



Demographic trends in attention deficit hyperactivity disorder diagnosis in United States children using National Health and Nutrition Examination Survey data between 2004 and 2012

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ABSTRACT

Background: Attention deficit hyperactivity disorder (ADHD) is the most common mental disorder in the pediatric population and affects education, finances, and medication. ADHD diagnostic criteria and resultant prevalence rates are also of special interest to the global psychiatric community. ADHD diagnosis rates and the corresponding demographic distributions through different years are thus an issue of great public health concern and debate. The objective of this study is to characterize changes in the demographic distribution of ADHD diagnosis from 2004 to 2012 in the United States. **Methods:** ADHD diagnosis data was extracted from the National Health and Nutrition Examination Survey (NHANES) Summary Health Statistics for United States Children, a source of nationally representative data on children in the United States. The ADHD cases were identified based on ICD9-CM diagnosis codes. Chi-square tests were used to investigate differences in ADHD diagnosis rates by demographic characteristics (age, race, and gender) within each year and simple linear regression was applied to determine the extent of change over time. **Results:** The ADHD diagnosis rate was higher among males, whites, and school-aged children and adolescents (vs. preschoolers aged 3-4) in each year examined. The total number of ADHD cases as well as all demographic groups with the exception of African Americans and preschoolers aged 3-4 exhibited an increasing trend between 2004 and 2012. **Conclusions:** ADHD diagnosis among youth showed a significant increase in the United States between 2004 and 2012. Notable increases and group differences were also observed among demographic subgroups. These findings indicate a need for future research in reasons for such group differences as well as treatment differences.

KEY WORDS: Attention deficit hyperactivity disorder, child, demographic trends, National Health and Nutrition Examination Survey

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INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is the most common mental disorder in the pediatric population [1,2]. ADHD is a developmental condition with patterns of hyperactivity, impulsivity, and inattention in various settings, including home and school, that lead to different levels of impairment [3,4]. This impairment may lead to long-term effects and negative outcomes that affect academic performance as well as the social and emotional well-being of the children [5]. With an annual estimated societal cost of illness for ADHD in children of approximately \$42.5 billion, ADHD constitutes a significant

financial burden on the global community [6]. The estimated prevalence of ADHD worldwide is approximately 5% [1,7], with time trends revealing a notable increase in its diagnosis [2,8-11].

Several reasons have contributed to the increased prevalence of ADHD and may influence the full validity of reported estimates [4]. In addition to the increase in the incidence of ADHD over time, the prevalence could potentially reflect increased diagnosis of ADHD in recent years [4,12]. This may also explain the apparent variability of estimates in various settings and the increased diagnosis rates in Western countries, especially the USA [4,13,14]. A study conducted by

Kelleher *et al.* reported a 5.4 fold increase in ADHD diagnosis prevalence in the United States between the years 1979 and 1996 [15]. Furthermore, even each single methodological design used to calculate the differences in population prevalence of mental health issues in youth over time has its own downfalls and could contribute to increased prevalence; such methodological approaches include but are not limited to: Meta-analyses, cross-sectional studies, and cross-cohort comparisons.

The changes and variability in ADHD diagnosis and prevalence rates themselves over time could also be attributed to changes in the diagnostic criteria with each update to diagnostic and statistical manual of mental disorders (DSM), published by the American Psychiatric Association. The publication of the DSM-5 [16], the most recent update to the DSM, brought about more extensive descriptions of ADHD symptoms, differences in the retrieval of information, and comments on appropriate use of criteria for varying age brackets [17], making major changes in ADHD diagnosis and prevalence practically inevitable. A meta-regression analysis conducted by Polanczyk *et al.* in 2007 in the original all-inclusive literature review on ADHD prevalence [1], linked variability in ADHD prevalence rates to diagnostic criteria [1,4].

