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Amrita Kumar Date

SCREEN TIME USE AMONG CHILDREN AGED 6 TO 17 YEARS WITH ATTENTION DEFICIT/HYPERACTIVITY DISORDER: RESULTS FROM THE 2016 NATIONAL SURVEY OF CHILDREN'S HEALTH

BY

Amrita Kumar, PhD
Degree to be awarded: M.P.H.
Executive MPH

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Abstract

SCREEN TIME USE AMONG CHILDREN AGED 6 TO 17 YEARS WITH ATTENTION DEFICIT/HYPERACTIVITY DISORDER: RESULTS FROM THE 2016 NATIONAL SURVEY OF CHILDREN'S HEALTH

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Amrita Kumar

Background
Children are engaging in longer duration of screen time use which includes activities done in front of a smartphone, television, computers, tablet, or game console. Screen time use can affect the health of children both positively and negatively. Research on screen time use in children with attention deficit/hyperactivity disorder (ADD/ADHD) in the United States (US) is limited and conflicting. Our objective was to examine if ADD/ADHD was associated with screen time use in children.

Methods
We utilized data from the 2016 National Survey of Children's Health (NSCH), a national, population-based, cross-sectional study that assesses the physical and emotional health of US children. We examined children aged 6-17 years. Average duration of time the child spent on a weekday watching television/video programs, or playing video games was used as an indicator of daily screen time use, examined as a dichotomous variable (≤ 1 hour vs. > 1 hours). ADD/ADHD was determined by parent/guardian reporting. Multivariable regression models were used to examine the association between screen time use and parent/guardian-reported diagnosis of ADD/ADHD, adjusting for potential confounders. Unadjusted and adjusted prevalence odds ratios (uPOR and aPOR), 95% confidence intervals (CI) were estimated to quantify the association.

Results
The analytical sample was comprised of 34,564 children of which 4,085 (12%) were reported to currently have ADD/ADHD. Children with screen time use > 1 hours were likely to be males, non-Hispanic black, obese, from low income families with parent/guardians with less than high school education. After controlling for sex, race, age, body mass index, education of adult, poverty level, type of health insurance, hours of sleep-time, physical activity, and family structure, children with ADD/ADHD were more likely to engage in screen time use > 1 hours per weekday (aPOR=1.35, 95% CI=1.14-1.60) compared to their counterparts.

Conclusions
Our findings from a large, nationally representative sample of children in the United States suggests that the total of screen time use per weekday differs significantly by ADD/ADHD status. Further research is needed to explore this association with a better understanding of duration, better assessment of ADD/ADHD diagnosis along with treatment status, and other co-variables.

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Chapter I: INTRODUCTION

Attention deficit/hyperactivity disorder (ADD/ADHD) is a growing public health concern worldwide that affects children and persists through adulthood in 30-50% of the affected children (1, 2). In the United States (US), according to the 2016 National Survey of Children's Health (NSCH), an estimated 6.1 million children between the ages of 2 to 17 years, representing 11% of the target population, were reported by their parents or guardians as having ADD/ADHD (3). According to the same survey, almost two-thirds (62%) of those reported to have ADD/ADHD were taking medication and almost half (47%) received behavioral treatment for the condition (3). ADD/ADHD is a growing concern in the US because affected children exhibit chronic symptoms of inattention, impulsivity, and/or hyperactivity in multiple settings that results in negative outcomes such as lower academic performance, impaired social functioning, increased use of substance abuse, and reduced participation in workforce compared to their non-symptomatic peers (4-9). Therefore, there is an urgent need to develop a better understanding of the genetic, environmental, and lifestyle factors that can impact the healthy behavior of this vulnerable population of children.

With the recent advances, accessibility, and explosion of online programs and games, children of all ages are spending more time using different screen-based technologies such as smartphone, television, computers, tablet, or video games (10). According to statistics provided by Common Sense Media Use Census, children between the ages of 8 to 10 years old spend an average of 6 hours per day, children between the ages of 11-14 years old spend an average of 9 hours per day, and children between the ages of 15-18 spend an average of 7.5 hours per day in front of electronic screens

(including television, smart phones, computers, and tablet) playing video games, streaming videos, and so forth (11-14). This increased duration of screen time use is resulting in negative health outcomes in children of all ages globally (13-16). For example, increased screen time use is associated with increased sleep problems, obesity, cardiovascular diseases, and depressive conditions (17, 18). More importantly, in a longitudinal cohort study consisting of 4,100 eligible high school students in the US, increased use of screen-based technology was shown to be associated with increased inattention and hyperactive-impulsive symptoms commonly associated with ADD/ADHD in children (19).

Understanding screen time use particularly among children who also have neurodevelopmental disorders, such as ADD/ADHD, is gaining prominence. The information is of importance for both for families and physicians in improving health outcomes. There are few studies on screen time use of children with ADD/ADHD published in the US and elsewhere, however, these are based on small samples and are not population-representative. The change in technology is very fast-paced and understanding changing screen time use in recent times is of significance in developing evidence-based screen time use guidelines, and relevant health messages, for children with ADD/ADHD. In this thesis, we examined the screen time use using latest data from the 2016 National Survey of Children's Health, and its association with ADD/ADHD, among children aged 6 to 17 years old in the US.

Chapter II. REVIEW OF LITERATURE

Children and screen time use

Screen time use is a term used for activities done in front of a smartphones, televisions, computers, tablet, or game console. Today's children are growing up surrounded by screen-based technology. Studies report that with increased accessibility and explosion of technologies, children are beginning to interact with screen-based media as early as a few months of age (17, 20-22). American Association of Pediatrics (AAP) reports that the average daily television (TV) time of children aged 8 years or older remains over 2 hours per day (17). The overall media use among children 8 years and older has continued to increase over the last two decades, aided by the explosion of accessibility to smart phones, tablet, computers, and other screen-based technologies (11, 12). More than three quarters of teenagers have cell phones, and teens ages 13 to 17 send an average of 3,364 texts per month, and the average daily time they spend watching television remains over 2 hours per day (23). In a cross-sectional study including 350 children between the ages of 6 months to 4 years in the United States (US), Kabali et al (2015) report that most households had television (97%), tablets (83%), and smartphones (77%), and by age 2, most children used a device daily and spent comparable screen time on television and mobile devices and by age 4, half the children had their own television and three-fourths their own mobile device and had universal exposure to mobile devices (10).

