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Latent class analysis of ADHD neurodevelopmental and mental health comorbidities

Benjamin Zablotsky, PhD,

National Center for Health Statistics, Hyattsville, MD

Matthew D. Bramlett, PhD,

National Center for Health Statistics, Hyattsville, MD

Susanna N. Visser, DrPH, MS,

National Center on Birth Defects and Developmental Disabilities, Atlanta, GA

Melissa L. Danielson, MSPH, and

National Center on Birth Defects and Developmental Disabilities, Atlanta, GA

Stephen J. Blumberg, PhD

National Center for Health Statistics, Hyattsville, MD

Abstract

Objective—Many children diagnosed with attention-deficit/hyperactivity disorder (ADHD) experience co-occurring neurodevelopmental and psychiatric disorders, and those who do often exhibit higher levels of impairment than children with ADHD alone. This study provides a latent class analysis (LCA) approach to categorizing children with ADHD into comorbidity groups, evaluating condition expression and treatment patterns among children in each group.

Method—Parent-reported data from a large probability-based national sample of children diagnosed with ADHD (2014 National Survey of the Diagnosis and Treatment of ADHD and Tourette Syndrome) were used for an LCA to identify groups of children with similar groupings of neurodevelopmental and psychiatric comorbidities among children with current ADHD (n=2,495). Differences between classes were compared using multivariate logistic regressions.

Results—The best LCA solution placed children who were indicated to have ADHD into four classes: (low comorbidity (LCM) (64.5%), predominantly developmental disorders (PDD) (13.7%), predominantly internalizing disorders (PID) (18.5%), and high comorbidity (HCM) (3.3%)). Children belonging to the HCM class were most likely to have a combined ADHD subtype and the highest number of impaired domains. Children belonging to the PDD class were most likely to be receiving school services, while children in the PID class were more likely to be

Correspondence: Benjamin Zablotsky, PhD, National Center for Health Statistics, Centers for Disease Control and Prevention, 3311 Toledo Road, Room, Hyattsville, MD, 20782, 301-458-4621: bzablotsky@cdc.gov.

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taking medication than children belonging to the LCM class who were least likely to receive psychosocial treatments.

Conclusion—Latent classes based on co-occurring psychiatric conditions predicted use of varied treatment types. These findings contribute to the characterization of the ADHD phenotype and may help clinicians identify how services could best be organized and coordinated in treating ADHD.

Keywords

ADHD; comorbidity; national survey

INTRODUCTION

Attention-deficit/hyperactivity disorder (ADHD) is a heterogeneous neurodevelopmental condition that affects approximately 1 in 10 school-aged children in the United States.¹ Children diagnosed with ADHD are characterized by inattentive and/or hyperactive and impulsive symptoms that are developmentally inappropriate and are causing functional impairment across multiple settings. Children with ADHD are at a higher risk than children without ADHD for developing other psychiatric disorders.^{2,3} Previous studies, frequently utilizing registries and clinical or convenience samples, found more than half of children diagnosed with ADHD are also diagnosed with one or more co-occurring neurodevelopmental and psychiatric conditions, such as learning disabilities, conduct or externalizing problems, and internalizing or mood disorders.^{2, 4-7} Children with neurodevelopmental and psychiatric comorbidities tend to experience greater levels of impairment than children with ADHD alone.^{4, 7-8}

Although the co-occurrence of neurodevelopmental and psychiatric comorbidities among children with ADHD has been well-documented, little research has been devoted to understanding the predictors that may increase a child's likelihood of being diagnosed with a co-occurring neurodevelopmental or psychiatric condition. There is evidence that predictors for increased risk for the diagnosis of a comorbid condition include perinatal problems,⁹ genetic susceptibilities,¹⁰ and receipt of an ADHD diagnosis at a young age.¹¹ Certain co-occurring disorders have been associated with specific ADHD subtypes, as children with the combined subtype are more likely to experience internalizing and externalizing disorders than those with either the predominantly hyperactive/impulsive or inattentive subtype.¹² As a result, the presence of a neurodevelopmental and/or psychiatric comorbidity may have treatment and service use implications. In fact, children with such comorbidities may be more likely to respond to both therapeutic treatments and medication than children with ADHD only.¹³ Differential treatment may be dictated by the neurodevelopmental and/or psychiatric comorbidity itself, including cognitive-behavioral therapy for children with internalizing disorders,¹⁴ behavioral parent training for children with oppositional behaviors,¹⁵ and increased services both in and out of school for children with autism spectrum disorder.¹⁶

Research on the subtypes of ADHD represents part of a larger effort to better understand variations in the presentation of ADHD symptoms among children with ADHD. The

products of these efforts have included latent class analyses (LCA) designed to group individuals with similar symptom patterns into classes. LCAs have been shown to yield findings of clinical relevance, given the ability of class membership to predict serious cognitive and achievement deficits,¹⁷ service use patterns,⁷ and familial heritability¹⁸ among children with ADHD. These types of studies have typically relied on clinical samples or twin registries, with a focus on subclasses constructed from combinations of the 18 ADHD *DSM-IV* hyperactive/impulsive and inattentive symptoms.¹⁸ While informative, these previous studies do not provide a nationally representative population of children diagnosed with ADHD, as they typically are subject to sampling biases related to inclusion criteria required for study participation. A nationally drawn sample of a noninstitutionalized population of children with ADHD would avoid this source of bias, thereby helping to ensure that the complete spectrum of comorbid conditions present among children with ADHD is more fully captured.