Changing ADHD prevalence rates are relevant in the discussion of the prevalence of prescribed medications. Not only do studies commonly reference the contribution of the pharmaceutical industry to the increased effort toward diagnosis of disorders such as ADHD and subsequent treatment by prescription medication [4,13] but also one study by Brault and Lacourse references the increasing role of school professionals in medicalization as they hand misbehaving children to medical professionals [2,18-20]. This could lead to a child's potential diagnosis and then subsequent acquisition of medication, providing evidence of the link between changing ADHD prevalence rates and prescribed medication prevalence rates. Furthermore, the prevalence of prescribed medications is only one of the many interconnecting topics that make ADHD diagnosis prevalence rates an important subject of study. With changes in diagnostic criteria, special education policies, higher levels of awareness of the disease, as well as pressure from the pharmaceutical industry to diagnose and treat ADHD with prescription medicines, ADHD prevalence rates are an issue of great public health concern and debate [4,13,21].

In addition, the epidemiology and characteristics of the disease varies between genders [22] and thus different approaches for ADHD are needed for males and females [7]. Boys are known to have a greater prevalence of ADHD and are prescribed more medications than girls [2]. Joelsson *et al.* also noted that sex distribution is different when measured in clinical versus population samples [7]. Based on a community sample, Willcutt reported that ADHD was 2-3 times more prevalent among males than females [23], while a study in a clinical sample by Nussbaum showed 2-9 fold greater diagnosis of ADHD in males [22]. Demographic distributions therefore remain essential to the investigation of ADHD diagnosis.

The objective of this study was to determine the total number of cases of ADHD diagnosed in children ages 3-17 years as reported in the National Health and Nutrition Examination Survey (NHANES) [24] data in the years 2004 through 2012. In addition, this study compared the number of cases by gender, race, and age in each of the aforementioned years to characterize changes in the demographic distribution of ADHD diagnosis among the general American youth population. An analysis of the demographic trends in ADHD diagnosis of youth using NHANES data in more recent years is lacking. This study provides an overview of continuities and changes in ADHD diagnosis using the most current nationally representative data available on ADHD diagnosis in American children.

METHODS

Data Source

The NHANES data from 2004 to 2012 were used for the study. NHANES provides nationally representative data on the nutrition and health of all age groups in the United States, extracting data from both physical examinations and information on socioeconomics, diet, health, and demographics. NHANES is an integral part of the National Center for Health Statistics, the source of health statistics for the centers for disease control and prevention [24].

The survey's findings generally help to derive the prevalence of dominant and large-scale diseases, such as ADHD, and the risk factors associated with such diseases.

NHANES participants represent the general, non-institutionalized American population, obtained using a complex, stratified, and multistage probability cluster design. This requires over-sampling from African Americans, Hispanics, and the elderly over the age of 60.

ADHD diagnosis data from the NHANES Summary Health Statistics for United States Children: National Health Interview Survey (NHIS) for the years 2004 [25], 2005 [26], 2006 [27], 2007 [28], 2008 [29], 2009 [30], 2010 [31], 2011 [32], and 2012 [33] were analyzed for differences between age groups, males and females, and races. The general trends over the period between 2004 and 2012 in each of the demographic groups were analyzed in this study as well to characterize the continuities and changes in ADHD diagnosis over the entire period.

Data on the children included in the NHIS sample are collected by surveying by an adult on behalf of the child. Survey questions directly investigate whether the child has a history with ADHD and the number of absences from school the child had over the previous year. In addition, the survey includes a mental health supplement; over the entire period examined in this study, NHIS included questions within this supplement that inquire about the child's ability to concentrate as well as his or her social skills, emotions, and behavior [34].

Statistical Analysis

Chi-square

Chi-square tests were used to investigate group differences in ADHD diagnosis within each year by different demographic characteristics including gender, age, and race.

Trend analysis

To investigate trends in ADHD diagnosis from the year 2004 to the year 2012, graphs were created with the year plotted against the number total number of ADHD cases in that year [Graph 1]. Similar graphs were created for each demographic group, race, age, and gender, with years plotted against the total number of ADHD cases in that particular subgroup [Graph 1]. A trend analysis was used for each line in each graph [Graph 1] to determine the extent of change over time in the data values. Simple regression was used to determine if there is a significant trend in the form of a line with a slope for each graph [35]. All statistical analyses were carried out using Statistical Analysis Software version 9.2 at an apriori alpha significance level of 0.05.

