Factors associated with attention deficit/hyperactivity disorder among US children: Results from a national survey

Ravi K Lingineni¹, Swati Biswas¹,²,⁵*, Naveed Ahmad³, Bradford E Jackson¹,⁴, Sejong Bae¹,⁴ and Karan P Singh¹,⁴

Abstract

Background: The purpose of this study was to investigate the association between Attention Deficit/Hyperactivity Disorder (ADHD) and various factors using a representative sample of US children in a comprehensive manner. This includes variables that have not been previously studied such as watching TV/playing video games, computer usage, family member’s smoking, and participation in sports.

Methods: This was a cross-sectional study of 68,634 children, 5–17 years old, from the National Survey of Children’s Health (NSCH, 2007–2008). We performed bivariate and multivariate logistic regression analyses with ADHD classification as the response variable and the following explanatory variables: sex, race, depression, anxiety, body mass index, healthcare coverage, family structure, socio-economic status, family members’ smoking status, education, computer usage, watching television (TV)/playing video games, participation in sports, and participation in clubs/organizations.

Results: Approximately 10% of the sample was classified as having ADHD. We found depression, anxiety, healthcare coverage, and male sex of child to have increased odds of being diagnosed with ADHD. One of the salient features of this study was observing a significant association between ADHD and variables such as TV usage, participation in sports, two-parent family structure, and family members’ smoking status. Obesity was not found to be significantly associated with ADHD, contrary to some previous studies.

Conclusions: The current study uncovered several factors associated with ADHD at the national level, including some that have not been studied earlier in such a setting. However, we caution that due to the cross-sectional and observational nature of the data, a cause and effect relationship between ADHD and the associated factors can not be deduced from this study. Future research on ADHD should take into consideration these factors, preferably through a longitudinal study design.

Keywords: National Survey of Children’s Health, Neurobehavioral disorder, Obesity, Depression, Medication, TV usage, Participation in sports, Smoking status
Background

The diagnosis of psychiatric, behavioral, and learning disorders has increased over the past decade. Attention Deficit/Hyperactivity Disorder (ADHD) is one of the most common childhood neurobehavioral disorders in the U.S [1,2]. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), ADHD is characterized by pervasive and developmentally inappropriate symptoms such as severe lack of attention, impulsive behavior, and hyperactivity that affects children and persists through adulthood in 30–50% of ADHD affected children [3-6]. It is a multi-factorial and clinically heterogeneous disorder that affects about 9% to 15% of school going children in the US [7-10]. Previous studies, as of 2007, have found that the percentage of parent reported (ever) ADHD diagnosed children below 17 years of age was 9.5% or about 5.4 million, which represents a 22% increase in four years from 2003 to 2007 [11-14].

In the past 15 years, studies on uncovering the etiology of ADHD focused mainly on the association between ADHD and genetic factors, specifically DRD2 and DRD4 genes [15,16]. Some other studies have shown an association of ADHD with factors such as obesity, depression, anxiety, sex, age, race, asthma, cigarette smoking, family structure, and socio economic status (SES) [17-27]. Many of these studies showed a significant association between ADHD and body mass index (BMI), however, these studies did not consider factors that may be common for both ADHD and BMI such as participation in sports, clubs, computer usage, and watching television/playing video games [27-30]. Some studies have shown that having ADHD increases the chance of early initiation of smoking habit in children [26,27]. Also, the effect of mother's smoking during pregnancy on ADHD has been previously studied [31,32]. However, the effect of family members' smoking on children's ADHD has not been considered. Thus, there is a need for a more comprehensive study of factors. Our study considers the potential factors from previous studies as well as the factors not considered earlier together. The purpose of this study was to explore the association between ADHD diagnosis and many factors together using a nationally representative sample, in particular, the National Survey of Child Health (NSCH) of the US. Even though our study cannot establish any of these factors as risk/protection factors due to the cross-sectional and observational nature of the data, we believe this type of comprehensive study on association is lacking in the ADHD literature and this article aims to fill this gap.

Methods

NSCH data

NSCH is a population-based, cross-sectional, random-digital-dialing survey using a complex, multi-cluster, probability sampling design [33]. This survey was sponsored by the Department of Health and Human Services (DHHS), Maternal and Child Health Bureau in partnership with the National Center for Health Statistics, which is a part of the Center for Disease Control and Prevention [34]. The data were collected by random-digital-dialing households with children under 18 years of age from each of the 50 states and the District of Columbia during the period of April 2007 to July 2008. A child was randomly selected from each of the sampled households to be the subject of the survey. The parent or guardian who knew the most about the selected child’s health and health care was interviewed with questions over the telephone. The interview was conducted in both English and Spanish, and consisted of questions regarding demographics, child’s health and functional status, health insurance coverage, health care access and utilization, medical home, family functioning, parental health, and neighborhood/community characteristics. A total of 91,642 children of age 17 years or under, with an overall weighted response rate of 55.3% were included in NSCH 2007 study. Population based estimates were obtained by assigning sampling weights to each sampled child for whom an interview was completed. Detailed information about the design of the NSCH is available at www.nschdata.org.

Study sample

According to the DSM-IV, the diagnosis of ADHD requires the child to experience ADHD characteristics such as lack of attention, impulsive behavior, and hyperactivity in at least two different settings, namely home and school; while previous studies also show that the earliest onset age for a child to be diagnosed and treated for ADHD can be below 7 years [35]. As one of the two settings required for the diagnosis of ADHD is school, we considered children between 5 to 17 years old to be our study sample. There were a total of 68,634 responses given by the parents or guardians of children aged 5 to 17 years. Since the NSCH is a population based survey, the selected sample is a representative sample of children aged 5 to 17 years in the US.