Moreover, previous clinical studies have focused exclusively on symptoms associated with common co-occurring internalizing and externalizing disorders.^{19–21} A focus on symptomatology rather than diagnosed conditions could introduce additional noise into modeling, as capturing symptoms alone may result in not fully or accurately capturing the disorders one intends to measure. This may be particularly true among children with ADHD, given that symptoms of inattention/distractibility are also symptoms related to other conditions.²² Indeed, it has been recommended that an important first step towards expanding our knowledge of the ADHD phenotype is better understanding the presentation of specific co-occurring conditions among children with ADHD.²³ For these reasons, the proposed study attempts to fill notable gaps in the literature by capturing classes of current parent-reported clinically diagnosed disorders (not symptoms) using a national probability-based sample of children currently diagnosed with ADHD in the United States.

METHODS

Data Source

Data for the current study are from the 2014 National Survey of the Diagnosis and Treatment of Attention-Deficit/Hyperactivity Disorder and Tourette Syndrome (NS-DATA), a follow-up survey to the 2011–2012 National Survey of Children's Health (NSCH), a cross-sectional random-digit-dial telephone survey (landlines and cell phones) of US households with at least one child aged 0 to 17 years at the time of interview. NS-DATA, conducted by the National Center for Health Statistics (NCHS), was a module of the State and Local Area Integrated Telephone Survey and was sponsored by the National Center on Birth Defects and Developmental Disabilities to collect information about the diagnostic experiences of children 4 to 17 years old ever diagnosed with ADHD or Tourette syndrome (TS). Additionally, NS-DATA was designed to provide information about current and past medication use, behavioral interventions, and school performance. Households eligible to be recontacted for NS-DATA participated in the 2011–12 NSCH, had a child aged 2–15 years at the time of NSCH, and reported that the child had ever been diagnosed with ADHD or TS. The interview completion rate among households eligible to participate in NS-DATA was 47%. NS-DATA shares the complex survey design of the NSCH, with stratification by state

and sample type (landline or cell phone). More information about both NS-DATA and NSCH, including consent procedures, can be found at <http://www.cdc.gov/nchs/slaits.htm>. Verbal consent was obtained from a parent or guardian respondent (herein referred to as the parent) at the time of the interview, with parents being informed of their rights as survey participants. The NCHS Research Ethics Review Board and the federal Office of Management and Budget approved all NS-DATA data collection procedures.

Sample

There were 2,966 participants included in the final interview sample for the ADHD module of NS-DATA, which included children who were 4–17 years old at the time of NS-DATA whose parent had completed the NSCH and reported at that time and confirmed in the NS-DATA interview that they had ever been told by a doctor or other healthcare provider that their child had ADHD. The statistical analysis for this study was restricted to those with a current parent-reported ADHD diagnosis in the NS-DATA interview (n=2,495).

Measures

ADHD diagnosis—At the time of the 2014 NS-DATA survey, parents were asked to confirm that they had ever been told by a doctor or other healthcare provider that their child had ADHD as was indicated during the 2011–2012 NSCH interview. Parents were then asked a follow-up question after confirming a previous diagnosis, “Does [your child] currently have ADHD?” Children whose parents answered in the affirmative to this question were labeled as having a current ADHD diagnosis. Parent-reported ADHD based on a doctor’s diagnosis within the NSCH has been found to have high convergent validity with medical records.²⁴

Co-occurring conditions—Parents were asked about whether their child had ever been diagnosed with 15 other conditions by a doctor or other healthcare provider, which included oppositional defiant disorder, conduct disorder, autism spectrum disorder or pervasive developmental disorder, sleep disorder, intellectual disability, learning disorder, language disorder, obsessive compulsive disorder, post-traumatic stress disorder, another anxiety disorder, bipolar disorder, intermittent explosive disorder, another mood disorder (e.g, depression or major depressive disorder), eating disorder, and substance use disorder. If the parent indicated they had ever been told that their child had a given condition, they were subsequently asked if the child currently had the condition.

Demographics—Child characteristics included child’s age, sex, race/ethnicity, and insurance type (public, private, uninsured). School characteristics included school type (private, public, home-school) and school population type (general, special needs). Household characteristics included region of residence (Northeast, Midwest, South, West), income recoded as federal poverty level percentage (<100%, 100% – 199%, 200% – 399%, 400%), highest educational attainment of household members (less than high school, high school, more than high school), household type (two parent household, other), and housing situation (family owned, rented, other arrangement). All household variables, with the exception of income, were collected during the 2011–2012 NSCH.

