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Predictors of Autism Spectrum Disorder and ADHD: Results from the National Survey of Children's Health

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Abstract

Background: Autism spectrum disorder (ASD) and Attention-Deficit/Hyperactivity Disorder (ADHD) are two of the most common neurodevelopmental disorders with comorbidity rates of up to 70%. Population-based studies show differential rates of ADHD and ASD diagnosis based on sociodemographic variables. However, no studies to date have examined the role of sociodemographic factors on the likelihood of receiving an ADHD, ASD, or comorbid ASD+ADHD diagnosis in a large, nationally representative sample.

Objective: This study aims to examine the impact of sociodemographic factors on the odds of experiencing ASD-only, ADHD-only, or both diagnoses for children in the United States.

Methods: Using a mixed effects multinomial logistic modeling approach and data from the 2016–2018 National Survey of Children's Health, we estimated the association between sociodemographic variables and the log odds of being in each diagnostic group.

Results: Sociodemographic variables were differentially related to the three diagnostic groups: ASD-only, ADHD-only, and ASD+ADHD. Compared to girls, boys experienced higher odds of all three diagnosis categories. White children had higher odds of having an ADHD-only or ASD+ADHD diagnosis compared to Non-Hispanic (NH) Black, NH multiple/other race, and Hispanic children. Odds ratios for levels of parent education, household income, and birth characteristics showed varying trends across diagnostic groups.

Conclusions: Overall, our findings point to unique sets of risk factors differentially associated ASD and ADHD, with lower income standing out as an important factor associated with receiving a diagnosis of ASD+ADHD.

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Keywords

Autism spectrum disorder; ADHD; National Survey of Children's Health

Introduction

Autism spectrum disorder (ASD) and Attention-Deficit/Hyperactivity Disorder (ADHD) are two of the most common neurodevelopmental disorders, but their etiologies remain largely unknown. ASD is characterized by difficulties with social communication and the presence of restricted interests and repetitive behaviors, while ADHD is characterized by difficulties with attention, impulse-control, and hyperactivity[1]. ASD and ADHD have a surprisingly high comorbidity rate[2,3] and share characteristics such as behavioral difficulties and impairments in social and academic domains. Studies have revealed shared genetic factors between these two disorders[4], and being diagnosed with either disorder increases the likelihood of being diagnosed with both disorders later in life[5]. Children diagnosed with comorbid ASD and ADHD experience more severe symptoms, such as more challenging behaviors and anxiety, and worse outcomes than children diagnosed with ASD or ADHD alone[5].

Population-based studies show discrepancies in the odds of receiving an ADHD and/or ASD diagnosis based on sociodemographic variables, such as race and ethnicity. Literature on ADHD diagnosis by race shows inconsistent results. For example, an early study of ADHD risk factors showed that Black children were more likely to be diagnosed with ADHD than white children[6]. However, more recent studies show that odds of diagnosis are lower among racial minorities (e.g., Black and Hispanic) compared to white children[7–9]. Further, higher odds of ADHD have been associated with other socially disadvantaged groups, such as children with lower levels of maternal education[10,11]. Regarding ASD, Black children experience lower odds of diagnosis than white children[12], which may be due to consequences of systemic racism (e.g., reduced access to health care, clinician bias, and decreased trust in medical providers[13]). A recent study of co-occurring ASD and ADHD shows that white children are significantly more likely to be diagnosed with comorbid ASD and ADHD than non-white children[14]. A range of other demographic factors have also been associated with both disorders, such as child's sex, intellectual disability, and ethnicity[15–17]. Families with lower socioeconomic status (SES) also show lower rates of ASD diagnosis[15,18]. Similarly, studies have shown that children from families of lower SES experience later diagnoses of ASD[19]. Studies outside the United States show a different pattern of results[18,20]. Regarding ADHD, some studies show a link between low SES and greater odds of being diagnosed with ADHD[21]. Finally, birth characteristics such as preterm birth and low birthweight have also been associated with increased diagnoses of both disorders[22].

Despite the documented links between ADHD/ASD and different sociodemographic variables, there is a relative lack of population-based studies that consider multiple diagnostic groups in relation to relevant sociodemographic factors. Most studies regarding risk factors of ADHD or ASD consider only a single diagnosis or compare the two

diagnoses. Few studies consider associations between demographic variables (e.g., race, SES, birth characteristics) and four mutually exclusive diagnostic outcomes (ASD-only, ADHD-only, both ASD and ADHD [ADHD+ASD], and neither ASD nor ADHD). Our study builds on existing work and leverages a large population-based survey, the National Survey of Children's Health (NSCH), with a mixed effects multinomial logistic modeling approach to examine the impact of race/ethnicity and SES characteristics on the odds of experiencing ASD-only, ADHD-only, both ASD and ADHD (ASD+ADHD), or neither diagnosis for children in the United States.