With the growing accessibility of screen-based technologies there are numerous studies that have examined the impact of technology, both beneficial and harmful, on the emotional, physical, and mental well-being of children (18, 24). There are several

benefits from exposure to screen time media which includes exposure to new ideas and information, raising awareness of current events and issues, opportunities for learning, promotion of community participation (17). However, excessive exposure to screen time is associated with unfavorable lifestyle habits and low levels of physical activity, unhealthy eating habits and obesity, sleep problems, and low vision (17, 18). Johnson et al. (2004) conducted a longitudinal investigation and examined the television viewing and sleep problems in children with average ages of 14, 16, or 22 years, and reported that children who watched 3 or more hours of television per day were at a significantly elevated risk for frequent sleep problems (25). Likewise in a more recent study Bruni et. al. (2015), conducted a study with a sample of 850 children with a mean age of 13.5 years, and reported that electronic devices in bedroom negatively impacted the sleep quality in children (26). Spending more hours with screen technologies is associated with sedentary behavior and low levels of physical activity (27). Studies show that low levels of physical activity contribute to weight gain and increased risk for obesity among children and adolescents and this leads to increased risk for associated chronic diseases, including diabetes, cardiovascular disease, and cancer. Watching TV for more than 2 hours daily has been linked with elevated blood pressure, elevated serum cholesterol, and being overweight or obese amongst youth (28, 29). Results from the work of Hermati et al., (2018) showed that children living in Probolinggo, Indonesia, with Autism spectrum disorder who spent viewing ≥ 3 hours per day demonstrated language delay, short attention span, and hyperactivity (22).

Screen time recommendations for children

Based on these observed negative effects of excessive screen time use in children, the AAP and Healthy People 2020 has put forth guidelines to encourage parents to help develop healthy media habits (17). In 2016, AAP introduced new screen time media guidelines for parents that recommends that screen media (other than video-chatting) should be discouraged in children younger than 18 months, children 18 to 24 months should be allowed to allowed to watch high-quality programming/apps with parents, whereas children between the ages of 2-5 years old should be limited to use screen time to 1 hour per day of high quality programs (30). For children ages 6 and older, there should be consistent limits on the time and types of media to ensure that the media does not take the place of adequate sleep, physical activity, and other behaviors essential to health (30).

Factors associated with screen time use

The literature provides evidence that many characteristics are associated with screen time use of children. Using the 2011-2012 National Survey of Children's Health (NSCH), Montes et al. (2016) reported that the average daily media usage of children aged 6-17 years in the US is associated with age, race, gender, education of the parents, and poverty level of the household (31). Screen time use is also positively associated with being a non-Hispanic black male in an NNHANES study sample included children between the ages of 8 to 16 years old in the United States (15). A survey examining 2221 low-income preschool-aged children with a mean age of 4.4 years in the United States in the Head Start Family and Child Experiences Survey (FACES) in spring 2007, showed that the children's reported time spent each weekday engaged in screen viewing at home

and school was dependent on the income of the household, age, race, gender, body mass index (BMI), education of mother, family structure, and household size (5). In a multi-national, cross-sectional study including 6,128 children 9-11 years of age, screen time usage varied as a function of physical activity and sleep period time (32, 33). These studies among others allowed us to select covariates for further analysis.

Attention deficit/hyperactivity disorder

ADD/ADHD is one of the most common early-onset neurobehavioral disorders, occurring in 9.4% of children between the ages of 2-17 in the United States (3). It is a medical condition in children that is described by the inability of the child to be focused and/or remain in attentive. The disorder has considerable consequences on the academic, social interactions, and well-being of the children (2). A child experiencing behavioral or academic problems as observed by parents, teachers, and other adults who care for the child in different setting is assessed for ADHD. While there is no single test to diagnose ADD/ADHD, healthcare professionals use the guidelines defined by the American Psychiatric Association's diagnostic and statistical manual (34). ADHD has been associated with risky behavior, poor relations, and lower levels of education amongst children (5, 7-9). ADHD children are also at a greater risk for substance-related disorders, as well as other addictive disorders, and they tend to exhibit worse treatment outcomes compared to individuals without ADHD, accompanying problems associated with substance use or addiction (34, 35).

The etiology of ADD/ADHD is complex, with both genetic and environmental factors implicated in the disorder (36). Genetic studies in twins estimate that the average hereditability of the disease is 70%- 80% (37). It is also reported that risk is increased

two to eight times in children of parents with ADD/ADHD (38). Genetic research studies implicate dopaminergic, serotoninergic, glutamatergic signaling, cell adhesion pathways genes as having an association with ADHD (reviewed in (39, 40)). In addition to genetic factors, there are several nutritional and environmental factors that have been linked with ADD/ADHD. The environmental risk factors include heavy metal and chemical exposures such as lead, mercury, organochlorine, organophosphates, and phthalates, as well as nutritional and lifestyle/psychosocial factors (41). Low levels of copper, iron, zinc, magnesium, and omega-3 fatty acids have been reported in children with ADD/ADHD and sugar, artificial food colorants, and preservatives are associated with an increased risk of ADD/ADHD (42, 43). Comorbidity of ADD/ADHD has been reported with other diseases such as obesity and several psychiatric disorders such as depression, autism, and bipolar (44-46). From a behavioral perspective, ADD/ADHD is individually associated with lifestyle related behaviors such as screen time use, eating behaviors, and physical activity (47).

ADD/ADHD and screen time

Special care must be given to those with ADD/ADHD in the new media environment. Studies suggest that increased screen time is associated with melanopsin-expressing neurons and decreasing gamma-aminobutyric acid (GABA) neurotransmitter, and thus results aberrant behavior, decreased cognitive, and language development (22). There is some concern that contemporary societal factors, notably the tendency for young children to spend greater amounts of time on electronic devices such as television, tablets and smart phones, may be a perpetuating factor in ADHD. A longitudinal cohort study of Los Angeles, California, high school students examined the frequency of digital media

use among 15-16 years old, and reported a higher frequency of digital media use is associated with subsequent symptoms of ADD/ADHD (19, 48). Despite this discussion that television habits often are given in discussions about ADD/ADHD, very little research exists that has actually examined the television use in children of this population.