ADHD treatment—Parents were asked whether their child had ever taken medication for ADHD and if so, whether their child was currently taking medication. Parents were also asked if their child had received or was currently receiving any of the following treatments for ADHD or difficulties with their emotions, concentration or behavior: school-based educational support, intervention or accommodation (such as tutoring, extra help from a teacher, preferential seating, extra time to complete work, or being enrolled in special education), and classroom management (such as reward systems, behavioral modification, or a daily report card). Reports of current school support and classroom management were grouped into an indicator for current receipt of school services. Additional treatment questions included those asking about the ever or current receipt of peer interventions (such as peer tutoring or the Good Behavior Game), social skills training (such as support in how to interact with others), Cognitive Behavioral Therapy, or parent training; reports of current receipt of any of these interventions were grouped into a current psychosocial treatment indicator. Parents were also asked to indicate if their child had a current formal education plan, such as an Individualized Education Program (IEP) or 504 plan.

ADHD symptoms and overall performance outcomes—The Vanderbilt ADHD Parent Rating Scale (VADPRS) was adapted to be administered over the telephone to parents to capture ADHD symptoms and associated impairment. The VADPRS contains diagnosis-based behavioral items intended to capture *DSM-IV* criteria for ADHD when the child is not taking medication, including 9 items measuring inattention and 9 items on hyperactivity/impulsivity. Each item is rated on a 4 point Likert scale, and parents are instructed to “think about your child’s behaviors in the past 6 months when he/she is not taking medication for ADHD or any other medication for other difficulties with [his/her] emotions, concentration or behavior.” Parents could rate the frequency of a given behavior as occurring never, occasionally, often or very often. Behavioral items were dichotomized for analysis into “never”/“occasionally” and “often”/“very often”. Children who exhibited a behavior “often” or “very often” were coded as having the symptom. The VADPRS has been found to have high concurrent validity with clinical evaluations, and high reliability.²⁵

To measure performance using a five point Likert scale from problematic to excellent, parents were asked to describe their child’s performance in school overall, and in reading, writing, and mathematics, their relationship with parents, siblings, and peers, and their participation in organized activities. Children whose performance was rated as “somewhat of a problem” or “problematic” on any of the eight performance and relationship items were considered to have an impaired performance.²⁵

Parent-reported ADHD subtype—As per the VADPRS, children who had 6 or more inattentive symptoms, but fewer than 6 hyperactive/impulsive symptoms, and at least one impaired performance item, were categorized as having a predominantly inattentive ADHD subtype (labeled ‘inattentive only’). Children who had 6 or more hyperactive/impulsive symptoms, but fewer than 6 inattentive symptoms, and at least one impaired performance item were categorized as having a predominantly hyperactive/impulsive ADHD subtype (labeled ‘hyperactive/impulsive only’). Children who had 6 or more inattentive symptoms and 6 or more hyperactive/impulsive symptoms, and at least one impaired performance item

were categorized as having combined ADHD subtype (labeled ‘combined’). Children who met the criteria for none of these subtype groups were coded as having no ADHD subtype at the time of the NS-DATA (labeled as ‘neither’).

Statistical Analysis

Latent class analysis—LCA involves the formation of classes that are dictated by the response patterns (or profiles) of categorical indicators, with the most like individuals being placed together into the same classes.²⁶ LCA can be viewed as a categorical analog to factor analysis, with the primary objective of reducing a series of categorical variables into a single categorical latent variable. However, instead of grouping like items, LCA groups like individuals. In this analysis, latent class models were fit using MPLUS 7.0,²⁷ using maximum likelihood with robust standard errors. Missingness of covariates was modeled using an expectation-maximization algorithm. Ten indicators were included in the model, based on a current diagnosis of a co-occurring neurodevelopmental or mental health condition. Like conditions were grouped together, as were rare conditions, in order to improve the ability of the LCA to form meaningful and distinguishable classes. As such, intermittent explosive disorder, substance use disorder and eating disorder were grouped into “other disorder,” obsessive compulsive disorder, post-traumatic stress disorder, and any other anxiety disorder were grouped into “anxiety disorder,” and bipolar and other mood disorder were grouped into “mood disorder.” All other reported co-occurring disorders were maintained as individual indicators. Appropriate statistical methods for measuring the goodness of fit of class models included Akaike information criterion (AIC); Bayesian information criterion (BIC); and Lo-Mendell-Rubin likelihood ratio test (LMR). Entropy was also used as a measure of class misclassification.

Demographic differences between classes were compared utilizing corrected χ^2 tests that accounted for the survey design (presented as F-values). Multivariate logistic regressions examined differences in treatment and ADHD symptomology and impairment between classes, adjusting for the child, school, and household characteristics listed above. Missingness on ADHD subtype was present for approximately 5% of cases, and missingness on ADHD treatments was present for approximately 4% of cases. All analyses made use of the survey sampling weights and the appropriate procedures to account for the complex survey design of the NS-DATA. Weights used in the public dataset were developed by NCHS which accounted for nonresponse to the questionnaire, and included a raking adjustment.