RESULTS

Chi-square results comparing the proportion of males to females, the age group categories, and the different racial categories among those diagnosed with ADHD for each year are summarized in Table 1. The proportion of males was significantly higher than females in every year over the period from 2004 to 2012 ($P < 0.0001$ for each year). The proportion among the age group 3-4 years was significantly lower than other age groups in every year examined ($P < 0.0001$ for each year). The proportion among children of white race was significantly higher than other racial groups in every year examined ($P < 0.0001$ for each year).

The trend analysis on the overall ADHD diagnosis showed a significant trend of increasing diagnosis through the years

examined [Graph 1]. A significant trend was also seen among males and females, but the proportion of males diagnosed was consistently higher through the years examined. There was also a significant trend of increasing diagnosis among the age group 5-11 years and 12-17 years but not among the age group 3-4 years ($P = 0.3076$). Graph 1 also presents a significant trend of increasing diagnosis among whites and the others racial category but not among African Americans.

DISCUSSION

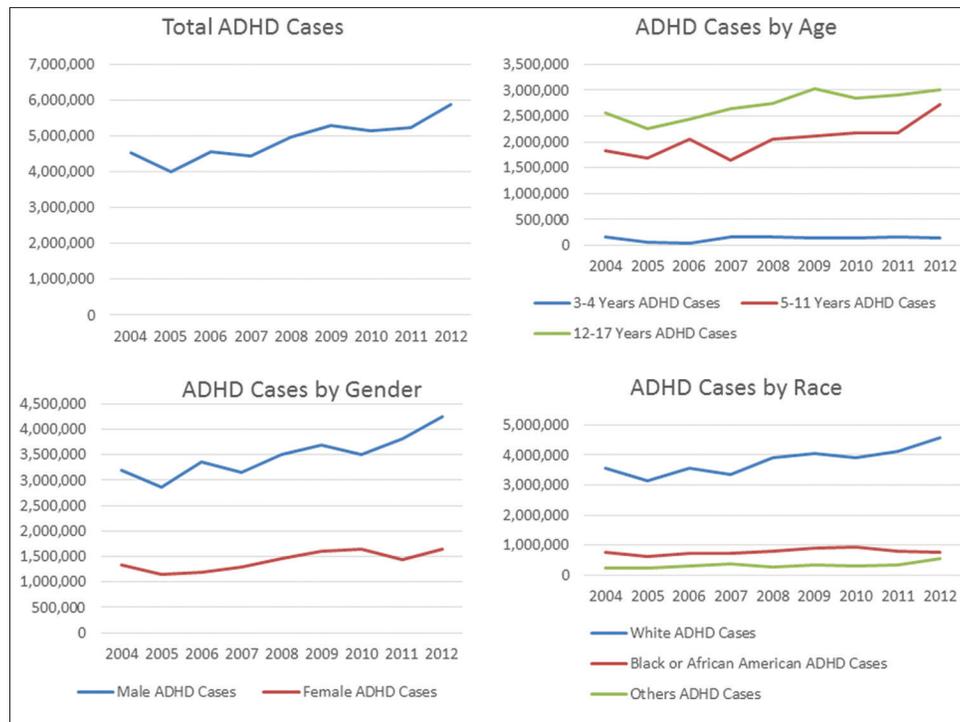
This study showed a higher proportion of males among those diagnosed with ADHD consistently in each year throughout the period examined (2004-2012). It also demonstrated a higher proportion of whites among those diagnosed in each year relative to the race groups and a lower proportion of children aged 3-4 years relative to the age groups. This could have resulted from the difficulty of diagnosing ADHD in children less than 4 years old. Symptoms such as inattention and hyperactivity used for ADHD diagnosis are difficult to distinguish from typical toddler and preschooler behavior, specifically because children at this age group are still developing and changing rapidly. Even though ADHD symptoms sometimes show up early, it might be difficult for parents to notice them when children are quite young [36,37].