An early study conducted in 1994 by Milich and Lorch (1994) asked parents to complete a 5-day television viewing behavior for 20 boys between the ages of 7-12 years, with and without ADHD in the United States (US). Their analysis revealed no significant differences in the amount of time spent watching television between boys who had ADD/ADHD and who did not have ADD/ADHD. In another study that included 77 children with confirmed diagnosis of ADD/ADHD and 11 non-referred children between 4 to 9 years age in the US, it was reported that children with ADD/ADHD were watching more television, however, this difference was non-significant when demographic characteristics were included in the analysis (49). To study the association between lifestyle behavior in children with ADD/ADHD, Holton and Nigg (2016) designed a questionnaire that queried the parents of 184 children aged 7 to 11 years old with ADD/ADHD about their water intake, sweetened beverage intake, supplement use, reading, screen time, physical activity, and sleep. Analysis of the survey showed that children with ADD/ADHD were more likely to watch ≥ 2 hours of screen time per day (50). Besides the above described studies, there are no other studies that examined the screen time behavior in children with and without ADD/ADHD in the US. While the above mentioned study examined the screen time behavior of children who had ADD/ADHD, one study conducted with children from China has also examined screen

time behavior of children who have ADHD. In this cross-sectional study done with 785 children aged 9-13 years old in China, Tong et. al (2016) report that boys with ADD/ADHD symptoms were more likely to use a computer, watch television on weekdays, and use smart phones, compared to girls. However, the association was insignificant when the model was adjusted for gender, age, education level of parents, age of parents, and annual household income (51).

In the current study, we sought to utilize recent data from the 2016 NSCH to examine the screen time use (as measured by the time spent watching TV/video or playing video games) of children who have ADD/ADHD compared to children who do have ADD/ADHD to extend previous studies that examined the association of screen time use in children. This study is important for several reasons. Firstly, children in today's world are growing up in an increasingly digital world, and their use of technology has an impact on their biological, psychological, and social development. Secondly, children with ADD/ADHD may be at even more risk than their peers because excessive technology has been shown to exacerbate symptoms also associated with ADD/ADHD such as loss of focus, inattentive, and hyperactivity. Thirdly, studies published examining the association between duration of time spend engaging with screen-based technology in children with ADD/ADDH were based on small samples and reported mixed results in children both in the US and China. The NSCH 2016 dataset was released in March 2018, so the study is timely and uses the latest publically deposited dataset that examined the wellbeing of a children between the ages of 0 to 17 years old living in the US.

Chapter III. METHODS

National survey of children's health

We used data from the 2016 NSCH (N=50,212). This survey was implemented between June 2016 and February 2017 by the US Census Bureau, Associate Director for Demographic Programs on behalf of the US Department of Health and Human Services. The US Census Bureau oversaw the 2016 NSCH's sampling plan and administration by mail and online.

NSCH used a multi-stage sampling design to obtain a nationally representative sample of the young population aged 0-17 years old residing in private households. Details about the survey design, methodology and can be obtained from the Data resource center (DRC) or Child and Adolescent health (http://childhealthdata.org/learn/NSCH). Briefly, 364,150 household addresses selected from the Census Master Address File (MAF) received a mailed invitation asking an adult in the household who is familiar with the child's health and health care (usually a parent) to go online to complete the survey online or via mail.

For the 2016 NSCH detailed topical questionnaires, 63% of respondents were mothers (biological, step, foster, or adoptive), 30% were fathers (biological, step, foster, or adoptive), and 7% were other relatives or guardians. Of the 50,212 completed detailed topical questionnaires, 40,493 (80.6%) were completed using the web instrument and 9,719 (19.4%) were completed using the paper instrument. The collected data was cleaned, labelled and publically available upon request from the website (www.nschdata.org).

Study population

The study population for the current study was derived from the 2016 NSCH. The 2016 dataset included a total of 50,212 children from the ages of 0-17 years old for whom responses were given by parents or their guardians. Of these, children who belonged to age groups 6 to 17 years old (N=35,718) were carried for further analysis (Figure 1). Values that were missing for either TV/Video screen time use (N=388), or current status of ADD/ADHD (N=393) were excluded from the analysis. Also, excluded from the analysis were children who were ever told they had ADD/ADDHD but did not currently have the condition (N=373). This resulted in selecting an overall analytic sample consisting of N=34,564 children between the ages of 6 to 17 years old,

Study variables

Screen time use (Dependent variable): This variable was derived from the survey questionnaire that asked the parent/guardian of the child to report the time the child spent watching TV/Video or playing Video games on an average weekday. The survey question asked for this variable is shown in Appendix 1, Table A. For the purpose of the current study, the hours the subject child spent watching TV/video or playing video games per weekday were dichotomized into two categories (≤ 1 hour vs. > 1 hours) (Figure 1).

ADD/ADHD (Independent variable): The independent variable for this analysis was derived from responses to two questions asked in the survey as shown in Appendix, Table A). Children who currently have or do not have ADD/ADHD as indicated by their parent or guardian were included in the analysis. Children whose parents or guardian answered, “Ever told, but do not currently have condition,” were excluded from the

analysis (Figure 1). All information about children's health conditions is based on parent/guardian reporting and is not independently verified.

Covariates: Based on the literature review, we evaluated a number of covariates as potential confounders (50-52). The survey questions for these covariates are included in the Appendix Table A. These covariates included sex (Male / Female), race and ethnicity of child (Hispanic / White, Non-Hispanic / Black, non-Hispanic / Multi-racial/Other / Non-Hispanic; body weight based on body mass index (Underweight - Less than the 5th percentile / Healthy weight - 5th percentile to less than the 85th percentile / Overweight - 85th to less than the 95th percentile / Obese - Equal to or greater than the 95th percentile); highest level of education among reported adults (Less than high school / High school degree or GED / Some college or technical school / College degree or higher); income level of the child's household (0-99%FPL / 100%-199% FPL / 200%-399% FPL / 400% FPL or above); type of health insurance at time of the survey (Public Only / Private Only / Private and public / Insurance type unspecified / Not insured); hours child sleeps on an average weeknight (Child sleeps recommended age-appropriate hours / Child sleeps less than recommended age-appropriate hours); exercise, play sport, or physical activity for 60 Minutes/day (0-3 days / 4-6 days); family structure (Two parents, currently married / Two parents, not currently married / Single mother (currently married (living apart), formerly married or never married / Other family type, no parent reported; age of subject child (6 to 11 years old / 12-17 years old); received behavioral treatment for ADD/ADHD (currently have condition and received behavioral treatment / currently have condition but did not receive behavioral treatment / do not currently have

condition); medication for ADD/ADHD (currently have condition and taking medication / currently have condition but not taking medication / do not currently have condition).