Variables

The primary dependent variable used in our study was ascertained through the following question to the parent or guardian: “Has a doctor or health professional ever told you that selected child (S.C.) has attention deficit disorder or attention deficit hyperactive disorder, that is, ADD or ADHD?”. We categorized the variable into: ‘ADHD’ if the response was ‘Yes’, and ‘No ADHD’ if the response was ‘No’. The psychological factors included in the study were depression (DEP); “Has a doctor or other health care provider ever told you that S.C. had...
depression?” and anxiety (ANX; “Has a doctor or other health care provider ever told you that S.C. had anxiety problems?”). The NSCH has a sex- and age-specific derived BMI variable that is categorized into underweight (<5th percentile), normal weight (≥5th and <85th percentile), at risk of overweight (≥85th and <95th percentile) and overweight (≥95th percentile). To explicate, we refer to the last two categories as overweight and obese, respectively. Other independent variables included in the analysis were sex, race/ethnicity (Non-Hispanic White vs. Non-Hispanic Black, Hispanic, Other), highest level of education (EDUC) attained by anyone in the household (More than high school vs. High school graduate or less), family structure (FAMILY; Two parent including biological, step, or adopted vs. Other including single mother), dichotomized poverty level based on DHHS Federal Poverty guidelines (POVERTY; ≤200% vs. >200%), healthcare coverage (INS; Having any health insurance such as Health Maintenance Organizations (HMOs) or Medicaid vs. Not having healthcare coverage), participation in sports (SPORTS; S. C. on a sports team or taking sports lessons after the school or on weekends vs. Not participating in sports), participation in clubs (CLUBS; S. C. on any clubs or organizations after school or on weekend vs. Not participating in clubs), daily average computer usage (COMP) for purposes other than school work (≥1 hour vs. <1 hour), daily average television watching/playing video games (TV; ≥1 hour vs. <1 hour), family member’s smoking status (SMOKE; Cigarettes, cigars, or pipe tobacco used by anyone in the household vs. No one in the household smokes) [17-32].

We also considered the effect of medication on the association between ADHD and BMI, as most of the medications prescribed for ADHD may have anorectic effects [36]. To do this we utilized the question: “Is S.C. currently taking medication for ADD or ADHD?” We combined responses to this question with the ones to the ADHD question mentioned earlier to create a variable with three categories: ‘ADHD and currently taking

### Table 1 Characteristics of subjects 5–17 years old, NSCH 2007

| Variable                              | N (Unweighted) | Weighted % ± SE |
|---------------------------------------|----------------|-----------------|
| **ADHD classification**               |                |                 |
| Yes                                   | 7137           | 10.08 ± 0.28    |
| No                                    | 61378          | 89.91 ± 0.28    |
| **BMI**                               |                |                 |
| Underweight                           | 2186           | 5.16 ± 0.27     |
| Normal                                | 29121          | 63.19 ± 0.60    |
| Overweight                            | 6754           | 15.26 ± 0.44    |
| Obese                                 | 6040           | 16.37 ± 0.48    |
| **Sex**                               |                |                 |
| Male                                  | 35677          | 51.13 ± 0.48    |
| Female                                | 32863          | 48.86 ± 0.48    |
| **Age: Median(IQR)**                  | 10.63 (6.51)   |                 |
| **Depression**                        |                |                 |
| Yes                                   | 3088           | 4.50 ± 0.21     |
| No                                    | 65481          | 95.49 ± 0.21    |
| **Anxiety**                           |                |                 |
| Yes                                   | 4125           | 5.31 ± 0.21     |
| No                                    | 64428          | 94.68 ± 0.21    |
| **Race/Ethnicity**                    |                |                 |
| Non-Hispanic White                    | 46739          | 56.75 ± 0.51    |
| Non-Hispanic Black                    | 6908           | 14.93 ± 0.33    |
| Hispanic                              | 8006           | 19.77 ± 0.50    |
| Other                                 | 5894           | 8.53 ± 0.29     |
| **Poverty**                           |                |                 |
| ≤200%                                 | 17008          | 37.68 ± 0.50    |
| >200%                                 | 45873          | 62.31 ± 0.50    |
| **Family member’s Smoking status**    |                |                 |
| By any one in household               | 17221          | 26.37 ± 0.42    |
| No one Smoke                          | 50901          | 73.62 ± 0.42    |
| **Highest level of Education in the household** | | |
| Less than/High School Education       | 15624          | 33.16 ± 0.49    |
| More than High School Education       | 52024          | 66.83 ± 0.49    |
| **Family structure**                  |                |                 |
| Two parent - biological/step/adopted  | 51682          | 73.19 ± 0.43    |
| Other - single mother/father/other    | 16532          | 26.80 ± 0.43    |
| **Healthcare coverage**               |                |                 |
| Yes                                   | 63154          | 90.43 ± 0.31    |
| No                                    | 5343           | 9.56 ± 0.31     |
| **Participation in Sports**           |                |                 |
| Yes                                   | 40673          | 58.30 ± 0.50    |
| No                                    | 23354          | 41.69 ± 0.50    |
| **Participation in Clubs**            |                |                 |
| Yes                                   | 40352          | 56.89 ± 0.51    |
| No                                    | 23649          | 43.10 ± 0.51    |
| **Average computer usage during a weekday** | | |
| ≥1 hour                               | 30744          | 61.36 ± 0.54    |
| <1 hour                               | 19811          | 38.64 ± 0.54    |
| Average TV usage during weekday       |                |                 |
| ≥1 hour                               | 50080          | 83.99 ± 0.39    |
| <1 hour                               | 9898           | 16.01 ± 0.39    |
| **Current Medication Use (in ADHD group)** | | |
| Yes                                   | 3735           | 66.72 ± 1.65    |
| No                                    | 1690           | 33.28 ± 1.65    |