RESULTS

Analysis of the 10 mental health condition items among eligible participants (n=2,495) indicated that a 4-class model was the best fitting solution when compared to 1-, 2-, 3- and 5-class models [See ONLINE SUPPLEMENT Table]. A Lo-Mendell-Rubin likelihood ratio test revealed the 4-class model had a significantly better fit than the 3-class model ($p<0.0001$), but not the 5-class model ($p=0.21$). The 4-class model had lower AIC, BIC, and BIC sample adjusted values than the 1-, 2- and 3-class models.

Among children with current ADHD, 61.3% had at least one current co-occurring neurodevelopmental or psychiatric disorder. The prevalence of individual disorders among children with current ADHD included: oppositional defiant disorder (12.8%), conduct disorder (8.7%), autism spectrum disorder (13.0%), sleep disorder (12.2%), intellectual disability (10.8%), learning disorder (33.8%), language disorder (13.2%), any anxiety disorder (25.1%), any mood disorder (19.4%), and any other disorder (4.8%).

A four class solution included a class of children who, on average, had 6 co-occurring psychiatric conditions (3.3%) (labeled ‘high comorbidity’), a class of children averaging less than 1 psychiatric conditions (64.5%) (labeled ‘low comorbidity’), a class of children with predominantly internalizing disorders (18.5%), and a class of children with predominantly developmental disorders (13.7%) (Figure 1). Children that belonged to the predominantly-developmental-disorders class were characterized by high rates of language disorder (62.2%), intellectual disability (47.1%), autism spectrum disorder (37.9%), and learning disability (85.7%). Children belonging to the predominantly-internalizing-disorders class were characterized by high rates of any anxiety disorder (54.4%) and any mood disorder (67.8%). More than four out of five children in the high comorbidity class had a current learning disability (96.3%), anxiety disorder (91.1%), intellectual disability (85.1%), or mood disorder (80.1%). Conduct disorder was commonly diagnosed in this class as well, with approximately three out of four children having the diagnosis (71.3%). Although less common, approximately two out of five children had oppositional defiant disorder (37.6%). Many of the children in the predominantly-internalizing-disorders class also had externalizing problems, with approximately one out of four children having conduct disorder (23.4%) and three out of ten children (29.7%) having oppositional defiant disorder. Children in the low comorbidity class were rarely diagnosed with another condition, with the most commonly diagnosed disorder—learning disability—occurring in approximately 1 in 6 children (15.9%).

The mean number of co-occurring psychiatric disorders among children with a current ADHD diagnosis was 1.46 (95% CI: 1.34–1.59). Understandably, children in the high comorbidity class had the greatest number of co-occurring disorders (\bar{x} =6.76, 95% CI: 6.18–7.35) while children in the low comorbidity group had the least (\bar{x} =0.40, 95% CI: 0.36–0.45). Children in the predominantly-developmental-disorders class (\bar{x} =3.08, 95% CI: 2.89–3.28) had a slightly higher number of co-occurring psychiatric disorders than children in the predominantly-internalizing-disorders class (\bar{x} =2.67, 95% CI: 2.51–2.82). Although this difference was statistically significant, it was not as large as the difference found between children in the low and high comorbidity classes.

Demographics

Table 1 presents the child, school and household characteristics of children in each of the four classes. Children in the high comorbidity class were most likely to be non-Hispanic Black (38.4%), have current public health insurance (90.8%) or live below the federal poverty line (64.3%), and least likely to live with someone who has more than a high school education (15.2%). Children in the predominantly-developmental-disorders class (63.5%) or children in the low comorbidity class (66.5%) were more likely to be in a two parent

household than children in the predominantly-internalizing-disorders class (45.7%). Children in the low comorbidity class were most likely to be living in a household at or above 400% of the federal poverty level (28.1%) and were least likely to be in rented housing (32.5%). Children in the high comorbidity (26.9%), predominantly-developmental-disorders (26.0%), and predominantly-internalizing-disorders (16.2%) classes were more likely to attend a special needs school than children in the low comorbidity class (5.1%).

ADHD Subtype

Figure 2 presents the prevalence of different parent-reported ADHD subtypes among children at the time of the survey in each of the four classes. Children in the high comorbidity class were the most likely to have a combined ADHD subtype (60.3%), while children in the low comorbidity class were the least likely to have a parent-reported ADHD subtype (47.8%). In total, approximately 39.6% of children with a current ADHD diagnosis did not have a parent-reported ADHD subtype at the time of the interview, and approximately 3 out of 4 of these children were placed in the low comorbidity class (73.8%) through the LCA. Children in the predominantly-developmental-disorders class were less likely to have the hyperactive/impulsive subtype (0.8%) than children in the low comorbidity class (3.5%) or the predominantly-internalizing-disorders class (7.3%).

ADHD Symptoms

Children in the high comorbidity class had the highest number of hyperactive/impulsive ($\bar{x}=6.37$, 95% CI: 5.62–7.11) and inattentive ($\bar{x}=7.14$, 95% CI: 6.40–7.87) symptoms. Children in the predominantly-developmental-disorders class and children in the predominantly-internalizing-disorders class had more hyperactive/impulsive and inattentive symptoms than children in the low comorbidity class. Children in the predominantly-internalizing-disorders class had more hyperactive/impulsive symptoms than children in the predominantly-developmental-disorders class.