Statistical analysis

The Data Resource Center for Child and Adolescent Health (DRC) created the sampling weights and provided the codebooks that included SAS codes used for creating child health indicators (CHI) and NSCH variables (2016 National Survey of Children's Health SAS CODEBOOK FOR DATA USERS: Child and Family Health Measures and Subgroups Version 2.0: April 2018). Samples were weighted as suggested in the SAS code book and essentially consisted of applying the following weights during the analysis: Strata, FIPSST (state of residence) and STRATUM (identifies households with children) variables; Cluster, HHID (unique household identifier) and Weight, FWC. A domain statement was included to restrict the analysis to children belonging to the age group 6-17 years old. Characteristics of children with screen time use ≤ 1 hour and > 1 per weekday were compared using Rao Scott chi test (*P* value significant at 0.05). Associations between co-variables and the exposure or the outcome variables was examined using unadjusted logistic regression. Multivariable regression models were used to examine the association between screen time use per weekday and ADD/ADHD, adjusting for potential confounders. Unadjusted and adjusted prevalence odds ratios (uPOR and aPOR), 95% confidence intervals (CI) were estimated to quantify the association. Interaction was assessed by sex and use of medication/behavioral treatment for ADD/ADHD. Variables that were identified as plausible confounders based on the literature (46-48) or were significantly associated with either variable having

ADD/ADHD or screen time use were included in the *a priori* model. All analyses were done using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Ethical statement

Research projects using secondary data set (NSCH public dataset) are designated as not human subject's research; hence this thesis dataset use was exempted from the Institutional Review Board approval at Emory University.

Chapter IV: RESULTS

The 2016 NSCH surveyed 50,212 children between the ages of 0-17 years old of whom 35,718 in the target age range of 6-17 years were eligible for our analysis. From these 35,718 children we excluded children with missing information on the dependent and independent variables were excluded (ADD/ADHD, N=393; screen time use, N= 388). Additionally, we excluded children who were "Ever told, but do not currently have ADD/ADHD" (N=373). Our final analysis included 34,564 children surveyed (Figure 1).

We used the "hours per weekday the child usually spends in front of a TV watching TV programs, videos, or playing video games" as an indicator of screen time use in children. Of the 34,564 children examined, 16,931 (45%) had screen time use ≤ 1 hour per weekday, and 17,633 (54%) had a screen time use > 1 hours per weekday (Table 1). As shown in Table 1, there were significant differences in all the characteristics of children who reported screen time use ≤ 1 hour vs. > 1 hours per weekday. Children with screen time use > 1 hours per weekday were more likely to be males (54%), white non-Hispanic (46%) or Hispanic (29%), in the older age group of 12-17 years (52%), with higher BMI being obese (18%) or overweight (17%). The family structure of children who engaged in > 1 hours of screen time use was also statistically different from children with screen time use ≤ 1 hours per weekday. Children who engaged in screen time use for ≤ 1 hour per weekday had proportionally more adults with college degree or higher education in the household (57% adults with college degree or higher), lived in household with two parents who were currently married (72%), and were at 400% FPL or above (36%). Children who engaged in screen time use > 1 hours per weekday had 39% of adults with college degree or higher, 60% of the children had a family structure of two

parents currently married and 11% percent of these children lived in other family type or no parents reported. Uninsured children (7%) were more likely to watch television for > 1 hours per weekday, while 5% of the not insured children were watching television ≤ 1 hour per weekday. Children with screen time use for >1 hours per weekday were also less likely to engage in physical activity for 4-7 days. Within the group of children who had ADD/ADHD, 8% of the children who were taking medication for ADD/ADHD had screen time use > 1 hour per weekday compared to 4% of children who had ADD/ADHD but did not take medication. More importantly, more percent of children (8%) who had ADD/ADHD and were taking medication for ADD/ADHD were engaging in screen time for > 1 hours per weekday compared to 4% of children who had ADD/ADHD and were not taking medication. Finally, 12% of children who had screen time use >1 hours per weekday were ADD/ADHD.

We also summarized the characteristics by ADD/ADHD classification and report the corresponding *P* values in Table 2. All factors were statistically significant at the 0.05 level. In particular, children in the ADD/ADHD and No ADD/ADHD groups differ strikingly in many characteristics, where children with ADD/ADHD were 70% males and 30% females, were non-Hispanic White (61%), and belonged to the older age group 12 to 17 years (53%). There were more children in the No ADD/ADHD category who were getting recommended age appropriate hours of sleep (67%), engaging in more physical activity 4-7 days of the week (53%), lived in household with two parents who were married (67%) and lived in household where the highest education of the adult was college degree or higher (47%). With children who had ADD/ADHD, 51% lived in household with two parents who were married and 43% lived in household in which one

adult had a college degree of higher. Finally, there were 64% of the children who had ADD/ADHD and were on medication for ADD/ADHD compared to 35% who had ADD/ADHD but were not taking medication for ADD/ADHD. Also, amongst children who had ADD/ADHD, 46% received behavioral treatment, and 54% were not receiving behavioral treatment for ADD/ADHD.

Association between screen time use and ADD/ADHD

Table 3 shows results from unadjusted and adjusted logistic regression analysis. We found a significant relationship between screen time use and having ADD/ADHD in both unadjusted and adjusted analyses. Children who were reported to have ADD/ADHD had 1.5 increased odds of screen time use > 1 hours per weekday as compared to children who did not have ADD/ADHD [uPOR=1.47; 95% CI=1.30-1.68] without controlling for co-factors.

We tested for interaction of the association by sex and whether or not the child was receiving behavioral or medical treatment for ADD/ADHD and found no significant interactions. Results from the multivariate analysis showed that children with ADD/ADHD between the ages of 6 to 17 years old had 1.35 odds of screen time use for > 1 hours per weekday [aPOR=1.35; 95% CI=1.14-1.60], controlling for sex, race and ethnicity, age, weight, hours of sleep, physical activity, family structure, family income, and medical insurance status (Table 3).

Chapter V. DISCUSSION

In this study, using a large population-based nationally representative sample of children aged 6 to 17 years old in the US, we found a significant association between screen time use per weekday and ADD/ADHD. This is the first study that uses the 2016 NSCH data to examine the association of screen time use with ADD/ADHD in children. Our analysis shows that children with ADD/ADHD between the ages of 6 and 17 years old are 1.35 times more likely to have screen use > 1 hours per weekday than children who do not have ADD/ADHD after adjusting for potential confounders.