Methods

Data Source

The data for this study comes from the 2016–2018 National Survey of Children's Health (NSCH). In recent years, the Census Bureau has directed and administered the NSCH. To collect data for the survey, the Census Bureau randomly samples households to find homes with children aged 0–17. If a household has children, one child is randomly selected to be the survey participant. Parents of the child answer questions, either via mail or a web-based implementation of the survey, that span a wide array of topics including, but not limited to, physical and mental health, access to quality health care, and family, neighborhood, school, and social contexts. The survey oversamples children with special health care needs and children younger than six years old. To be eligible, children must be living in the home at the time of the survey[23].

We used the NSCH for years 2016 (n=50,212), 2017 (n=21,599), and 2018 (n=30,530). The weighted overall response rate was 40.7% in 2016, 37.4% in 2017, and 43.1% in 2018. Only children older than five years of age were included in our analytic sample, as most children are not diagnosed with ADHD until after the age of five. Participants with missing data on any outcome or predictor variables were excluded.

Outcome Variable

We defined a four-level outcome variable capturing ASD and ADHD status using two identification questions from the NSCH survey, each asking whether the parent has ever been told by a doctor or other health care provider that they have ADHD or ASD. Response options were ‘‘Yes, currently", "Yes, not currently", and "No". If a participant's answer was either of the "Yes" responses to both questions, we coded this survey participant as having "Both ADHD and ASD" (ADHD+ASD). If a participant answered one of the "Yes" responses to the ADHD question and "No" to the ASD question, we coded the participant as having "ADHD only". We created an analogous coding for "ASD only". Finally, if a participant answered "No" to both questions, we coded this participant as having "Neither ADHD nor ASD".

Independent Variables

Our study's independent variables included: biological sex, highest parental educational attainment (either parent), race/ethnicity, and household income. Due to small cell counts in several race categories, the following categories were combined for analysis: Asian,

American Indian/Alaska Native, Native Hawaiian/Other Pacific Islander, Multiple Races, and Other. In addition, three dichotomous variables were included: low birthweight (<2500 grams), preterm birth (<37 weeks gestation), and intellectual disability.

The biological sex variable recorded sex of the child at birth. The parental educational attainment variable captured education level, such as less than high school education, high school education or General Educational Development (GED) completion, some college education, or college completion. The race/ethnicity variable identified whether children were Hispanic, non-Hispanic (NH) Black, NH white, or NH multiple/other race. Household income was defined as the percentage bracket a household's income belonged to relative to the federal poverty level (FPL) as follows: 0%−199%, 200%−299%, 300%−399%, or ≥ 400% of the FPL. The intellectual disability variable indicated whether a parent had ever been told that their child had intellectual disability.

Statistical Analysis

To assess the relation between the four outcome categories (ADHD+ASD, ADHD-only, ASD-only, Neither) and the independent variables, we used a weighted multinomial logistic mixed effects regression model. This approach is adequate for outcomes with more than two discrete categories. For each outcome category, the model estimates the association between the independent variables and the log odds of being in each diagnostic group compared to the reference diagnostic group (having neither ADHD nor ASD). Additionally, the multinomial framework allows for Type III statistical tests that compare log odds across diagnostic group within given levels of the independent variables. The NSCH samples children from the U.S. according to a complex survey design, where children are sampled for survey participation with unequal probability. To account for this inverse probability weighting with the NSCH, we used survey weights, which allows analyses to be generalizable to the population of 5- to 17-year-old children in the U.S. Specifically, we followed guidance to from the Census Bureau and accounted for two strata for each state[24]. To do so, we first rescaled child-level weights as described by Carle and Rabe-Hesketh and Skrondal[25,26]. Then, to create state-stratum weights, we aggregated the rescaled child-level weights for each state-stratum combination as in Goldstein[27]. Our multinomial model then utilized pseudo-maximum-likelihood estimation, which accommodated the use of weights at different levels of the model (here, child and state-stratum levels)[26–28]. A final important aspect of the analysis is the use of fixed and random effects in the multinomial model. Fixed effects capture the average effect of the sociodemographic variables across all the children in the study sample, while random effects control for any remaining variability in these factors. In our study, we use a random intercept at the state and stratum combination level to control for any state-to-state variability in the sociodemographic factors not captured by the fixed effects.

