4, 6.8) | 0.03 |  | -0.4 (-1.4, 0.6) | Reference | 3.2 (-0.2, 6.7) | 0.23 |
| Adjusted difference (95% CI) | 0.3 (-0.6, 1.2) | Reference | 4.2 (1.5, 7.0) | 0.03 |  | -0.4 (-1.4, 0.6) | Reference | 3.3 (-0.2, 6.7) | 0.23 |
|  |  |  |  |  |  |  |  |  |  |
| Thought problems |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 54.3 ± 5.7 | 54.3 ± 5.6 | 56.8 ±5.5 | 0.02 |  | 55.9 ± 6.6 | 55.6 ± 6.8 | 57.3 ± 6.5 | 0.42 |
| Adjusted difference (95% CI) | 0.0 (-0.8, 0.8) | Reference | 1.8 (-0.5, 4.2) | 0.24 |  | 0.3 (-0.7, 1.3) | Reference | 1.3 (-2.2, 4.8) | 0.64 |
| Adjusted difference (95% CI) | 0.0 (-0.8, 0.8) | Reference | 1.9 (-0.4, 4.3) | 0.18 |  | 0.3 (-0.7, 1.3) | Reference | 1.4 (-2.0, 4.9) | 0.62 |
|  |  |  |  |  |  |  |  |  |  |

1 <9, 9 to 12, or ≥12 h per 24 h, respectively, in children aged 6 to <13 y and <8, 8 to 10, or ≥10 h per 24 h in children aged ≥13 y.

2 Kruskal-Wallis tests for unadjusted means and χ2 Score test for adjusted estimates.

3  From linear generalized estimating equation models with each behavior problems score as the continuous outcome. Adjustment variables included child’s sex, age, screen time, mother’s education, parity, food insecurity, anemia, iron deficiency, low vitamin B-12 serostatus, child height, and body mass index-for-age Z. Robust variances were specified in all models and accounted for within family correlations among children with siblings in the sample. Multiple Imputation analysis.

4 Further adjusted for a history of asthma and allergies.

Supplemental Table 14. Nighttime sleep duration in middle childhood and attention, social, and thought problems in adolescence per the YSR stratified by sex.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Other problems | Boys | | | |  | Girls | | | | *P3* |
| Sleep duration per recommendations1 | | | *P*2 |  | Sleep duration per recommendations | | | *P* |
| Under  *n* = 157 | Within  *n* = 221 | Above  *n* = 11 |  | Under  *n* = 206 | Within  *n* = 264 | Above  *n* = 13 |
|  |  |  |  |  |  |  |  |  |  |  |
| Attention problems |  |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 51.9 ± 3. 7 | 51.6 ± 3.0 | 52.8 ± 4.1 | 0.43 |  | 52.0 ± 3.1 | 52.7 ± 3.7 | 52.8 ± 3.7 | 0.07 | 0.08 |
| Adjusted difference (95% CI)4 | 0.3 (-0.4, 1.0) | Reference | 0.9 (-1.2, 3.0) | 0.52 |  | -0.7 (-1.3, -0.04) | Reference | -0.4 (-2.3, 1.5) | 0.12 | 0.14 |
|  |  |  |  |  |  |  |  |  |  |  |
| Social problems |  |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 55.9 ± 5.8 | 55.6 ± 6.0 | 60.8 ± 6.9 | 0.03 |  | 56.6 ± 7.2 | 56.4 ± 6.9 | 60.0 ± 7.6 | 0.19 | 0.84 |
| Adjusted difference (95% CI) | 0.3 (-0.9, 1.5) | Reference | 5.1 (1.4, 8.7) | 0.10 |  | 0.3 (-1.0, 1.6) | Reference | 3.5 (-0.4, 7.5) | 0.27 | 0.90 |
|  |  |  |  |  |  |  |  |  |  |  |
| Thought problems |  |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 54.5 ± 5.8 | 54.0 ± 5.4 | 57.4 ± 4.9 | 0.03 |  | 54.1 ± 5.6 | 54.5 ± 5.8 | 56.2 ± 6.0 | 0.20 | 0.41 |
| Adjusted difference (95% CI) | 0.4 (-0.7, 1.5) | Reference | 3.3 (-0.1, 6.8) | 0.12 |  | -0.3 (-1.4, 0.7) | Reference | 1.1 (-2.1, 4.4) | 0.59 | 0.57 |
|  |  |  |  |  |  |  |  |  |  |  |

1 <9, 9 to 12, or ≥12 h per 24 h, respectively, in children aged 6 to <13 y and <8, 8 to 10, or ≥10 h per 24 h in children aged ≥13 y.