There are very few studies that have examined the screen time use of children with ADD/ADHD in a large population-based study sample in the past. Acevedo-Polakovich et al. (2007) examined 77 children in the US with a confirmed diagnosis of ADD/ADHD and 111 non symptomatic children between the ages of 4- 9 years old, and reported that children of the symptomatic group were spending more hours in front of the television than children of the asymptomatic group, however, when the association was adjusted to include covariables, age and interactions of age with disease condition, the relationship was attenuated (53). There are several differences between our study and the study described by Acevedo-Polakovich et al. (2007) (53). Firstly, their study design included fewer children than were included in our study, but the former study had confirmed ADD/ADHD diagnosis. Secondly, the television screen time variable included the viewing time on weekends, unlike in our study that only included viewing time on weekday. Thirdly, their study was conducted in 2007, and, during the past 10 years, technology has developed rapidly and accessibility to screen products have become more

widespread. Finally, the study included children between the ages of 4 and 9 years old, unlike our study which included children between the ages of 6 to 17 years old.

Tong et al. (2016) examined screen time use in Chinese children between the ages of 9 to 13 years and found no statistical difference between the screen time behavior of children with or without ADHD (51), which is in contrast to our study findings. A likely explanation for the difference with our observed study could be due to the longitudinal design of the study that included the screen time use categorized into four groups- time spent using computer per day on school days for ≤ 30 mins / 30-60 mins / 2-3 hours / and ≥3 hours. For our study, we dichotomized the time spent watching television or playing video games and compared ≤ 1 hour vs. > 1 hours. Further, in their study the marker for screen time use was time spent using computer per day on school days, while in our study the parents reported the time the child was spending watching television, video, or playing video games. While, both activities are based on using screen-based technologies, there could be differences in way the children use these screen based technology. Television and playing video games could be considered to be more addictive behavior, whereas the subject child may be concentrating on doing homework on the computer. The survey question asked by NSCH did not allow us to differentiate in the type of activity the subject child was engaging in during the hours he/she spend in front of the screen. Finally, the contrast between our observations and that of the Chinese children could be attributed to race and/or accessibility to technology to children as it is suggested that Chinese parents in contrast to American parents limit the time children can watch television or play video games (54).

While our studies cannot be directly compared due to differences in study designs, our results are somewhat similar to another published study that examined lifestyle behavior in symptomatic ADD/ADHD children compared to non-symptomatic children. Holton and Nigg (2016) analyzed a cohort of 184 children aged 7 to 11 years in the US classified as having ADD/ADHD, and found that children with ADD/ADHD were almost twice as likely to report unhealthy behaviors (one of which included hours the child has spent on screen time to watch movies, video games, etc.) after adjusting for age, sex, ADHD medication use, household income, and four comorbid psychiatric disorders (ORs; 95% CI) (1.95, (1.16-3.30), p =0.01) (50). The association between ADD/ADHD and screen time use in this study includes other behavior such as water intake, sweetened beverage intake, supplement use, reading, physical activity and sleep (50). In conclusion, given that our study has a much larger sample size for children with ADD/ADHD than the other published studies on the same topic, the main conclusion of the study is that children residing the US and between the ages of 6-17 years old with ADD/ADHD are likely to engage in longer durations of watching television and playing video games than children who do not have ADD/ADHD.

The present study also corroborated that standard social determinants for screen time use such as age, gender, race and ethnicity, poverty level, physical activity, living with adults who have less education was correlated to higher hours of time spent watching TV/video or playing video games (50, 51). The characteristics of children engaging in more hours of watching television or playing video games are similar to that observed in National Health and Nutrition Examination Survey (NHANES) 2012 dataset (51). In both studies the highest level of watching television was observed among

children of male sex, of non-Hispanic white race/ethnicity, and in the oldest age category (14-17 years in this study). In addition to the characteristics considered in the study of data from the NHANES, we also assessed the percentage of children watching > 1 hours of television per weekday by highest level of education of parent, household income, poverty, family structure, and insurance of the child.

There are several strengths to our study. We used a population-based sample of over 30,000 children to examine the association between screen time use and ADD/ADHD. The study uses current data from the NSCH. The weighting of study sample, and standard design and data collection procedures of NSCH add to the study strengths. The wealth of information available from various questions in NSCH allowed us to examine a multitude of co-variables, and adjust for them in the analysis.

This study also has several limitations. Firstly, the NSCH survey requests the parent or the parent of the surveyed child to fill out the questionnaire. An analysis based on parent- or guardian-reported data may be underreporting or over reporting the prevalence of the disease condition, the hours of watching TV, or the covariates used in this study. There can be an under-reporting of ADD/ADHD due to the possible stigma. Contrarily, an over-reporting could occur because there is no single definitive diagnostic test for ADD/ADHD and the symptoms can be confused with normal emotional immaturity by non-clinicians. Secondly, duration of time spent watching television was not available to us as a continuous variable. This limited our potential to investigate the association between numbers of hours of time spent watching television, and ADD/ADHD. Thirdly, we dichotomized the variables of interest in this study, which limits our ability to fully explain the nature of the association of interest. Fourthly, the

NSCH question asked about weekday screen time and does not include screen time use during weekends. This may result in underestimating the child's screen time use. Thus, the association may be more exacerbated than as reported in the study. Finally, because the study is based on cross sectional data, we could only establish a temporal association or determine causality.

As highlighted by our data, children between the ages of 6 to 17 years old who have ADD/ADHD are spending > 1 hours per weekday watching TV/video or playing video games. The survey questionnaire did not allow us to tease out the programs they were watching, for example, was it being used only for recreational activities, like watching videos or playing online games, or also for school-related work. The behavioral and neurological relationship between spending time watching television and having ADD/ADHD is a complex issue, and many experts believe that these children do spend more time playing video games and watching television than their peers. It is not clear if this is bidirectional where symptoms of ADD/ADHD may make spend more time in front of TV more attractive, while, increased duration of spending time in front of electronic screen may exacerbate symptoms of ADD/ADHD (Lissak, 2018). Some studies have found that children who spend more time in front of the screen are more likely to develop attention problems later on (22, 55). Overall, understanding how screen time can influence attention problems and hyperactivity levels during this particular period of life is therefore of importance, especially in the light of the increase of ADD/ADHD diagnosis over the past decades.