Unweighted N = 68634. SE: Standard Error; IQR: Inter-Quartile Range.
Table 2 Factors stratified by ADHD classification for subjects 5–17 years old, NSCH 2007

| Variable                        | ADHD (N Unweighted) | N (Weighted) % ± SE | NO ADHD (N Unweighted) | N (Weighted) % ± SE | P-value |
|--------------------------------|---------------------|---------------------|------------------------|---------------------|---------|
| **BMI**                        |                     |                     |                        |                     |         |
| Underweight                    | 292                 | 4.26 ± 0.58         | 1892                   | 5.28 ± 0.36         | <0.001  |
| Normal                         | 3418                | 58.57 ± 1.73        | 25664                  | 63.84 ± 0.64        |         |
| Overweight                     | 867                 | 16.21 ± 1.34        | 5876                   | 15.13 ± 0.46        |         |
| Obese                          | 952                 | 20.94 ± 1.48        | 5078                   | 15.73 ± 0.51        |         |
| **Sex**                        |                     |                     |                        |                     |         |
| Male                           | 5068                | 70.90 ± 1.37        | 30536                  | 48.90 ± 0.51        | <0.001  |
| Female                         | 2063                | 29.09 ± 1.37        | 30754                  | 51.09 ± 0.51        |         |
| **Age:** Median(IQR)           | 13 (5)              | 11.98 (5.69)        | 12 (7)                 | 10.46 (6.59)        | <0.001  |
| **Depression**                 |                     |                     |                        |                     |         |
| Yes                            | 1505                | 22.93 ± 1.39        | 1573                   | 2.43 ± 0.15         | <0.001  |
| No                             | 5611                | 77.07 ± 1.39        | 59778                  | 97.56 ± 0.15        |         |
| **Anxiety**                    |                     |                     |                        |                     |         |
| Yes                            | 1854                | 23.73 ± 1.21        | 2257                   | 3.22 ± 0.19         | <0.001  |
| No                             | 5260                | 76.26 ± 1.21        | 59084                  | 96.77 ± 0.19        |         |
| **Race/Ethnicity**             |                     |                     |                        |                     |         |
| Non-Hispanic White             | 5110                | 63.62 ± 1.47        | 41567                  | 56.00 ± 0.54        | <0.001  |
| Non-Hispanic Black             | 741                 | 16.25 ± 1.06        | 6148                   | 14.76 ± 0.35        |         |
| Hispanic                       | 613                 | 11.97 ± 1.22        | 7374                   | 20.64 ± 0.54        |         |
| Other                          | 586                 | 8.14 ± 0.77         | 5292                   | 8.58 ± 0.31         |         |
| **Poverty**                    |                     |                     |                        |                     |         |
| ≤200%                          | 2205                | 43.73 ± 1.52        | 14759                  | 36.94 ± 0.54        | <0.001  |
| >200%                          | 4446                | 56.26 ± 1.52        | 41376                  | 63.05 ± 0.54        |         |
| **Family members’ Smoking status** |                 |                     |                        |                     |         |
| By any one in household        | 2453                | 39.60 ± 1.45        | 14724                  | 24.86 ± 0.43        | <0.001  |
| No one Smoke                   | 4645                | 60.39 ± 1.45        | 46182                  | 75.13 ± 0.43        |         |
| **Highest level of Education in the household** |                 |                     |                        |                     |         |
| Less than/High School Education| 1938                | 38.31 ± 1.47        | 13641                  | 32.54 ± 0.52        | <0.001  |
| More than High School Education| 5137                | 61.68 ± 1.47        | 46993                  | 67.45 ± 0.52        |         |
| **Family structure**           |                     |                     |                        |                     |         |
| Two parent - biological/step/adopted | 4570            | 59.76 ± 1.45        | 47043                  | 74.74 ± 0.44        | <0.001  |
| Other - single mother/father/other | 2528            | 40.23 ± 1.45        | 13955                  | 25.25 ± 0.44        |         |
| **Healthcare coverage**        |                     |                     |                        |                     |         |
| Yes                            | 6719                | 93.35 ± 0.86        | 56333                  | 90.12 ± 0.33        | 0.002   |
| No                             | 408                 | 6.66 ± 0.86         | 4919                   | 9.87 ± 0.33         |         |
| **Participation in Sports**    |                     |                     |                        |                     |         |
| Yes                            | 3688                | 48.51 ± 1.47        | 36933                  | 59.50 ± 0.54        | <0.001  |
| No                             | 3333                | 51.49 ± 1.47        | 19969                  | 40.50 ± 0.54        |         |
| **Participation in Clubs**     |                     |                     |                        |                     |         |
| Yes                            | 3839                | 51.38 ± 1.48        | 36463                  | 57.57 ± 0.54        | <0.001  |
| No                             | 3179                | 48.61 ± 1.48        | 20417                  | 42.43 ± 0.54        |         |
| **Average computer usage during a weekday** |                 |                     |                        |                     |         |
| ≥1 hour                        | 3633                | 69.88 ± 1.52        | 27066                  | 60.37 ± 0.58        | <0.001  |
| <1 hour                        | 1677                | 30.12 ± 1.52        | 18115                  | 39.62 ± 0.58        |         |
medication’ (ADHD-CM), ‘ADHD and not currently taking medication’ (ADHD-NCM), and ‘No ADHD’; ‘No ADHD’ was considered as the reference group. This trichotomized variable is used as a dependent variable in one of the models. We chose not to use this variable as our primary dependent variable due to several limitations with the medication use question and its discrepancy in sample size with the ADHD question (elaborated later in the Discussion section).

Statistical analysis
We computed descriptive statistics based on unweighted sample sizes and weighted percentages for children aged 5 to 17 years. Next, we used chi-square tests for testing the association of each variable with ADHD. Then we performed logistic regression analysis with ADHD as the response variable and the independent variables specified above, first with each of the variables individually (bivariate analysis) and then with all of them in the model (multivariate analysis) to obtain unadjusted and adjusted odds ratios (OR), respectively. For the trichotomized dependent variable that incorporates the medication effect, we used the multinomial logistic regression with independent variables same as in our previous model. All analyses were carried out in SAS version 9.2 to account for the complex survey design of the study [37,38]. In particular, we performed domain analysis for the 5–17 years age group [39].