2 Kruskal-Wallis tests for unadjusted means and χ2 Score test for adjusted estimates.

3  χ2 Score test for interaction by sex for unadjusted and adjusted models.

4 From linear generalized estimating equation models with each behavior problems score as the continuous outcome. Adjustment variables included child’s sex, age, screen time, mother’s education, parity, food insecurity, anemia, iron deficiency, low vitamin B-12 serostatus, child height, and body mass index-for-age Z. Robust variances were specified in all models and accounted for within family correlations among children with siblings in the sample. Multiple Imputation analysis.

Supplemental Table 15. Nighttime sleep duration in middle childhood and attention, social, and thought problems in adolescence per the YSR stratified by weekday and weekend.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Other problems | Weekday Sleep | | | |  | Weekend Sleep | | | |
| Sleep duration per recommendations1 | | | *P*2 |  | Sleep duration per recommendations | | | *P* |
| Under  *n* = 417 | Within  *n* = 437 | Above  *n* = 18 |  | Under  *n* = 161 | Within  *n* = 643 | Above  *n* = 68 |
|  |  |  |  |  |  |  |  |  |  |
| Attention problems |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 52.1 ± 3.5 | 52.1 ± 3.3 | 51.8 ± 2.3 | 0.96 |  | 51.9 ± 3.1 | 52.1 ± 3.5 | 52.9 ± 3.6 | 0.009 |
| Adjusted difference (95% CI)4 | 0.0 (-0.4, 0.5) | Reference | -0.7 (-2.3, 1.0) | 0.46 |  | -0.2 (-0.8, 0.4) | Reference | 0.6 (-0.2, 1.4) | 0.27 |
|  |  |  |  |  |  |  |  |  |  |
| Social problems |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 56.2 ± 6.6 | 56.2 ± 6.5 | 59.1 ± 7.9 | 0.24 |  | 56.4 ± 6.5 | 56.1 ± 6.7 | 57.2 ± 6.4 | 0.18 |
| Adjusted difference (95% CI) | 0.1 (-0.8, 1.0) | Reference | 3.0 (-0.1, 6.2) | 0.28 |  | 0.4 (-0.8, 1.5) | Reference | 1.0 (-0.7, 2.6) | 0.41 |
|  |  |  |  |  |  |  |  |  |  |
| Thought problems |  |  |  |  |  |  |  |  |  |
| Mean ± SD | 54.2 ± 5.6 | 54.4 ± 5.7 | 55.7 ± 6.0 | 0.29 |  | 54.5 ± 5.9 | 54.3 ± 5.6 | 55.2 ± 5.2 | 0.14 |
| Adjusted difference (95% CI) | -0.2 (-0.9, 0.6) | Reference | 0.9 (-1.8, 3.6) | 0.70 |  | 0.1 (-0.9, 1.1) | Reference | 0.7 (-0.7, 2.1) | 0.56 |
|  |  |  |  |  |  |  |  |  |  |

1 <9, 9 to 12, or ≥12 h per 24 h, respectively, in children aged 6 to <13 y and <8, 8 to 10, or ≥10 h per 24 h in children aged ≥13 y.

2 Kruskal-Wallis tests for unadjusted means and χ2 Score test for adjusted estimates.

3  From linear generalized estimating equation models with each behavior problems score as the continuous outcome. Adjustment variables included child’s sex, age, screen time, mother’s education, parity, food insecurity, anemia, iron deficiency, low vitamin B-12 serostatus, child height, and body mass index-for-age Z. Robust variances were specified in all models and accounted for within family correlations among children with siblings in the sample. Multiple imputation analysis.