In the statistical analysis, we first examined weighted proportions of children within the diagnostic groups and the independent variables. Differences were tested using weighted chi-square tests. Next, we fitted crude univariate multinomial models with a random intercept (state-level) for each independent variable on diagnostic group. In the last step, to account for the relationships between the independent variables, we fitted a fully

adjusted model, which included all independent variables in a mixed effects multivariable multinomial logistic regression. All weighted mixed effects models were fitted using PROC GLIMMIX (SASv9.4; SAS Institute Inc, 2013). We also conducted sensitivity analyses where age was incorporated.

Results

The 2016–2018 NSCH datasets included 102,341 children. After excluding n=8,969 with missing data and n=22,459 outside of age range, the final sample was n=70,913 children. Table 1 shows the descriptive weighted proportions and unweighted counts of children for each independent variable within the three diagnostic groups and the reference group (having neither ADHD nor ASD). There was approximately the same proportion of females and males in the sample; however, higher proportions of males were observed within the three diagnostic groups. More than half of the study participants were white, and this race/ethnicity group was also the majority within each diagnostic group and the reference group. In regard to education, children with parents with higher education levels (i.e., completed college) formed the majority of the study sample, and this trend remained constant within the diagnostic and reference groups. Both overall and within the diagnostic groups, there were higher proportions of children from households with incomes within 0–199% and greater than 400% of the FPL. Finally, children without the preterm, low birthweight, and intellectual disability status formed most of the total sample and within group proportions. The average age across the diagnostic and reference groups ranged from 10.4–11.9 and was 11.0 years old overall.

Table 2 shows the results of the univariate models, indicating a significant impact of all variables on the outcome. For all three diagnostic groups, the unadjusted odds ratio for girls indicated lowers odds of ADHD-only, ASD-only, or ADHD+ASD compared to boys. For Black, Hispanic, and multiple/other race children, the odds of having ADHD-only or ADHD+ASD were significantly lower compared to white children (confidence intervals exclude value of 1). In contrast, Hispanic children were observed to have significantly higher odds of being diagnosed with ASD-only compared to white children. There was no significant difference in the odds of receiving an ASD-only diagnosis for children of Black or Multiple/Other races. For children with parents with high school or some college education, the odds of ADHD-only, ASD-only, and ADHD+ASD were significantly higher than for children with parents with completed college education. Children with parents with less than high school education had significantly lower odds of ADHD-only and ASD-only compared to children with parents with college education, however, their odds of having ADHD+ASD were significantly higher than those of children with parents with college education. For children with preterm births, low birthweight, and intellectual disability, the odds were significantly higher across all diagnostic groups compared to children without these characteristics.

Figures 1 and 2 show the adjusted odds ratios (ORs) of the full mixed effects multivariable multinomial logistic regression model, with 95% confidence intervals. Confidence intervals that cross the horizontal null line indicate statistical non-significance, (p-value > 0.05). To contextualize the meaningfulness of statistically significant ORs, we compare them against

small, medium, and large effect sizes (ORs = 1.68, 3.47, and 6.71, respectively)[29]. The Type III hypothesis tests comparing ORs across diagnostic groups were significant for all independent variables and all variable levels. For the race/ethnicity variable, Figure 1 shows that white children experience higher odds of having ADHD-only (NH Black OR: 0.89, CI: 0.80–0.99, Hispanic OR: 0.67, CI: 0.61–0.74, NH Multiple/Other OR: 0.61, CI: 0.54–0.70), and higher odds of having ADHD+ASD (NH Black OR: 0.64, CI: 0.49–0.84, Hispanic OR: 0.69, CI: 0.56–0.86, NH Multiple/Other OR: 0.62, CI: 0.46–0.86) versus neither condition. However, a different trend is observed for the ASD-only diagnosis, where NH Black children have lower odds (OR: 0.88, CI: 0.77–1.00) than white children, whereas Hispanic children have higher odds (OR: 1.44, CI: 1.18–1.75) than white children, with a non-significant odds ratio for NH Black children or children of multiple/other races. Although statistically significant, these results correspond to very small-to-small effect sizes. Females had lower odds than males of experiencing ADHD-only (OR: 0.44, CI: 0.41–0.47), ASD-only (OR: 0.20, CI: 0.16–0.24), and ADHD+ASD conditions (OR: 0.31, CI: 0.26–0.37), with the lowest odds for ASD-only diagnosis, second lowest odds for both diagnoses, and third lowest odds for ADHD-only diagnosis. These ORs correspond to small-to-medium effect sizes.

For the parental educational attainment variable, odds ratios between the levels of education have varying trends across the diagnostic groups (Figure 1) and correspond to very small-to-small effect sizes. The odds of ADHD-only are higher for children whose parents have high school or some college education (high school OR: 1.22, CI: 1.11–1.35, some college OR: 1.34, CI: 1.23–1.47) compared to children whose parents have completed college. Alternatively, children whose parents have less than high school or high school education have lower odds of ASD (less than high school OR: 0.50, CI: 0.36–0.69, high school OR: 0.82, CI: 0.65–0.1.03) than children whose parents have completed college. When examining the odds of having ADHD+ASD, there were no significant differences between children of parents who completed college and children of parents with less than high school education, high school education, or some college education.