Results
The descriptive statistics (Table 1) show that the prevalence of ADHD is about 10% (n = 7,137). In this study, 51.13% were male; 56.75% were non-Hispanic White, 14.93% were non-Hispanic Black and 19.77% were Hispanic. About 16.37% of the study subjects were obese while 63.19% were normal weight, and only 5.16% were underweight. DEP and ANX were reported in 4.50% and 5.31% of the children, respectively. Further, 62.31% were above the 200% POVERTY level specified by DHHS and around two thirds (66.35%) of the households had more than high school EDUC. Most of the children (90.43%) had INS, were (73.19%) living in two-parent FAMILY, had (73.62%) no one SMOKE in the household. Additionally, 58.30% and 56.89% were in SPORTS and CLUBS, respectively; and 61.36% and 83.99% had used

| Table 2 Factors stratified by ADHD classification for subjects 5–17 years old, NSCH 2007 (Continued) |
|-------------------------------------------------|
| Average TV usage during weekday | ADHD |
| 21 hour | 5788 | 90.02 ± 0.68 | 44204 | 83.24 ± 0.43 | <0.001 |
| <1 hour | 847 | 9.97 ± 0.68 | 9041 | 16.75 ± 0.43 | |

Unweighted N = 68634.
SE: Standard Error; IQR: Inter-Quartile Range.
* Weighted Mean (Weighted SE).

| Table 3 Unadjusted odds ratios for factors associated with ADHD classification, NSCH 2007 |
|---------------------------------|
| Variable | ADHD |
| | OR | LCL | UCL |
| BMI | Underweight | 0.88 | 0.65 | 1.20 |
| | Normal | Ref | Ref | Ref |
| | Overweight | 1.17 | 0.95 | 1.44 |
| | Obese | 1.45* | 1.19 | 1.77 |
| Sex | Male | 2.55* | 2.22 | 2.92 |
| | Female | Ref | Ref | Ref |
| Age | 1.10* | 1.08 | 1.11 |
| Depression | Yes | 11.94* | 9.75 | 14.61 |
| | No | Ref | Ref | Ref |
| Anxiety | Yes | 9.35* | 7.82 | 11.18 |
| | No | Ref | Ref | Ref |
| Race/Ethnicity | Non- Hispanic White | Ref | Ref | Ref |
| | Non-Hispanic Black | 0.97 | 0.82 | 1.14 |
| | Hispanic | 0.51* | 0.40 | 0.65 |
| | Other | 0.83 | 0.67 | 1.04 |
| Poverty | ≤200% | 1.33* | 1.17 | 1.51 |
| | >200% | Ref | Ref | Ref |
| Family members’ smoking status | At least one member smokes | 1.98* | 1.75 | 2.25 |
| | No one smokes | Ref | Ref | Ref |
| Highest level of Education in the household | Less than/High School Education | Ref | Ref | Ref |
| | More than High School Education | 0.78* | 0.68 | 0.89 |
| Family structure | Two parent -biological/step/adopted | 0.50* | 0.44 | 0.57 |
| | Other - single mother/father/other | Ref | Ref | Ref |
| Healthcare coverage | Yes | 1.54* | 1.16 | 2.04 |
| | No | Ref | Ref | Ref |
| Participation in Sports | | | | |
COMP for other than schoolwork and watched TV on an average for ≥1 hour during a weekday, respectively. Finally, of the children classified as with ADHD, 66.72% take medication.

We summarize various factors by ADHD classification and report the corresponding p-values in Table 2. All the factors were statistically significant at the 0.05 level. In particular, children in the ADHD and No ADHD groups differ strikingly in many characteristics including: 70.90% vs. 48.90% males, 22.93% vs. 2.43% DEP, 23.73% vs. 3.22% having ANX, 39.60% vs. 24.86% having someone SMOKE, 59.76% vs. 74.74% living in a two-parent FAMILY, and 48.51% vs. 59.50% in SPORTS, respectively. The ORs and their confidence intervals (CI) from the bivariate analysis are shown in Table 3. The following variables showed significantly increased odds of being classified as having ADHD: when a child was male (OR 2.55, 95% CI 2.22–2.92); obese (OR 1.45, 95% CI 1.19–1.77); had DEP (OR 11.94, 95% CI 9.75–14.61); had ANX (OR 3.96, 95% CI 2.68–5.87); belonged to ≤200% POVERTY level (OR 1.22, 95% CI 1.17–1.27); had INS (OR 1.21, 95% CI 1.09–1.34); had someone SMOKE (OR 1.38, 95% CI 1.25–1.51); used COMP for ≥1 hour for the purpose other than school work in a weekday (OR 1.52, 95% CI 1.31–1.77); or watched TV for ≥1 hour (OR 1.52, 95% CI 1.31–1.77); than the respective reference group. Additionally, the odds of a child being diagnosed with ADHD increased 10% (OR 1.10, 95% CI 1.08–1.11) with every one year increase in age. A child was significantly less likely to be classified as having ADHD if he/she was living in a two-parent FAMILY (OR 0.50, 95% CI 0.44–0.57); was Hispanic (OR 0.51, 95% CI 0.40–0.65); had at least one of the parent/guardian with more than high school EDUC (OR 0.78, 95% CI 0.68–0.89); was in SPORTS (OR 0.64, 95% CI 0.57–0.73); or was in CLUBS (OR 0.78, 95% CI 0.69–0.88).

**Table 3 Unadjusted odds ratios for factors associated with ADHD classification, NSCH 2007 (Continued)**

| Variable                                | ADHD | OR  | LCL | UCL |
|-----------------------------------------|------|-----|-----|-----|
| Participation in Clubs                  |      |     |     |     |
| Yes                                     | 0.64*| 0.57| 0.73|
| No                                      |      | Ref | Ref | Ref |
| Average computer usage during a weekday |      |     |     |     |
| ≥1 hour                                 | 1.52*| 1.31| 1.77|
| <1 hour                                 |      | Ref | Ref | Ref |
| Average TV usage during weekday         |      |     |     |     |
| ≥1 hour                                 | 1.82*| 1.55| 2.13|
| <1 hour                                 |      | Ref | Ref | Ref |

* Significant association at 0.05 level.