A trend of increasing diagnosis was presented among all subgroups of gender, age, and race except for blacks and children aged 3-4 years. This could be in part explained by the type of data used in this study. NHANES data are collected by interviewers asking parents a defined set of questions that screen for ADHD symptoms. Based on the answers given by parents, the computer summarizes the information and determines if the child meets the screening criteria of ADHD [25-33]. As the data are self-reported by the parents and screening questions remain the same [25-33], drastic differences in numbers are not expected to be seen from year to year. In contrast, many of the studies available in literature were based on an actual

Table 1: Number in 1000% of children ages 3-17 reported to have ever been diagnosed as having ADHD in the years 2004-2012

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total cases	4527 (100%)	3998 (100%)	4545 (100%)	4452 (100%)	4968 (100%)	5288 (100%)	5161 (100%)	5240 (100%)	5876 (100%)
Sex									
Male	3194 (70.55)	2854 (71.39)	3352 (73.75)	3161 (71.00)	3508 (70.61)	3689 (69.76)	3511 (68.03)	3803 (72.58)	4239 (72.14)
Female	1333 (29.45)	1143 (28.59)	1193 (26.25)	1291 (29.00)	1459 (29.37)	1599 (30.24)	1649 (31.95)	1436 (27.40)	1636 (27.84)
P value	$P < 0.0001$	$P < 0.001$	$P < 0.0001$						
Age group (years)									
3-4	*151 (3.34)	*60 (1.50)	*46 (1.01)	*170 (3.82)	171 (3.44)	*133 (2.52)	139 (2.69)	158 (3.02)	136 (2.31)
5-11	1822 (40.25)	1682 (42.07)	2055 (45.21)	1644 (36.93)	2059 (41.45)	2121 (40.11)	2181 (42.26)	2174 (41.49)	2726 (46.39)
12-17	2553 (56.39)	2256 (56.42)	2443 (53.75)	2637 (59.23)	2738 (55.11)	3035 (57.39)	2840 (55.03)	2907 (55.48)	3014 (51.29)
P value	$P < 0.0001$								
Race									
White ADHD cases	3545 (78.31)	3123 (78.11)	3553 (78.17)	3354 (75.34)	3922 (78.95)	4057 (76.72)	3920 (75.95)	4102 (78.28)	4567 (77.72)
Black or African American ADHD cases	762 (16.83)	634 (15.86)	705 (15.51)	718 (16.13)	792 (15.94)	904 (17.10)	939 (18.19)	792 (15.11)	769 (13.09)
Others ADHD cases	220 (4.86)	241 (6.03)	287 (6.31)	380 (8.54)	254 (5.11)	327 (6.18)	302 (5.85)	346 (6.60)	540 (9.19)
P value	$P < 0.0001$								

*Estimates with an asterisk have standard errors between 30% and 50% and may be unreliable, ADHD: Attention deficit hyperactivity disorder



Graph 1: Attention deficit hyperactivity disorder cases reported (total and by subgroup) in the years 2004-2012

diagnosis by a healthcare provider [25-33], which may in part explain the disparities between the results of this study and past literature. Polanczyk *et al.* found that information source and diagnostic criteria both had a significant association with ADHD prevalence rates. Studies that derived information from parents or teachers revealed substantially higher ADHD prevalence rates than studies using other methods [1]. Information source was also cited by Skounti *et al.* as a potential reason for varying ADHD prevalence estimates [38].

The findings of this study exhibit a general increasing trend in ADHD diagnosis using NHANES data from 2004-2012 [25-33]. A study conducted by Getahun *et al.* found a similar increase in ADHD diagnosis rates from 2.5% to 3.1% between 2001 and 2010 and a 24% increase of ADHD in children aged 5-11, diagnosed by physicians in Kaiser Permanente Southern California. The study also specifically reported an increase in the diagnosis rates in the racial demographic groups of hispanics, whites, and blacks, with whites still having the highest diagnosis rates. The upward trend in ADHD diagnosis in blacks was attributed to an increase in ADHD diagnosis among black females. Furthermore, Getahun *et al.* reported that the diagnosis of ADHD was consistently higher for boys than girls in any given racial category [39]. The results of this study are consistent with regards to gender and ADHD diagnosis in whites but did not have an increased prevalence in black females. Studies across different settings and countries have consistently reported an upward trend similar to the present study. While this study evaluated self-reported data, the increased prevalence was also seen when Getahun *et al.* investigated a clinic and was reported in Danish Psychiatric Hospitals and insurance carrier data from Germany [39]. In a study of office-based visits in the United

States that lead to ADHD diagnosis between 1990 and 1995, Robison *et al.* examined data from the National Ambulatory Medical Care Survey (NAMCS) and found an increase in ADHD diagnosis linked to office-based visits, consistent with the general upward trend in ADHD diagnosis [8]. Furthermore, the findings of this study documented a significant upward trend in the age group containing 9.7 years and 10.8 years ($P < 0.05$), consistent with findings of Robison *et al.* [8].