Supplemental Table 16. Sociodemographic characteristics and nighttime sleep duration in adolescence in the Bogotá School Children Cohort

| Characteristics1 | Sleep duration per recommendations2 | | | *P*3 |
| --- | --- | --- | --- | --- |
| Under  *n* = 326 | Within  *n* = 418 | Above  *n* = 90 |
|  |  |  |  |  |
| Children |  |  |  |  |
| Sex, % girls | 54.3 | 57.2 | 56.7 | 0.73 |
| Age (y) | 14.5 ± 1.8 | 14.5 ± 1.8 | 14.9 ± 1.2 | 0.35 |
| Height-for-age Z score4 | -0.7 ± 0.9 | -0.7 ± 0.9 | -0.9 ± 0.9 | 0.14 |
| Body mass index-for-age Z score4 | 0.2 ± 1.03 | 0.1 ± 0.98 | -0.1 ± 0.87 | 0.02 |
| Screen time (hours/week)5 | 20.5 ± 13.9 | 20.4 ± 14.6 | 22.8 ± 17.7 | 0.80 |
| Time playing outdoors (hours/week) | 5.9 ± 7.3 | 6.7 ± 7.6 | 5.8 ± 6.3 | 0.36 |
| Middle childhood sleep duration (hours/night) | 9.0 ± 1.2 | 9.3 ± 1.2 | 9.6 ± 1.6 | 0.0002 |
|  |  |  |  |  |
| Mothers |  |  |  |  |
| Age at child’s birth (y) | 27.2 ± 6.6 | 27.7 ± 6.6 | 27.1 ± 6.2 | 0.52 |
| Height (cm) | 157 ± 5.9 | 158 ± 6.4 | 158 ± 7.2 | 0.24 |
| Body mass index (kg/m2) | 24.5 ± 3.4 | 23.9 ± 3.8 | 24.6 ± 4.3 | 0.03 |
| Parity | 2.5 ± 1.0 | 2.7 ± 1.1 | 2.8 ± 1.2 | 0.08 |
| Single parent, % | 27.2 | 22.1 | 26.7 | 0.24 |
| Education level (y) | 9.6 ± 3.5 | 9.8 ± 3.4 | 8.6 ± 3.7 | 0.05 |
|  |  |  |  |  |
| Household |  |  |  |  |
| Home ownership, % | 49.5 | 42.8 | 50.7 | 0.15 |
| Number of household assets6 | 5.0 ± 1.1 | 4.9 ± 1.2 | 4.9 ± 1.3 | 0.49 |
| Severe food insecurity, % | 2.3 | 2.3 | 2.5 | 0.99 |
| Socioeconomic status7 | 2.7 ± 0.6 | 2.5 ± 0.6 | 2.4 ± 0.6 | 0.0006 |
|  |  |  |  |  |

1 Data are means ± SD unless noted otherwise.

2 <9, 9 to 12, or ≥12 h per 24 h, respectively, in children aged 6 to <13 y and <8, 8 to 10, or ≥10 h per 24 h in children aged ≥13 y.

3 χ2 test for categorical variables, Kruskal-Wallis test for continuous variables.

4 According to the World Health Organization growth reference for children and adolescents.

5 Time spent watching television or playing video games.

6 From a list that included refrigerator, bicycle, blender, television, stereo, and washing machine.

7 Per the local government’s classification for tax and public services fees.

Supplemental Table 17. Likelihood ratio test for the interaction between nighttime sleep duration (hours) and age at sleep assessment for different age cut points on the association between sleep duration in adolescence and behavior problems in adolescence per the YSR.

| Age cut point (years) | *n* above cut point1 | Total externalizing behavior2 | Total internalizing behavior2 | Attention problems2 | Social problems2 | Thought problems2 |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
| 14.0 | 534 | 4.6 | 5.4 | 3.4 | 2.0 | 4.0 |
| 14.5 | 449 | 6.3 | 2.9 | 3.0 | 5.0 | 1.8 |
| 15.0 | 367 | 10.2 | 1.9 | 0.6 | 8.9 | 3.7 |
| 15.5 | 272 | 4.8 | 0.2 | 0.3 | 3.9 | 2.1 |
| 16.0 | 185 | 4.5 | 1.3 | 3.1 | 5.3 | 6.0 |
| 16.5 | 102 | 6.0 | 1.9 | 4.7 | 3.6 | 2.0 |
| 17.0 | 48 | 3.1 | 4.0 | 5.4 | 4.1 | 2.1 |
|  |  |  |  |  |  |  |

1 Total *n* = 818.

2 χ2 values with three degrees of freedom from -2 log-likelihood comparisons of main effects (including linear and 2 spline terms for sleep duration and the age-at-assessment cut point plus adjustment covariates) and saturated linear regression models (additionally including interaction terms between sleep duration terms and age-at-assessment).