In conclusion, our study showed that children who have ADD/ADHD have a screen time use > 1 hours on a weekday compared to children who do not have ADHD.

The study might help health care workers to advise the parents of children with ADD/ADHD on their role for controlling screen time usage. With advances in technology screen time is becoming a central component of daily lives of young children. Excessive screen time is a growing problem in the US especially in children with mental health disorders. Therefore, the results of this study are timely and provide guidelines to the pediatricians, clinicians, and healthcare workers that families with children with ADD/ADHD need additional interventions and recommendations.

Recommendations for future research on the screen time use of children who have ADD/ADHD use may include studying the duration of screen time that includes hours watched on weekend. The present study used only hours of screen time use on weekdays, and this might underestimate the duration of time children spent watching TV/video or playing video games. Since this association appears to be positive across different gender, race and ethnic, and socio-economic groups of children, next steps in the prevention of childhood exposure to excessive screen time use may include policy efforts to limit the duration of time the children with ADD/ADHD are allowed on screen based technologies. Future studies can examine the association between duration of screen time use and severity of ADD/ADHD categories (mild, moderate or severe). It is important to collect and analyze prospective longitudinal data to better assess temporality between screen time and ADD/ADHD, and better measures of screen time and ADD/ADHD diagnosis. Overall, further research is needed to explore this association with a better understanding of duration, better assessment of ADD/ADHD diagnosis along with treatment status, and other co-variables.

Figure 1. Flowchart for selection of study sample.

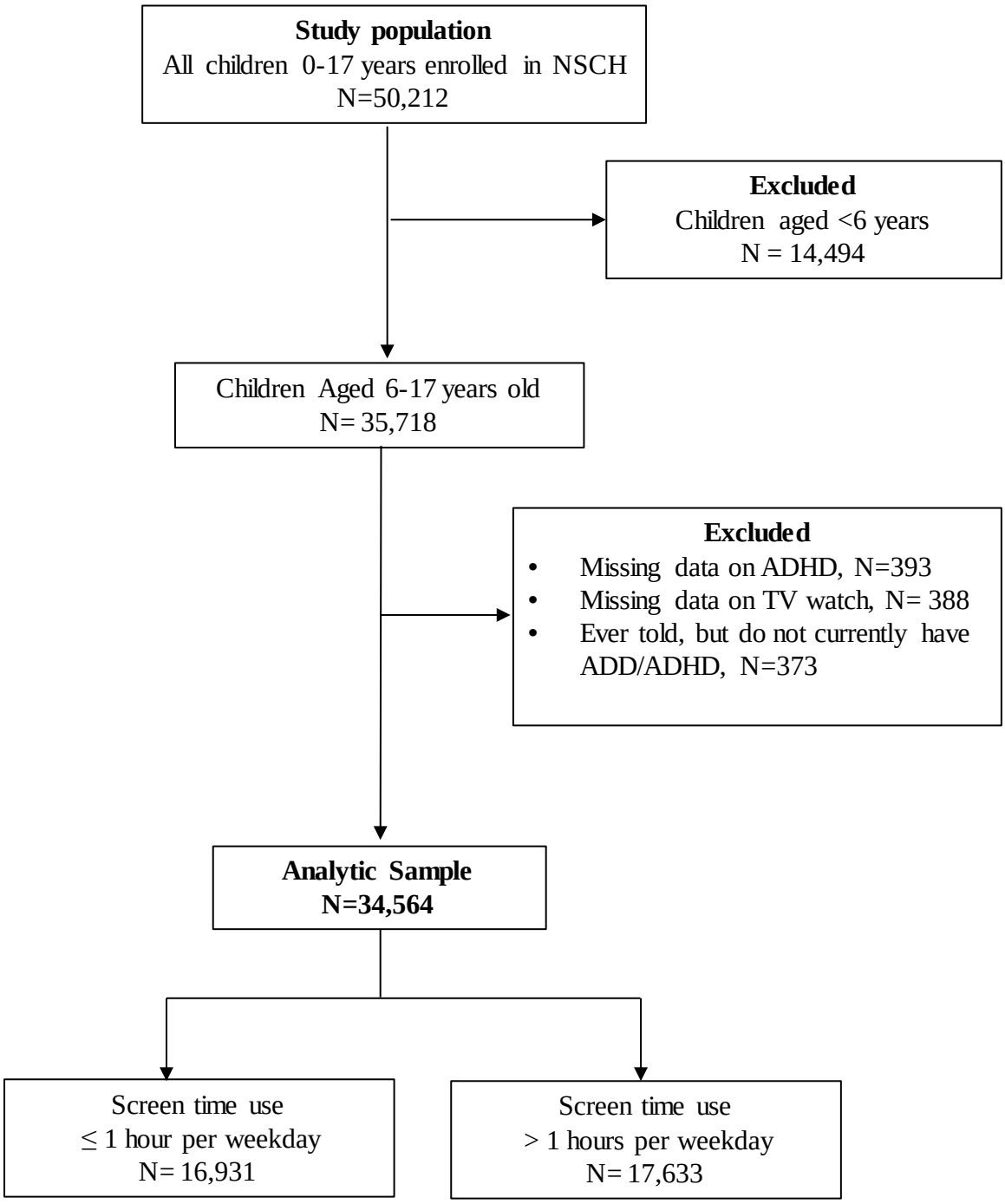

Table 1. Demographics of children aged 6-17 years based on their screen time use per weekday, NSCH 2017.