Performance

On average, children experienced impairments across three domains ($\bar{x}=3.12$, 95% CI: 2.95–3.28). Children in the high comorbidity class had the highest number of domains of impairment ($\bar{x}=4.50$, 95% CI: 3.56–5.44). Children in the predominantly-developmental-disorders class ($\bar{x}=4.09$, 95% CI: 3.61–4.58) or predominantly-internalizing-disorders class ($\bar{x}=3.71$, 95% CI: 3.36–4.05) had a comparable number of impaired domains, which were both higher than children in the low comorbidity class ($\bar{x}=2.60$, 95% CI: 2.41–2.79).

Treatment

Table 2 presents the current treatment usage among children in each of the four classes. Children in the predominantly-internalizing-disorders class (77.5%) were more likely to be currently taking medication for ADHD than children in the low comorbidity class (63.9%). Children in the predominantly-developmental-disorders class were the most likely to be receiving current school services (93.7%), and nine out of ten children in the predominantly-developmental-disorders class had a formal education plan (i.e., an IEP or 504 plan). Children in the predominantly-developmental-disorders class (59.1%) also had higher rates

of current psychosocial treatment than children in the low comorbidity class (18.1%) or in the predominantly-internalizing-disorders class (46.2%), but had lower rates than children in the high comorbidity class (75.7%).

DISCUSSION

Despite a large volume of research on pediatric ADHD, there is relatively little literature on the role of common co-occurring disorders within the ADHD phenotype at a national population-based level. One way to gain insight into phenotypic variation for ADHD is through LCA. The current study builds upon previous population-based, birth cohort research²⁸ by recruiting a large and nationally representative sample of children with a current parent-reported community diagnosis of ADHD. We found that approximately six out of ten children with current ADHD (61.3%) had a co-occurring parent-reported neurodevelopmental and/or mental health condition, a number similar to those found in other community samples and population-based surveys^{7,8} but lower than clinical samples such as the NIMH Collaborative Multisite Multimodal Treatment Study of Children with Attention-Deficit/Hyperactivity Disorder (MTA).²⁹ Given clinic samples tend to recruit a more severe population, typically the result of stricter inclusion criteria (e.g. combined ADHD subtype as in the MTA), this difference is expected.³⁰

The LCA identified four classes, which conceptually appeared to cluster by number of co-occurring conditions (high or low comorbidity) and type of co-occurring disorder (predominantly-developmental-disorders or predominantly-internalizing-disorders). Surprisingly, despite the high co-occurrence of ADHD and disruptive behavior disorders (co-occurrence of oppositional-defiant disorder and conduct disorder is 44%-60%),⁸ a separate class did not emerge that represented ADHD and predominantly externalizing disorders. Children with these disorders were divided into the high comorbidity and predominantly-internalizing-disorders classes, suggesting that these children are not commonly diagnosed with the presence of disruptive behavior disorders without also being diagnosed with other disorders. It also appeared that intellectual disability and language disorders were highly discriminating conditions within the LCA, with both conditions infrequently occurring within children in the low comorbidity class and the predominantly internalizing disorder class.

Treatment

Children with ADHD in the predominantly-developmental-disorders class were more likely than other groups to receive school services, have a formal education plan, and receive psychosocial treatments. It is possible that the higher prevalence of intellectual disability and language disorders within this group may dictate the use of these services. Children with ADHD in the predominantly-internalizing-disorders class were more likely than children with low comorbidity to be taking medication for ADHD, but were less likely to be receiving psychosocial treatment than children in the predominantly-developmental disorders class and the high comorbidity class. It is possible that these children are primarily receiving medication to treat symptoms related to their internalizing symptoms in place of psychosocial treatments, an intriguing outcome given previous studies have shown

effectiveness in behavioral treatments yet mixed findings for stimulants in treating internalizing symptoms within this population.^{31,32}

Limitations

These findings and conclusions are presented within the context of a set of limitations and considerations. The NS-DATA is a national survey specific to ADHD, with a large nationally-drawn sample of respondents about children who had been diagnosed with ADHD. The large sample size allowed for the comparison of multiple classes of children produced from an LCA, with the ability to consider multiple conditions with a low prevalence. Despite these strengths, this study does possess several limitations. First, the snapshot nature of the data prevents the ability to evaluate the developmental onset of the child's co-occurring conditions, which could influence the child's treatment.³³ Future studies could incorporate the classes identified, but adopt a longitudinal methodology --- the use of latent-class growth analysis may provide additional insight into the evolving needs of children with varying clinical presentations. Second, the parent-reported information about treatment and mental health diagnoses was not validated by a clinician. As a result, it is not possible to rule out unmeasured confounding among children who may have an undiagnosed condition or received an inappropriate diagnosis. Moreover, although parents were asked to consider their child's condition while not using medications when answering questions about their child's current ADHD symptoms, it is not known if parents likewise considered their child's condition while not receiving non-pharmaceutical treatments. In some instances parents reported their child to have a sub-threshold number of symptoms in the past 6 months for a clinical diagnosis; this may indicate that the parent did not consider the child when off medication, or could suggest that the child no longer had the condition. Additionally, the VADPRS does not require impairment across two settings, which is a requirement in making an ADHD diagnosis. Nonetheless, there is evidence that parent report of a neurodevelopmental or psychiatric disorder diagnosis has good convergent validity with other epidemiological methods of characterizing these disorders²⁴ and the majority of children in the sample were diagnosed following best practices.³⁴ Moreover, the demographic composition of the population of children ever diagnosed with ADHD based on NS-DATA was comparable to children ever diagnosed with the disorder based on the 2011–2012 NSCH as well as the 2011 and 2012 National Health Interview Survey.