**Table 4 Adjusted odds ratios for factors associated with ADHD classification, NSCH 2007**

| Variable                                | ADHD | OR  | LCL | UCL |
|-----------------------------------------|------|-----|-----|-----|
| BMI                                     |      |     |     |     |
| Underweight                             | 0.64*| 0.43| 0.95|
| Normal                                  |      | Ref | Ref | Ref |
| Overweight                              | 1.05 | 0.81| 1.36|
| Obese                                   | 1.06 | 0.81| 1.39|
|Sex                                      |      |     |     |     |
| Male                                    | 2.82*| 2.26| 3.52|
| Female                                  |      | Ref | Ref | Ref |
| Age                                     | 1.00 | 0.95| 1.04|
| Depression                              |      |     |     |     |
| Yes                                     | 5.28*| 3.65| 7.64|
| No                                      |      | Ref | Ref | Ref |
| Anxiety                                 |      |     |     |     |
| Yes                                     | 3.04*| 2.20| 4.19|
| No                                      |      | Ref | Ref | Ref |
| Race/Ethnicity                          |      |     |     |     |
| Non-Hispanic White                      |      | Ref | Ref | Ref |
| Non-Hispanic Black                      | 0.72*| 0.53| 0.98|
| Hispanic                                | 0.65*| 0.43| 0.95|
| Other                                   | 0.78 | 0.54| 1.14|
| Poverty                                 |      |     |     |     |
| ≤200%                                   | 1.07 | 0.84| 1.37|
| >200%                                   |      | Ref | Ref | Ref |
| Family members’ smoking status          |      |     |     |     |
| At least one member smokes              | 1.33*| 1.08| 1.64|
| No one smokes                           |      | Ref | Ref | Ref |
| Highest level of Education in the household |      |     |     |     |
| Less than/High School Education         |      | Ref | Ref | Ref |
| More than High School Education          | 1.11 | 0.89| 1.38|
| Family structure                        |      |     |     |     |
| Two parent -biological/step/adopted     | 0.70*| 0.56| 0.87|
| Other - single mother/father/other      |      | Ref | Ref | Ref |
| Healthcare coverage                     |      |     |     |     |
| Yes                                     | 1.45*| 1.00| 2.08|
| No                                      |      | Ref | Ref | Ref |
| Participation in Sports                 |      |     |     |     |
| Yes                                     | 0.80*| 0.65| 0.98|
| No                                      |      | Ref | Ref | Ref |
| Participation in Clubs                  |      |     |     |     |
| Yes                                     | 0.86 | 0.71| 1.04|
| No                                      |      | Ref | Ref | Ref |
| Average computer usage during a weekday |      |     |     |     |
| ≥1 hour                                 | 1.06 | 0.85| 1.33|
| <1 hour                                 |      | Ref | Ref | Ref |
The adjusted odds ratios from the multivariate analysis (Table 4) showed that when adjusted for other variables a child had significantly increased odds of being classified as having ADHD if the sex was male (OR 2.82, 95% CI 2.26–3.52); had DEP (OR 5.28, 95% CI 3.65–7.64); had ANX (OR 3.04, 95% CI 2.20–4.19); had INS (OR 1.45, 95% CI 1.00–2.08); watched TV ≥1 hour (OR 1.32, 95% CI 1.03–1.70); or had someone SMOKE (OR 1.33, 95% CI 1.08–1.64). On the other hand, there were significantly decreased odds of being diagnosed with ADHD if a child was underweight (OR 0.64, 95% CI 0.43–0.95); was either Non-Hispanic Black (OR 0.72, 95% CI 0.53–0.98) or Hispanic (OR 0.65, 95% CI 0.43–0.95); was living in a two-parent FAMILY (OR 0.70, 95% CI 0.56–0.87); or was in SPORTS (OR 0.80, 95% CI 0.65–0.98).

The multinomial logistic regression model using the trichotomized ADHD classification with medication as the dependent variable showed similar results (Table 5) with some variables such as sex (OR 3.53, 95% CI 2.79–4.46), DEP (OR 6.97, 95% CI 4.66–10.44), ANX (OR 3.38, 95% CI 2.36–4.85), age (OR 0.92, 95% CI 0.86–0.97), INS (OR 2.24, 95% CI 1.24–4.07), and TV (OR 1.56, 95% CI 1.17–2.09) showing significance for the group ADHD-CM, and some variables such as BMI underweight (OR 0.41, 95% CI 0.23–0.75), sex (OR 2.52, 95% CI 1.54–4.14), DEP (OR 4.66, 95% CI 2.57–8.43), ANX (OR 2.77, 95% CI 1.63–4.69), and FAMILY (OR 0.56, 95% CI 0.37–0.85) showing significance for the group ADHD-NCM. In particular, with respect to the variable BMI, obesity was not significant as before while the decreased odds for underweight (OR 0.41, 95% CI 0.23–0.75) was only significant for the ADHD-NCM group. Furthermore, the variables SMOKE and SPORTS lost their significance in this model. Nevertheless, the results from this particular model need to be interpreted with caution due to some limitations to be discussed in the next section.

### Table 4 Adjusted odds ratios for factors associated with ADHD classification, NSCH 2007 (Continued)

| Variable                        | ADHD Not taking Medication OR (95% CI) | ADHD taking Medication OR (95% CI) |
|---------------------------------|--------------------------------------|-----------------------------------|
| **BMI**                         |                                       |                                   |
| Underweight                     | 0.41 (0.23–0.75)                      | 0.49 (1.40)                       |
| Normal                          | Ref (Ref)                             | Ref (Ref)                         |
| Overweight                      | 0.84 (0.56–1.25)                      | 0.69 (1.44)                       |
| Obese                           | 1.43 (0.83–2.47)                      | 0.60 (1.06)                       |
| **Sex**                         |                                       |                                   |
| Male                             | 2.52 (1.54–4.14)                      | 2.79 (4.46)                       |
| Female                           | Ref (Ref)                             | Ref (Ref)                         |
| **Age**                         | 1.05 (0.96–1.15)                      | 0.92 (0.86)                       |
| **Depression**                  |                                       |                                   |
| Yes                              | 4.66 (2.57–8.43)                      | 6.97 (4.66)                       |
| No                               | Ref (Ref)                             | Ref (Ref)                         |
| **Anxiety**                     |                                       |                                   |
| Yes                              | 2.77 (1.63–4.69)                      | 3.38 (2.36)                       |
| No                               | Ref (Ref)                             | Ref (Ref)                         |
| **Race/Ethnicity**              |                                       |                                   |
| Non-Hispanic White              | Ref (Ref)                             | Ref (Ref)                         |
| Non-Hispanic Black              | 0.78 (0.42–1.44)                      | 0.74 (0.48)                       |
| Hispanic                        | 0.90 (0.41–1.98)                      | 0.61 (0.35)                       |
| Other                           | 1.00 (0.57–1.74)                      | 0.70 (0.40)                       |

* Significant association at 0.05 level.