Supplemental Table 18. Nighttime sleep duration in adolescence and behavior problems in adolescence per the YSR.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Mean ± SE behavior problem score at sleep duration1 | | |  | 7 hours vs. 8 hours | | 12 hours vs. 8 hours | |
| 7 hours | 8 hours | 12 hours |  | Adjusted difference  (95% CI)2 | *P* | Adjusted difference  (95% CI) | *P* |
|  |  |  |  |  |  |  |  |  |
| Total externalizing |  |  |  |  |  |  |  |  |
| <15 years-old | 54.8 ± 1.2 | 52.7 ± 1.4 | 50.9 ± 1.8 |  | 1.8 (0.2, 3.6) | 0.03 | -0.4 (-3.7, 2.9) | 0.82 |
| ≥15 years-old | 54.5 ± 1.0 | 54.4 ± 1.4 | 56.3 ± 2.6 |  | 0.3 (-1.3, 2.0) | 0.71 | 1.8 (-2.8, 6.3) | 0.45 |
|  |  |  |  |  |  |  |  |  |
| Total internalizing | 54.8 ± 0.8 | 52.9 ± 1.0 | 53.6 ± 1.7 |  | 2.0 (1.0, 2.9) | <0.0001 | 1.9 (-1.2, 5.0) | 0.23 |
|  |  |  |  |  |  |  |  |  |
| Attention problems | 52.6 ± 0.3 | 52.4 ± 0.3 | 51.7 ± 0.4 |  | 0.3 (-0.1, 0.7) | 0.13 | -0.4 (-1.1, 0.3) | 0.24 |
|  |  |  |  |  |  |  |  |  |
| Social problems |  |  |  |  |  |  |  |  |
| <15 years-old | 57.6 ± 0.8 | 56.2 ± 1.0 | 57.2 ± 1.2 |  | 1.3 (0.4, 2.2) | 0.007 | 1.1 (-1.2, 3.4) | 0.36 |
| ≥15 years-old | 55.2 ± 0.7 | 54.8 ± 0.9 | 57.1 ± 1.6 |  | 0.6 (-0.4, 1.7) | 0.25 | 2.2 (-0.9, 5.3) | 0.17 |
|  |  |  |  |  |  |  |  |  |
| Thought problems | 55.3 ± 0.5 | 54.4 ± 0.6 | 55.4 ± 1.0 |  | 0.9 (0.2, 1.6) | 0.009 | 1.5 (-0.2, 3.3) | 0.08 |
|  |  |  |  |  |  |  |  |  |

1 Estimates are from linear generalized estimating equation models with externalizing behavior score as the continuous outcome; predictors include linear and spline terms for sleep duration (hours).

2 Adjusted for child’s age, body mass index-for-age Z score, and socioeconomic status at the adolescence assessment, and sex and middle childhood sleep duration. In all models, the robust sandwich estimate of the variance was used to account for intra-family correlations. *P* from χ2 Score test. Complete case analysis (n= 818).

Supplemental Table 19. Likelihood ratio test for the interaction between nighttime sleep duration (hours) and age at sleep assessment for different age cut points on the association between sleep duration in adolescence and behavior problems in adolescence per the CBCL.

| Age cut point (years) | *n* above cut point1 | Total externalizing behavior2 | Total internalizing behavior2 | Attention problems2 | Social problems2 | Thought problems2 |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
| 14.0 | 471 | 3.4 | 3.5 | 5.4 | 6.7 | 1.3 |
| 14.5 | 394 | 4.2 | 4.2 | 2.7 | 7.1 | 2.7 |
| 15.0 | 321 | 6.7 | 4.2 | 5.8 | 10.8 | 3.7 |
| 15.5 | 234 | 6.1 | 7.2 | 2.9 | 4.7 | 1.5 |
| 16.0 | 158 | 3.5 | 5.4 | 1.8 | 4.4 | 0.5 |
| 16.5 | 85 | 8.5 | 7.2 | 2.9 | 4.7 | 4.9 |
| 17.0 | 43 | 7.5 | 8.3 | 1.3 | 2.8 | 2.9 |
|  |  |  |  |  |  |  |

1 Total *n* = 728.

2 χ2 values with three degrees of freedom from -2 log-likelihood comparisons of main effects (including linear and 2 spline terms for sleep duration and the age-at-assessment cut point plus adjustment covariates) and saturated linear regression models (additionally including interaction terms between sleep duration terms and age-at-assessment).