In a review of manuscripts published between 1992 and 2006 focusing on ADHD, Skounti *et al.* found that ADHD is more widespread in boys than girls as well as in children in younger age groups, which may explain the higher proportion of males among those diagnosed seen in this study during the period examined [38]. In a study focusing on girls between 1990 and 1998, Robison *et al.* found a significant increase in office-based visits linked to ADHD diagnosis ($P < 0.05$). There was also an increase in office-based visits linked to ADHD among girls greater than the increase among boys, though boys had higher instances of office-based visits linked to ADHD in both 1990 and 1998 [9]. A meta-analysis of 86 studies of youth ADHD diagnosis based on DSM-IV criteria [16] found that across all ADHD diagnosis reviewed, males had a higher chance of being diagnosed with ADHD both overall and within every subtype [23]. The findings of this study also showed that boys had a significantly higher rate of ADHD diagnosis than girls ($P < 0.05$).

While this study focused on disparities in ADHD diagnosis, medication use was not examined. Whether the upward trends in diagnosis are reflected in increased medication use is important to consider. The previous studies examining trends in medication use in ADHD patients have cited a general

increasing trend in the recent past, though multiple studies have reported a newly stagnating or decreasing trend in medication use. Beau-Lejdstrom *et al.* cited an increase in the use of ADHD medications in the UK from 1992 until 2008, after which the rates of medication use stagnated [41]. Another review study by Steinhausen *et al.* reported an international increase in prescribed medication for ADHD but also noted a decreasing trend in prescribed medication in Germany [42]. Many possible factors could contribute to increasing, stabilizing, or even decreasing trends in the prevalence of prescribed medication for ADHD. Beau-Lejdstrom *et al.* reference a more favorable image of prescribed medication and improved awareness of the disorder as potentially responsible for the increasing trends while changes toward stagnating or decreasing trends could be explained by sufficient awareness of ADHD as well as negative effects of the medication, respectively [41].

LIMITATIONS

Study findings should be interpreted within the context of its limitations. The study carries the general limitations of the cross-sectional design. For example, one is unable to make conclusions regarding cause and effect relationships given the study design [43]. In addition, the study examined subgroups of gender, race, and age among those with ADHD diagnosis as reported by parents, but the total number of individuals examined in each subgroup is unknown. Furthermore, the reasons behind the observed group differences in this study cannot be ascertained and follow-up studies are needed to further investigate and address these differences. The study also carries the limitations of self-reported data [25-33] as the parents' views of their child's symptoms, and personal interpretation of the questions may vary from parent to parent and could influence their responses. The NHANES data, however, are widely used and are a representative sample of the United States population [24]. This also exposes that the generalizability of the study findings to other international populations may be limited.

Implications and Future Research

Future research is needed to confirm the study findings and evaluate the reasons behind the group differences documented. For example, studies are needed to evaluate if males are more likely to be diagnosed with ADHD or if their comparatively higher diagnosis rates are a result of over-diagnosing in males or under-diagnosing in females. Moreover, treatment differences in all subcategories such as medication use, office visits, follow ups, and interventions need further investigation. Finally, more studies are also needed for ADHD diagnosis in the age group 3-4 years, as there was limited reliability of the data in that particular age subgroup in this study.

CONCLUSIONS

The results of this study indicate that in the United States over the period from 2004 to 2012, ADHD diagnosis among youth showed a significant increase. Increasing diagnosis trends overall

in the period between 2004 and 2012 were discerned in all subgroups except African Americans and children aged 3-4 years. A higher proportion of males than females among those diagnosed with ADHD was identified consistently in each year throughout the period examined (2004-2012). Similarly, a higher proportion of whites among those diagnosed in each year relative to the race groups and a lower proportion of children aged 3-4 years relative to the age groups were found. Thus, the results of this study offer insight into potential subgroups of gender, race, and age as well as a recent period in the realm of ADHD diagnosis.

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