OR: Odds Ratio; LCL: 95% Lower Confidence Limit; UCL: 95% Upper Confidence Limit; Ref: Reference Category.

### Table 5 Adjusted odds ratios for factors associated with ADHD and Medication use classification, NSCH 2007 (Continued)

| Variable                      | ADHD Not taking Medication OR (95% CI) | ADHD taking Medication OR (95% CI) |
|-------------------------------|--------------------------------------|-----------------------------------|
| **Poverty**                   |                                       |                                   |
| ≤200%                        | 1.01 (0.66–1.54)                      | 1.26 (0.91–1.75)                  |
| >200%                        | Ref (Ref)                             | Ref (Ref)                         |
| **Family Member’s smoking status** |                                       |                                   |
| At least one member smokes   | 1.38 (0.99–1.93)                      | 1.32 (0.98–1.79)                  |
| No one smokes               | Ref (Ref)                             | Ref (Ref)                         |
| **Highest level of Education in the household** |                                       |                                   |
| Less than High School Education | Ref (Ref)                             | Ref (Ref)                         |
| More than High School Education | 1.03 (0.69–1.54)                      | 1.13 (0.87–1.47)                  |
| **Family structure**          |                                       |                                   |
| Two parent -biological/step/adopted | 0.56 (0.37–0.85)                      | 0.89 (0.67)                       |
| Other - single mother/father/other | Ref (Ref)                             | Ref (Ref)                         |
| **Healthcare coverage**       |                                       |                                   |
| Yes                           | 1.34 (0.73–2.44)                      | 2.14 (4.07)                       |
| No                            | Ref (Ref)                             | Ref (Ref)                         |
| **Participation in Sports**   |                                       |                                   |
| Yes                           | 0.69 (0.47–1.01)                      | 0.84 (0.65)                       |
| No                            | Ref (Ref)                             | Ref (Ref)                         |
| **Participation in Clubs**    |                                       |                                   |
| Yes                           | 0.83 (0.57–1.19)                      | 0.93 (0.73)                       |
| No                            | Ref (Ref)                             | Ref (Ref)                         |
| **Average Computer usage during weekday** |                                       |                                   |
| ≥1 hour                       | 1.25 (0.83–1.87)                      | 0.89 (0.65)                       |
| <1 hour                       | Ref (Ref)                             | Ref (Ref)                         |
| **Average TV usage during weekday** |                                       |                                   |
| ≥1 hour                       | 1.25 (0.76–2.06)                      | 1.17 (2.09)                       |
| <1 hour                       | Ref (Ref)                             | Ref (Ref)                         |

* Significant association at 0.05 level.

OR: Odds Ratio; LCL: 95% Lower Confidence Limit; UCL: 95% Upper Confidence Limit; Ref: Reference Category.
Discussion

Our comprehensive study found several factors associated with ADHD including some that have not been examined together in conjunction with other variables, especially at the national level. The significant association found between ADHD and DEP, ANX, sex, race, FAMILY, POVERTY, and EDUC is consistent with previous studies on ADHD [22-25]. However, after accounting for the ADHD related factors, obesity was not found to be significant, contrary to some previous studies [25]. The variables SMOKE, INS, SPORTS, and TV were found to be associated with ADHD at the national level for the first time in our study. A child with DEP, ANX, TV ≥1 hour, or with someone SMOKE in household had an increased odds of being diagnosed with ADHD. On the other hand, if a child was underweight, non-Hispanic White, living in a two-parent FAMILY, or in SPORTS, he/she had decreased odds of being diagnosed with ADHD.

This study is not without limitations. The NSCH is a random digital dialing telephone survey based on the responses of parent/guardians. So the responses could be affected by recall bias or the given information could be fallacious (such as misreporting of height/weight). In particular, the diagnosis of ADHD was solely dependent on the response given by a parent to a single question [“Has a doctor or health professional ever told you that S.C. has attention deficit disorder or attention deficit hyperactive disorder, that is, ADD or ADHD?”]; this may have resulted in diagnostic misclassification. In other words, as this is not a clinical study, it is unclear how many children who met the ADHD criteria were undiagnosed and/or untreated. Further, the survey question on SMOKE [Does anyone living in the household use cigarettes, cigar, and pipe tobacco?] does not specify whether the child or someone else in the household including parent/guardian was a smoker; results may alter if the smoker in the household was the child him/herself. Also, some bias is expected due to the cross-sectional nature of the study. For example, the survey fails to capture whether the ADHD, DEP, and ANX diagnosis were concurrent or at different time points in the lifetime of the child. Due to these and the observational nature of the study design, the association found in our study cannot be interpreted as causation for ADHD. For example, the association observed between ADHD and the factors SPORTS and CLUBS could be due to the fact that ADHD diagnosed children are just not welcomed on a sport/club teams because of their behavioral problems rather than lack of sporting/physical activity being a risk factor for ADHD. That is, some of the associated factors could be consequences of having ADHD.

The results show that the ADHD diagnosed children were most likely from a household having insurance. It is not known how many of the children from the uninsured households may have met the ADHD criteria but were undiagnosed. We performed a sensitivity analysis by analyzing only the insured 5–17 years old. The results were similar as before (Table 4) except for minor changes in significance of few variables: TV and race lost their significance marginally while CLUBS gained significance marginally.