Finally, due to the implementation of the NS-DATA survey taking place approximately 2 years (median=29 months) after the initial report of an ADHD diagnosis in the 2011–12 NSCH, only children who had an ADHD diagnosis for two or more years are represented in the NS-DATA sample, and these children may display a different phenotype regarding current co-occurring conditions than children with a more recent diagnosis.

Estimates based on telephone surveys with low response rates may be biased due to differences between respondents and nonrespondents. The final response rate for NS-DATA was 11%, but this is a misleading estimate of the potential for nonresponse bias in weighted estimates. Because NS-DATA was a follow-back survey to the NSCH, the NS-DATA response rate is the NS-DATA interview completion rate (47%) multiplied by the NSCH final response rate (23%). The NSCH sample weights were adjusted to account for known

demographic correlates of nonresponse and were calculated in accordance with best practices for sample surveys, and the NS-DATA sample weights were adjusted to account for follow-back nonresponse (using NSCH data for respondents and nonrespondents alike to precisely identify correlates of response propensity), but bias resulting from nonresponse cannot be completely ruled out. However, it should be noted that a nonresponse bias analysis was conducted to examine estimates before and after the nonresponse weighting adjustments, and results indicated that bias was found to greatly decrease after the weighting adjustments, and the estimated observable biases using the final weights tended to be smaller than sampling error (i.e., not statistically significant).³⁵ Finally, the 47% interview completion rate of the NS-DATA should not be interpreted as a 53% refusal rate because it includes households that could not be recontacted. Among recontacted households, the interview completion rate for NS-DATA (i.e., the cooperation rate) exceeded 80%.

Implications

Just as diagnostic classifications help clinicians identify the most promising treatments, the classes identified in the current study may help clinicians identify how services could best be organized and coordinated, in accordance with AAP guidelines for diagnosing, evaluating and treating ADHD.³⁶ For example, children in the high comorbidity class are the most likely to have complex treatment needs. In such instances, the AAP guidelines recommend family-centered coordinated care in a medical home, a standard for high-quality comprehensive health care that is often lacking for children with ADHD.³⁷ Children in the predominantly-developmental-disorders class are nearly certain to need or receive school services. Previous research by Cooley and colleagues³⁸ has shown that a collaboration between school and medical professionals yields good outcomes, including appropriate referrals. Children in the predominantly-internalizing-disorders class may be more likely than others to need medication. In circumstances where the child has severe mood or anxiety disorders, which could alter the treatment of ADHD, AAP guidelines recommend primary care clinicians seek support and guidance from subspecialists for assessment and management. Pediatric primary clinician-child psychiatric collaborations³⁹ have been shown to decrease unmet psychiatric needs among this population of children.⁴⁰ Taken together, these findings contribute to the characterization of the ADHD phenotype and relate 4 classes of clinical presentation to functional outcomes and treatment usage.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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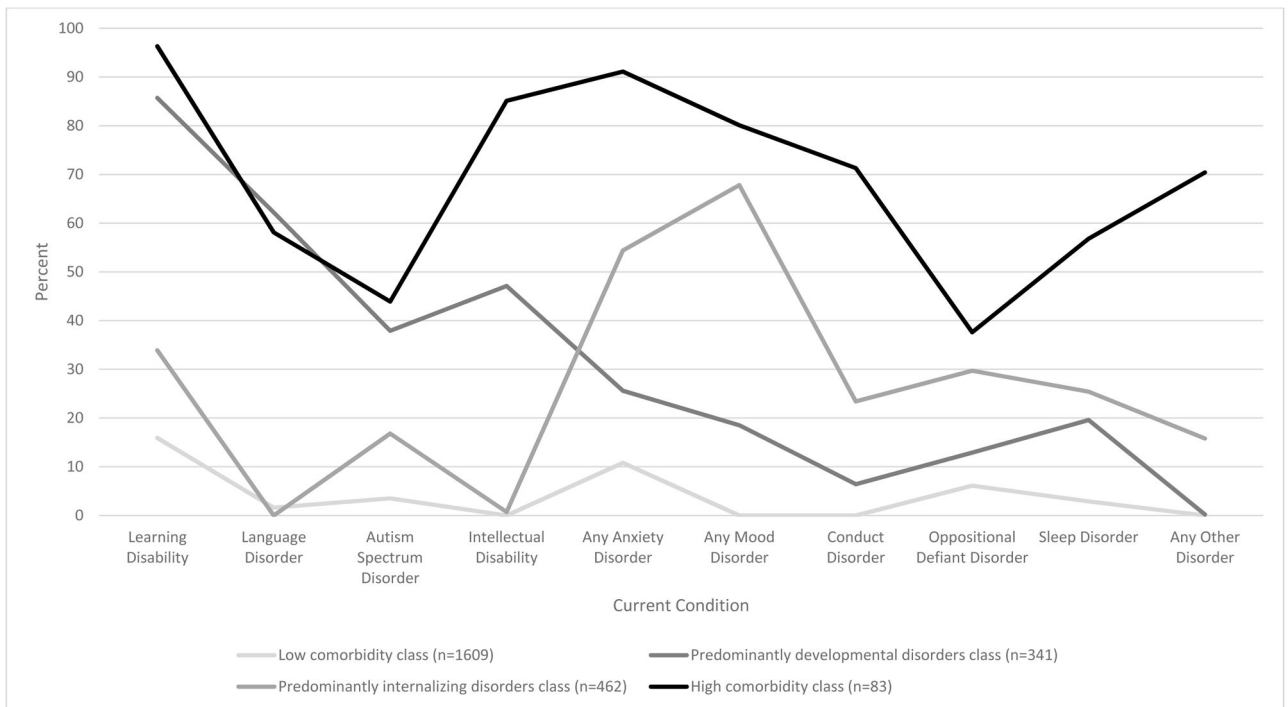