Characteristics	Screen time use per weekday				*P* values*
	≤ 1 hour		> 1 hours		
	N=16,931	%	N=17,633	%	
Sex					<.0001
Male	7863	47.38	9695	54.40	
Female	9068	52.62	7938	45.60	
Race and Ethnicity					<.0001
Hispanic	1603	20.53	2167	28.82	
Non-Hispanic White	12346	58.36	12080	46.31	
Non-Hispanic Black	694	9.14	1337	16.36	
Non-Hispanic/Multi-racial/Other	2288	11.97	2049	8.51	
Age groups (years)					<.0001
6-11	7949	53.93	6685	47.25	
12-17	8982	46.07	10948	52.75	
Weight categories based on BMI					<.0001
Underweight	711	6.95	734	5.74	
Normal	7833	67.94	8049	58.65	
Overweight	1385	12.56	1960	17.12	
Obese	992	12.55	1973	18.48	
Adequate hours of sleep per day					<.0001
Recommended age-appropriate	12378	72.29	11531	61.99	
<Recommended age-appropriate	4318	27.71	5745	38.01	
Days/week doing physical activity					<.0001
0-3 days	6502	40.87	8985	52.41	
4-7 days	10195	59.13	8295	47.59	
Education level of adult					<.0001
Less than high school	284	7.56	500	11.67	
High school degree or GED	1583	15.51	2886	25.02	
Some college or technical school	3214	20.18	4640	24.79	
College degree or more	11553	56.74	9208	38.52	
Family structure					<.0001
Two parents, currently married	12862	72.18	12083	59.88	
Two parents, not currently	867	6.50	1166	9.16	
Single mother	1969	13.88	2629	20.22	
Other family type, no parent	999	7.44	1505	10.74	
Family income (relative to FPL)					<.0001
0-99% FPL	1299	17.39	2011	24.99	
100%-199% FPL	2315	20.60	3139	24.13	
200%-399% FPL	4950	26.00	5560	26.16	
400% FPL or above	8367	36.02	6923	24.72	

Characteristics	Screen time use per weekday				*P* values*
	≤ 1 hour		**> 1 hours**		
	N=16,931	**%**	**N=17,633**	**%**	
Insurance type					<.0001
Public only	2433	25.85	3646	34.95	
Private only	13203	63.17	12321	52.12	
Public and private	538	4.41	680	4.25	
Insurance type unspecified	168	1.57	212	1.79	
Not insured	553	4.99	731	6.90	
Received behavioral treatment for ADD/ADHD					<.0001
Currently have ADD/ADHD					
Received treatment	735	3.91	1110	5.61	
Did not receive treatment	899	4.73	1328	6.57	
Do not have ADD/ADHD	15294	91.36	15185	87.82	
Medication for ADD/ADHD					<.0001
Currently have ADD/ADHD					
Taking medication	1040	5.45	1651	8.03	
Not taking medication	587	3.17	784	4.14	
Currently no ADD/ADHD	15294	91.39	15185	87.83	
ADD/ADHD current status					<.0001
No	15294	91.35	15185	87.76	
Yes	1637	8.65	2448	12.24	

Abbreviations: ADD/ADHD=attention deficit/hyperactivity disorder, BMI = body mass index, FPL=federal poverty level, GED = general education development.

* *P v*alues reported are from the Rao-Scott chi-square test.

The values for N are unweighted; the percentages are weighted.

Table 2. Characteristics of children aged 6-17 years old who had ADD/ADHD, NSCH 2017

Characteristics	Current ADD/ADHD status				*P* values*
	No		Yes		
	N=30,479	%	N= 4,085	%	
Sex					<.0001
Male	14754	48.95	2804	70.11	
Female	15725	51.05	1281	29.89	
Race and Ethnicity					<.0001
Hispanic	3374	26.08	396	16.22	
Non-Hispanic White	21392	50.76	3034	60.72	
Non-Hispanic Black	1762	12.73	269	15.81	
Non-Hispanic/Multi-	3951	10.43	386	7.26	
Age groups					<.0001
6-11	13079	51.18	1555	42.97	
12-17	17400	48.82	2530	57.03	
Weight categories based on BMI					0.003
Underweight	1221	6.18	224	6.92	
Healthy Weight	14004	63.25	1878	58.74	
Overweight	2923	15.31	422	13.83	
Obese	2459	15.26	506	20.51	
Adequate hours of sleep					<.0001
Recommended age-appropriate	21345	67.47	2564	60.28	
<Recommended age-appropriate	8611	32.53	1452	39.72	
Physical activity per week					0.015
0-3 days	13374	46.69	2113	50.72	
4-7 days	16538	53.30	1907	49.27	
Education level of adult					0.0002
Less than high school	690	10.14	94	6.86	
High school degree or GED	3869	20.49	600	22.26	
Some college or technical	6741	22.12	1113	27.46	
College degree or higher	18580	47.26	2181	43.41	
Family structure					<.0001
Two parents, currently married	22435	67.09	2510	51.99	
Two parents, not currently	1747	7.82	286	8.96	
Single mother	3811	16.24	787	26.58	
Other family type, no parent	2072	8.85	432	12.48	
Family income (relative to FPL)					0.033
0-99% FPL	2755	21.12	555	24.82	
100%-199% FPL	4718	22.53	736	22.44	
200%-399% FPL	9326	26.39	1184	23.52	
400% FPL or above	13680	29.96	1610	29.23	

Characteristics	Current ADD/ADHD status				*P* values*
	No		**Yes**		
	N=30,479	**%**	**N= 4,085**	**%**	
Insurance type					<.0001
Public only	4931	29.49	1148	41.76	
Private only	23020	58.40	2504	46.81	
Public and private	948	4.05	270	6.60	
Insurance type unspecified	341	1.70	39	1.57	
Not insured	1174	6.35	110	3.27	
Received behavioral treatment for ADD/ADHD					#
Currently have ADD/ADHD					
received treatment	0	.	1845	45.79	
did not receive treatment	0	.	2227	54.21	
Do not currently have condition	30479	100.0	0	.	
Medication for ADD/ADHD					#
Currently have ADD/ADHD					
taking medication	0	.	2691	64.94	
not taking medication	0	.	1371	35.06	
Do not currently have condition	30479	100.0	0	.	

Abbreviations: ADD/ADHD=attention deficit/hyperactivity disorder, BMI = body mass index, FPL=federal poverty level, GED=general education development.
subjects who did not have ADD/ADHD did not receive medication or behavioral
* *P* values reported are from the Rao-Scott chi-square test
The values for N are unweighted; the percentages are weighted.

Table 3. Association between screen time use per weekday and ADD/ADHD in children aged 6-17 years old, NSCH 2017.