With the inclusion of the medication effect, the significance of the association of ADHD with TV and SPORTS was lost. This suggests that these associations could be due to a behavior related factor that could be monitored. However, the results from the model utilizing medication effect may not be totally reliable due to limitations in the medication variable as collected in the NCSH. First, the survey question does not collect information about past medication use for ADHD because of which a child who was diagnosed with ADHD in the past and hence took medication in the past would be categorized into the ADHD-NCM group. While this group is supposed to include only those children who satisfy the conditions of having ADHD and not taking medication for ADHD concurrently. This limitation is similar in essence to the one elucidated earlier due to the cross-sectional nature of the survey. Secondly, the unweighted sample sizes for ADHD-NCM (1,690) and ADHD-CM (3,735) groups do not add up to the total number of ADHD-diagnosed children (7,137 from Table 1) due to missing values for the medication use question. Although our bivariate analysis showed obesity to be significantly associated with ADHD, this was not the case in the multivariate analysis irrespective of whether medication use was considered, contrary to some previous studies [18,21,22,24]. Following Waring and Lapane [24], who had analyzed the NCSH 2003 data, we fitted a model using the same data and with the following subset of variables: sex, race, DEP, ANX, POVERTY, age, and BMI, and the dependent variable as the trichotomized ADHD with medication classification, and indeed found obesity to be significantly associated in this model. However, with the addition of even one or two of the remaining variables, the significance of this association was lost. Thus, our study shows that obesity per se may not have a direct association with ADHD and hence sheds a new light on this research topic.

Conclusions

ADHD diagnosis and management has been an important feature of child healthcare over the past few decades. Our study uncovered some new factors associated with ADHD at a national level such as TV, SPORTS, SMOKE, and INS after accounting for many other factors. Our findings suggest that children with ADHD are to be monitored for the above factors in addition to the other
known factors. This may help pediatricians diagnose and manage ADHD. Further, after accounting for the ADHD related factors, obesity was not found to be significant, contrary to some previous studies. Future research should be directed towards a longitudinal study designed to examine the association between pharmacological factors, ADHD, and related factors in a concurrent manner.

Abbreviations

ADD: Attention Deficit Disorder; ADHD: Attention Deficit/Hyperactivity Disorder; ADHD-CM: Attention Deficit/Hyperactivity Disorder and currently taking medication; ADHD-NCM: Attention Deficit/Hyperactivity Disorder and not currently taking medication; ANX: Anxiety; BMI: Body Mass Index; CI: Confidence Interval; CLUBS: Participation in Clubs; COMP: Computer usage; DEP: Depression; DHHS: Department of Health and Human Services; DSM: Diagnostic and Statistical Manual of Mental Disorders; EDUC: Education; FAMILY: Family structure; HMOs: Health Maintenance Organizations; INS: Healthcare coverage; POVERTY: Poverty Level; IQR: Inter-Quartile Range; NSCH: National Survey of Children’s Health; OR: Odds Ratio; POVERTY: Department of Health and Human Services Poverty guideline; S.C: Selected Child; SE: Standard Error; SES: Socio-Economic Status; SMOKE: Family member’s smoking status; SPORTS: Participation in Sports; TV: Watching TV/playing video games.

Competing interests

None of the authors have any conflict of interest.

Authors’ contributions

Ravi K. Lingineni reviewed literature, carried out all data analyses, and drafted the manuscript. Swati Biwas supervised Ravi Lingineni in data analysis, interpretation, and critical re-drafting of the manuscript. Naveed Ahmad helped in the conception and design of the study and revision of the manuscript. Bradford E. Jackson helped in data analysis and drafting of the manuscript. Sejong Baeg supervised Ravi Lingineni in analysis using complex survey procedures in SAS and revision of the manuscript. Karan P. Singh supervised the whole group, helped in the conception and design of the study, and revision of the manuscript. All authors have approved the final version of the manuscript.

Financial disclosure

The authors do not have any financial interests related to this study.

Acknowledgements

We are thankful to the two reviewers for constructive comments and suggestions, which led to improvement and clearer presentation of the manuscript.

Author details

1Department of Biostatistics, School of Public Health, University of North Texas Health Science Center, Fort Worth, TX, USA. 2Department of Mathematics, University of Texas at Dallas, Richardson, TX, USA. 3Department of Pediatrics, University of Mississippi Medical Center, Jackson, MS, USA. 4Division of Preventive Medicine, Department of Medicine, University of Alabama at Birmingham, Birmingham, AL, USA. 5Department of Biostatistics, School of Public Health, University of North Texas Health Science Center, 3500 Camp Bowie Blvd, Fort Worth, TX 76107, USA.