Figure 1. Prevalence of mental health conditions in children with current ADHD, by class

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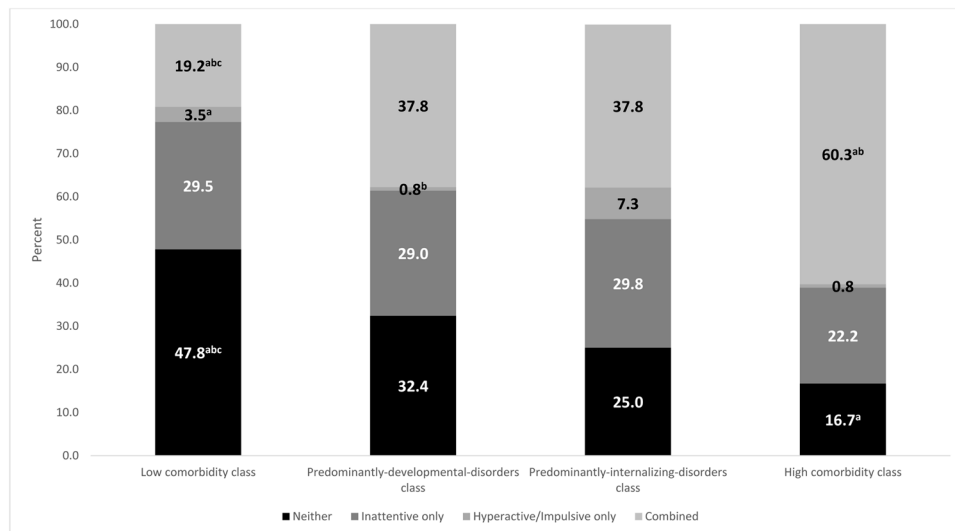


Figure 2. ADHD subtype among children with current ADHD, by class

Notes: ^a significantly differs from predominantly-developmental-disorders class ($p < .05$);

^b significantly differs from predominantly-internalizing-disorders class ($p < .05$);

^c significantly differs from high comorbidity class ($p < .05$)

Table 1

Characteristics of children with current ADHD, by class membership

	Low comorbidity class (n=1609) % (SE)	Predominantly-developmental- disorders class (n=341) % (SE)	Predominantly-internalizing- disorders class (n=462) % (SE)	High comorbidity class (n=83) % (SE)	F-value
<i>Child characteristics (%)</i>					
Age group					1.53
4–11 years	32.4 (2.0)	40.0 (4.7)	36.7 (4.1)	22.4 (7.6)	
12–17 years	67.6 (2.0)	60.0 (4.7)	63.3 (4.1)	77.6 (7.6)	
Male	71.9 (2.0)	72.2 (4.2)	65.3 (3.9)	64.7 (8.8)	0.96
Race/ethnicity					2.15*
Non-Hispanic white	65.8 ^c (2.2)	62.4 (4.7)	59.9 (4.2)	33.1 ^{ab} (8.6)	
Non-Hispanic black	13.3 ^c (1.7)	16.3 (3.5)	14.8 (3.1)	38.4 ^{ab} (9.5)	
Non-Hispanic other	6.5 (1.0)	5.5 (2.1)	8.0 (1.9)	11.6 (4.7)	
Hispanic	14.4 (1.7)	15.8 (3.8)	17.3 (3.7)	17.0 (7.8)	
Insurance type					22.27***
Public	37.4 ^{abc} (2.2)	62.7 (4.5)	68.2 (3.6)	90.8 ^{ab} (4.0)	
Private	60.3 ^{abc} (2.3)	36.9 (4.5)	31.4 (3.6)	7.3 ^{ab} (3.7)	
Uninsured	2.3 ^b (0.8)	0.4 (0.4)	0.4 (0.2)	1.9 (1.4)	
<i>School characteristics (%)</i>					
School type					1.23
Private	9.0 (1.0)	9.9 (2.8)	6.1 (1.9)	4.5 (2.7)	
Public	89.3 (1.2)	88.3 (2.9)	90.8 (2.3)	88.7 (5.5)	
Home	1.7 (0.6)	1.9 (0.8)	3.1 (1.3)	6.8 (4.8)	
School population					15.49***
General	94.9 ^{abc} (1.0)	74.0 (4.5)	83.8 (3.4)	73.1 (9.1)	
Special needs	5.1 ^{abc} (1.0)	26.0 (4.5)	16.2 (3.4)	26.9 (9.1)	