Supplemental Table 20. Nighttime sleep duration in adolescence and behavior problems in adolescence per the CBCL.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Mean ± SE behavior problem score at sleep duration1 | | |  | 7 hours vs. 8 hours | | 12 hours vs. 8 hours | |
| 7 hours | 8 hours | 12 hours |  | Adjusted difference  (95% CI)2 | *P* | Adjusted difference  (95% CI) | *P* |
|  |  |  |  |  |  |  |  |  |
| Total externalizing |  |  |  |  |  |  |  |  |
| <16.5 years-old | 56.6 ± 0.9 | 55.9 ± 1.1 | 56.9 ± 1.7 |  | 0.6 (-0.6, 1,8) | 0.30 | 1.3 (-1.7, 4.2) | 0.41 |
| ≥16.5 years-old | 51.7 ± 2.1 | 54.0 ± 2.7 | 58.7 ± 3.7 |  | -2.5 (-6.9, 1.9) | 0.27 | 4.1 (-3.1, 11.3) | 0.26 |
|  |  |  |  |  |  |  |  |  |
| Total internalizing |  |  |  |  |  |  |  |  |
| <17 years-old | 57.1 ± 0.9 | 56.4 ± 1.1 | 58.1 ± 2.0 |  | 0.7 (-0.5, 1.9) | 0.27 | 1.6 (-1.7, 4.9) | 0.33 |
| ≥17 years-old | 49.7 ± 3.2 | 53.1 ± 4.7 | 66.0 ± 4.3 |  | -3.7 (-11.6, 4.3) | 0.37 | 13.3 (4.7, 22.0) | 0.003 |
|  |  |  |  |  |  |  |  |  |
| Attention problems | 54.2 ± 0.4 | 53.7 ± 0.5 | 54.0 ± 0.8 |  | 0.5 (-0.1, 1.1) | 0.09 | 0.2 (-1.1, 1.6) | 0.75 |
|  |  |  |  |  |  |  |  |  |
| Social problems |  |  |  |  |  |  |  |  |
| <15 years-old | 59.7 ± 0.9 | 58.8 ± 1.1 | 57.7 ± 1.6 |  | 0.8 (-0.5, 2.0) | 0.22 | -1.5 (-4.2, 1.2) | 0.27 |
| ≥15 years-old | 55.7 ± 0.8 | 55.7 ± 1.0 | 58.4 ± 1.9 |  | 0.1 (-0.9, 1.1) | 0.78 | 2.8 (-1.1, 6.7) | 0.15 |
|  |  |  |  |  |  |  |  |  |
| Thought problems | 56.0 ± 0.6 | 55.2 ± 0.8 | 56.1 ± 1.3 |  | 0.8 (0.0, 1.7) | 0.05 | 1.2 (-1.0, 3.4) | 0.27 |
|  |  |  |  |  |  |  |  |  |

1 Estimates are from linear generalized estimating equation models with externalizing behavior score as the continuous outcome; predictors include linear and spline terms for sleep duration (hours).

2 Adjusted for child’s age, body mass index-for-age Z score, and socioeconomic status at the adolescence assessment, and sex and middle childhood sleep duration. In all models, the robust sandwich estimate of the variance was used to account for intra-family correlations. *P* from χ2 Score test. Complete case analysis (n= 728).

Supplemental Figure 1. Adjusted differences in externalizing scores in adolescence per the YSR by nighttime sleep duration in adolescence stratified by age at sleep assessment.

|  |  |
| --- | --- |
| ≥ 15 years | < 15 years |

The dark line represents mean adjusted differences in the behavior score between a given sleep duration (hours) and 8 hours. Gray lines represent 95% confidence intervals. Estimates are from linear generalized estimating equation models with externalizing behavior score as the continuous outcome; predictors included linear and spline terms for sleep duration and child’s age, body mass index-for-age Z score, and socioeconomic status at the adolescence assessment, and sex and middle childhood sleep duration. In all models, the robust sandwich estimate of the variance was used to account for intra-family correlations.