Characteristics	Unadjusted Analysis uPOR (95% CI)	Adjusted Analysis aPOR (95% CI)
ADD/ADHD current status		
No	1.00	1.00
Yes	1.47 (1.30-1.68)	1.35 (1.14-1.60)
Sex		
Female	1.00	1.00
Male	1.32 (1.20-1.46)	1.44 (1.27-1.63)
Race and Ethnicity		
Hispanic	1.00	1.00
White, non-Hispanic	0.57 (0.486-0.657)	0.75 (0.61-0.91)
Black, non-Hispanic	1.28 (1.033-1.57)	1.19 (0.91- 1.56)
Multi-racial/Other, non-Hispanic	0.51 (0.42-0.61)	0.65 (0.50-0.83)
Age groups (years)		
6-11	1.00	1.00
12-17	1.31 (1.19-1.40)	1.25 (1.07- 1.46)
Weight categories based on BMI		
Underweight	0.96 (0.76-1.20)	0.86 (0.69-1.07)
Normal	1.00	1.00
Overweight	1.58 (1.34-1.86)	1.43 (1.20-1.72)
Obese	1.70 (1.40-2.10)	1.22 (0.98-1.50)
Adequate hours of sleep		
Recommended age-appropriate	1.00	1.00
<Recommended age-appropriate	1.60 (1.48-1.78)	1.13 (0.98-1.29)
Physical activity per week		
0-3 days	1.00	1.00
4-7 days	0.63 (0.57-0.69)	0.61 (0.54-0.70)
Highest level of education in household		
<High school	2.27 (1.74-2.98)	1.30 (0.89-1.91)
High school degree or GED	2.38 (2.06-2.74)	1.86 (1.53-2.26)
Some college or technical school	1.81 (1.62-2.03)	1.54 (1.33-1.78)
College degree or higher	1.00	1.00
Family Structure		
Two parents, currently married	1.00	1.00
Two parents, not currently married	1.70 (1.38-2.10)	1.31 (1.00-1.72)
Single mother	1.76 (1.54- 2.00)	1.24 (1.03 1.48)
Other family type, no parent	1.74 (1.45-2.08)	1.00 (0.80- 1.28)
Family income (relative to FPL)		
0-99% FPL	1.00	1.00
100%-199% FPL	0.82 (0.68-0.98)	1.13 (0.86-1.48)
200%-399% FPL	0.70 (0.60-0.82)	1.01 (0.79-1.29)
400% FPL or above	0.48 (0.41-0.56)	0.94 (0.74-1.21)

Characteristics	Unadjusted Analysis uPOR (95% CI)	Adjusted Analysis aPOR (95% CI)
Insurance type		
Public only	0.98 (0.75-1.27)	1.01 (0.70 1.44)
Private only	0.60 (0.47-0.76)	1.11 (0.81 1.54)
Public and private	0.70 (0.50-0.98)	0.78 (0.50 1.23)
Insurance type unspecified	0.82 (0.47-1.45)	0.76 (0.36-1.62)
Not insured	1.00	1.00

Abbreviations: ADD/ADHD=attention deficit/hyperactivity disorder; BMI = body mass index; FPL=federal poverty level, uPOR/aPOR=Crude/unadjusted prevalence odds ratio; aPOR=Adjusted prevalence odds ratio; CI= Confidence Interval

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APPENDIX TABLE A.

SUPPLEMENTAL TABLE A. Glossary And Explanation Of Variables used in 2016 National Survey of Children's Health.

Variable	Survey questions (Variable name in public use data file)	Answer Options
Time spent watching TV/Video or playing Video games	ON AN AVERAGE WEEKDAY, about how much time does this child usually spend in front of a TV watching TV programs, videos, or playing video games? (K7Q60_R)	None, Less than 1 hour, 1 hour, 2 hours, 3 hours, 4 or more hours
ADD/ADHD	Has a doctor or other health care provider EVER told you that this child has Attention Deficit Disorder or Attention Deficit/Hyperactivity Disorder, that is, ADD or ADHD? (K2Q31A).	Yes or No
	Does this child CURRENTLY have the condition? (K2Q31B)	Yes or No
		If yes, is it Mild, Moderate or Severe
Sex of child	What is the Child's sex?	Male, Female
Race and ethnicity of child	What is the child's race?	White alone, Black or African American alone, Other.
Body mass index	What is the weight status of this child based on Body Mass Index (BMI)-for-age?"	Less than the 5th percentile, 5th percentile to less than the 85th percentile, 85th percentile to less than the 95th percentile, Equal to or greater than the 95th percentile.

Variable	Survey questions (Variable name in public use data file)	Answer Options
Highest level of education among reported adults	What is the highest grade or year of school you (adult) have	8th grade or less; 9th-12th grade No diploma; High School Graduate or GED Completed; Completed a vocational, trade, or business school program, Some College Credit, but no Degree; Associate Degree (AA, AS); Bachelor's Degree (BA, BS, AB); Master's Degree (MA, MS, MSW, MBA); Doctorate (PhD, EdD) or Professional Degree (MD, DDS, DVM, JD)
Income level of the child's household	What is the income level (federal poverty level, FPL) of the household that this child lives in?	0-99% FPL, 100%-199% FPL, 200%-399% FPL, 400% FPL or above
Type of health insurance at time of the survey.	"What type of health insurance coverage, if any, did the child have at the time of the survey?"	Public Only, Private Only, Private and public, Insurance type unspecified, Not insured
Hours child get sleep on an average weeknights	DURING THE PAST WEEK, how many hours of sleep did this child get on an average weeknight?	Less than 6 hrs, 6 hours, 7 hours, 8 hours, 9 hours, 10 hours, 11 or more hours.
Exercise, Play Sport, or Physical Activity for 60 Minutes	DURING THE PAST WEEK, on how many days did this child exercise, play a sport, or participate in physical activity for at least 60 minutes?	0 days, 1-3 days, 4-6 days, every day.

Variable	Survey questions (Variable name in public use data file)	Answer Options
Family Structure	What is the family structure that this child lives in?	1 = Two biological/adoptive parents, currently married; 2 = Two biological/adoptive parents, not currently married, 3 = Two parents (at least one is a step-parent), currently married; 4 = Two parents (at least one is a step-parent), not currently married; 5 = One mother, currently married (living apart) or formerly married; 6 = One mother, never married; 7 = Other, at least one currently married or formerly married biological/adoptive parent; 8 = Other, at least one never married biological/adoptive parent; 9 = Other, no biological/adoptive parent in household
Age of subject child	What is the child's age (SC_AGE_YEARS)	Two age groups: Age 6-11 years, Age 12-17 years
Received behavioral treatment for ADD/ADHD	At any time during the past 12 months, did this child receive behavioral treatment for ADD or ADHD, such as training or an intervention that you or this child received to help with his or her behavior?	Yes or No
Medication for ADD/ADHD	Is this child CURRENTLY taking medication for ADD or ADHD?	Yes or No

Source: http://childhealthdata.org/learn/NSCH