	Low comorbidity class (n=1609) % (SE)	Predominantly-developmental- disorders class (n=341) % (SE)	Predominantly-internalizing- disorders class (n=462) % (SE)	High comorbidity class (n=83) % (SE)	F-value
<i>Household characteristics (%)</i>					
Region					1.69
Northeast	13.7 (1.3)	11.8 (2.7)	23.2 (3.6)	14.8 (7.1)	
Midwest	22.1 (1.4)	23.4 (4.1)	22.7 (3.2)	23.7 (7.3)	
South	44.6 (1.9)	46.5 (4.6)	37.1 (3.8)	56.7 (9.0)	
West	19.5 (1.5)	18.2 (3.5)	17.0 (2.9)	4.7 (2.2)	
Federal poverty level					7.47***
<100%	20.1 ^{abc} (2.1)	35.1 (5.0)	38.8 (43)	64.3 ^{ab} (8.4)	
100% – 199%	20.6 ^b (1.9)	20.8 (4.0)	29.4 (3.8)	18.8 (6.3)	
200% – 399%	31.2 ^{bc} (2.1)	24.7 (4.1)	19.2 (3.0)	12.7 (5.7)	
400%	28.1 ^{abc} (1.9)	19.4 (3.4)	12.3 (2.3)	4.2 (3.6)	
Highest education individual					4.77***
Less than high school	14.6 ^c (1.7)	21.2 (4.3)	21.0 (3.6)	52.6 ^{ab} (10.2)	
High school	37.2 (2.2)	31.3 (4.4)	36.3 (4.0)	32.2 (9.3)	
More than high school	48.2 ^c (2.3)	47.5 (4.9)	42.6 (4.1)	15.2 ^{ab} (5.2)	
Household type					6.58***
Two parent household	66.5 ^b (2.2)	63.5 ^b (4.6)	45.7 (4.1)	56.0 (9.4)	
Other	33.5 ^b (2.2)	36.5 ^b (4.6)	54.3 (4.1)	44.0 (9.4)	
Housing situation					7.99***
Own	65.6 ^{bc} (2.2)	56.3 (4.9)	44.7 (4.0)	28.9 ^d (7.2)	
Rent	32.5 ^{abc} (2.2)	43.5 ^b (4.9)	51.2 (4.1)	69.0 ^d (7.4)	
Other	1.9 ^d (0.6)	0.2 ^b (0.2)	4.1 (1.9)	2.1 ^d (1.4)	

Notes.

* $p < .05$

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 d

d significantly differs from predominantly-developmental-disorders class ($p < .05$);

b significantly differs from predominantly-internalizing-disorders class ($p < .05$);

c significantly differs from high comorbidity class ($p < .05$)

SE: standard error

Table 2
Treatment and service usage among children with current ADHD, by class membership

	Low comorbidity class (n=1609) % (SE)	Predominantly-developmental- disorders class (n=341) % (SE)	Predominantly-internalizing- disorders class (n=462) % (SE)	High comorbidity class (n=83) % (SE)	F-value
Current medication	63.9 ^b (2.2)	65.1 (4.6)	77.5 (3.5)	68.7 (8.8)	2.85 [*]
Current school services	53.5 ^{ab} (2.2)	93.7 ^b (2.2)	73.2 (3.7)	79.0 ^d (7.8)	23.86 ^{***}
Current psychosocial treatment	18.1 ^{abc} (1.7)	59.1 ^b (4.7)	46.2 (4.3)	75.7 ^b (7.9)	38.38 ^{***}
Formal educational plan ^f	42.9 ^{ab} (2.2)	90.0 ^b (2.8)	63.9 (4.0)	69.5 (8.9)	35.53 ^{***}

Notes:

^{*} $p < .05$

^{***} $p < .001$

^f Formal education plans include Individualized Education Programs (IEPs) or 504 plans

^a significantly differs from predominantly-developmental-disorders class ($p < .05$);

^b significantly differs from predominantly-internalizing-disorders class ($p < .05$);

^c significantly differs from high comorbidity class ($p < .05$)

SE: standard error