Received: 29 November 2011 Accepted: 17 April 2012 Published: 14 May 2012

References

1. Pliska S: Practice parameter for the assessment and treatment of children and adolescents with attention-deficit/hyperactivity disorder. J Am Acad Child Adolesc Psychiatry 2007 July; 46(7):894–921.
2. Prince JB, Spencer TJ, Wilen TE, Biederman J Jr: Stern TA, Rosenbaum JF, Fava M, Biederman J, Rauch SL eds. Massachusetts General Hospital Comprehensive Clinical Psychiatry. In Pharmacotherapy of attention-deficit/hyperactivity disorder across the life span, Volume 1st ed. Philadelphia, PA: Mosby Elsevier, 2008 chap 49.
3. American Psychiatric Association (Ed): Diagnostic and Statistical Manual of mental disorders. 4th edition. Washington, DC: American Psychiatric Association; 2000.
4. Curtis C, Bandini LG, Perrin EC, Tybor DJ, Must A: Prevalence of overweight in children and adolescents with attention deficit hyperactivity disorder and autism spectrum disorders: a chart review. BMC Pediatr 2005; 5:48.
5. Faraone SV, Biederman J, Spencer T, et al: Attention-deficit/hyperactivity disorder in adults: an overview. Biol Psychiatry 2000, 48(5):20.
6. Seaigh HR, Burke JM, Rottenk F: Adult ADHD: evaluation and treatment in family medicine. Am Fam Physician 2000, 62:2077–2086.
7. Biederman J, Faraone SV: Attention-deficit/hyperactivity disorder. Lancet 2005, 366(9481):237–248.
8. Biederman J: Attention-deficit/hyperactivity disorder: a selective overview. Biol Psychiatry 2005, 57(11):1215–1220.
9. Nolan EE, Gadov KD, Sparfink J: Teacher reports of DSM-IV ADHD, ODD and CD symptoms in schoolchildren. J Am Acad Child Adolesc Psychiatry 2001, 40:241–249.
10. Stattmann P: The epidemiology of attention-deficit hyperactivity disorders. Child Adolesc Psychiatr Clin N Am 1992, 1(2):261–271.
11. CDC: Mental Health in the United States: Increasing prevalence of parent-reported attention deficit/hyperactivity disorder–United States, 2003–2007. MMWR 2010, 59(44):1439–1443.
12. CDC: Mental Health in the United States: Prevalence of Diagnosis and medication treatment for attention-deficit/hyperactivity disorder–United States, 2003–2005. MMWR 2005, 54:842–847.
13. Skounts M, Philibithis A, Galanakis E: Variations in prevalence of attention-deficit/hyperactivity disorder worldwide. Eur J Pediatr 2007, 166(2):117–123, 1211–1221.
14. Boyle CA, et al: Trends in the Prevalence of Developmental Disabilities in US Children, 1997–2008. Pediatrics 2011, 127:1034–1042.
15. Noble EP: The DRO2 gene in psychiatric and neurological disorders and its phenotypes. Pharmacogenomics 2000, 1:309–333.
16. Poston WS 2nd, Ericsson M, Linder J, et al: D4 dopamine receptor gene exons III polymorphism and obesity risk. Eat Weight Disord 1998, 3(1):77–87.
17. Freeman-Foibbs P: Feeding our children to death: The tragedy of childhood overweight in America. J Nat Med Assoc 2003, 95(2):119.
18. Bazar KA, Yun AJ, Lee PP, et al: Obesity and ADHD may represent different manifestations of a common environmental oversampling syndrome: a model for revealing mechanistic overlap among cognitive, metabolic, and inflammatory disorders. Med Hypotheses 2005, 66(2):263–269.
19. Stevens J, Harman JS, Kelleher KJ: Race/Ethnicity and insurance status as factors associated with ADHD treatment patterns. J Child Adolesc Psychopharmacol 2005, 15(1):88–96.
20. Must A, Strauss RS: Risks and consequences of childhood and adolescent obesity. Int J Obes Relat Metab Disord 1999, 23(Suppl 2):S25–S31.
21. Agranat-Meged AN, Deitcher C, Goldzweig G, et al: Childhood obesity and attention deficit/hyperactivity disorder: A newly described co-morbidity in obese hospitalized children. Int J Eat Disord 2005, 37(4):357–359.
22. Contese S, Angisman M, Maffies C, et al: Attention-deficit/hyperactivity disorder (ADHD) and obesity: a systematic review of the literature. Crit Rev Food Sci Nutr 2008, 48:524–553.
23. Visser SN, Lesene CA, Perou C: National estimates and factors associated with medication treatment for childhood Attention-deficit/hyperactivity disorder. Pediatrics 2007, 119:599–5106.
24. Waring ME, Lapane KL: Overweight in children and adolescents in relation to attention-deficit/hyperactivity disorder: Results from a national sample. Pediatrics 2008, 122:661–66.
25. Bramlett MD, Bumber S: Family structure and children’s physical and mental health. Heal Aff 2007, 26(2):549–555.
26. Kollins SH, McClemore FJ, Fuermetter BF: Association between smoking and attention-deficit/hyperactivity disorder symptoms in a population-based sample of young adults. Arch Gen Psychiatry 2005, 62:1142–1147.
27. Milberger S, et al: ADHD is associated with early initiation of cigarette smoking in children and adolescents. J Am Acad Child Adolesc Psychiatry 1997, 36:317–34.
28. Tseng MH, Henderson A, Chou SMK, Yao GI: Relationship between motor proficiency, attention, impulse, and activity in children with ADHD. Dev Med Child Neurol 2004, 46(6):381–388.
29. Chan PA, Rabinowitz T: A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. Ann Gen Psychiatry 2006, 5:16.
30. Kiluk B: Sport participation and anxiety in children with ADHD. J Atten Disord 2009, 12:6:499–506.

31. Galarca C, Côté SM, Bouvard MP, Pingault JB, Mekhior M, Michel G, Boivin M, Tremblay RE: Early factors for hyperactivity-impulsivity and inattention trajectories from age 17 months to 8 years. Arch Gen Psychiatry 2011, 68(12):1267–1275.

32. Langley K, Rice F, van den Bree MB, Thapar A: Maternal smoking during pregnancy as an environmental factor for attention deficit hyperactivity disorder behaviour: A review. Minerva Pediatr 2005, 57(6):359–371.

33. Blumberg SJ, Foster EB, Frasier AM, et al: Design and Operation of the National Survey of Children’s Health, National Center for Health Statistics, Volume Forthcoming, Vital Health Stat 1st edition, 2007.

34. National Survey of Children’s Health. [http://www.cdc.gov/nchs/slaits/nsch.htm].

35. Applegate B, et al: Validity of the age-of-onset criterion for ADHD: A report from the DSM-IV field trials. J Am Acad Child Adolesc Psychiatry 1997, 36:9.

36. Cortese S, Penalver CM: Comorbidity between ADHD and Obesity: Exploring shared mechanisms and clinical implications. Postgrad Med 2010, 122(5):88–96.

37. An AB, et al: Performing logistic regression on survey data with the new Survey logistic procedure. SUGI 2002, 258:27.

38. SAS/STAT 9.2 user’s guide: The Surveylogistic procedure. [http://support.sas.com/documentation/cdl/en/statugsurveylogistic/61836/pdfs/statugsurveylogistic.pdf].

39. Berglund PA: Getting the most out of the SAS Survey procedures: Repeated replication methods, subpopulation analysis and missing data options in SAS V9.2. SAS Global Forum 2009, 246.

Cite this article as: Lingineni et al: Factors associated with attention deficit/hyperactivity disorder among US children: Results from a national survey. BMC Pediatrics 2012 12:50.