For household income in terms of the FPL, trends in odds ratios varied across the diagnostic groups (Figure 1) and correspond to small effect sizes. For children from households with income within 0%−199% of the FPL, the odds of having ASD-only and ADHD+ASD conditions were significantly higher (ASD OR: 1.75, CI: 1.40–2.18, ADHD+ASD OR: 1.75, CI: 1.38–2.21) than for children from households with incomes ≥ 400% of the FPL. There was no significant difference within the diagnostic groups between children in the 200%−299% FPL range and those in the ≥ 400% range. The odds of having ASD-only or ADHD+ASD were higher (ASD OR: 1.31, CI: 1.00–1.72, ADHD+ASD OR: 1.57, CI: 1.20–2.06) for children in the 300%−399% FPL range compared to those in the ≥ 400% range, whereas the odds of having ADHD-only were lower (OR: 0.84, CI: 0.74–0.94) for these same children.

The impact of clinical variables was highly significant as illustrated in Figure 2 and translated to large effect sizes for some variables. Low birthweight raised the odds of experiencing ADHD-only (OR: 1.18, CI: 1.04–1.33) whereas the odds ratios for the other diagnostic groups were non-significant. Children born prematurely had higher odds than

children born at term in all diagnostic groups (ADHD OR: 1.35, CI: 1.21–1.50, ASD OR: 1.30, CI: 1.02–1.66, ADHD+ASD OR: 2.47, CI: 1.98–3.08), with the highest odds for the diagnostic group with both conditions. Finally, for children with an intellectual disability (ID), the odds of ADHD-only were notably higher (OR: 4.62, CI: 3.58–5.96) than for children without ID, however, for ASD-only and ADHD+ASD these odds were much higher (ASD OR: 40.54, CI: 31.28–52.53, ADHD+ASD OR: 46.06, CI: 35.73–59.38). Finally, the sensitivity analysis including the age variable did not change the model results for the other independent variables and had a ratio close to one for age (results omitted for brevity). As a result, we did not include age in the final multivariable model.

Discussion

The goal of this study was to examine sociodemographic factors associated with the odds of being diagnosed with ASD-only, ADHD-only, or both ASD and ADHD (ASD+ADHD). This is the first study, to our knowledge, to simultaneously compare sociodemographic factors across these diagnostic groups within the same statistical framework (multinomial regression). The multinomial framework offers advantages over conducting multiple but separate logistic regressions in that it enabled hypothesis testing across diagnostic groups and within levels of independent variables. In regard to sex, females were observed to have lower odds of all three diagnoses. Between diagnostic groups, the odds of females receiving a diagnosis of ADHD-only was higher compared to ASD-only and ASD+ADHD. This is unsurprising, as the male-to-female sex ratio of diagnosis for ADHD (2–3:1) is lower than ASD (3–4:1) and previous studies have found similar ratios for those diagnosed with ASD-only compared to those with ASD+ADHD[30].

Birth circumstances also had a substantial impact on diagnosis. Lower birthweight was significantly associated with increased odds of ADHD-only, but not ASD-only or ASD+ADHD. Preterm birth was associated with all three diagnostic groups but had a significantly greater impact on ASD+ADHD compared to ADHD-only and ASD-only. This suggests that preterm birth puts infants at greater risk for ASD+ADHD and, albeit to a lesser degree, ASD-only and ADHD-only. In contrast, birthweight had an isolated impact on ADHD-only diagnoses, consistent with existing literature showing a stronger association between birthweight and ADHD compared to birthweight and ASD[31]. Intellectual disability had the greatest impact on odds of ASD+ADHD, a smaller impact on ASD-only, and a smaller but still significant impact on ADHD-only diagnoses.

Regarding race/ethnicity, we found unique associations with diagnostic groups. First, children with a minority status, including Black, non-white Hispanic, mixed/other non-white race/ethnicities, evidenced lower odds of ADHD-only and ASD+ADHD compared to white children. However, Hispanic children demonstrated higher odds of an ASD-only diagnosis compared to white children. This contrasts with some existing literature showing that Hispanic children have lower odds of being diagnosed with ASD compared to white children[15,19]. However, this literature should be viewed in light of other studies showing that Hispanic children with ASD may be diagnosed at earlier ages compared to white children with ASD[32,33] and recent studies showing that prevalence rates of ASD in Hispanic children are accelerating and, in some places, exceed the prevalence rate of white children[25,26].

Moreover, our analytic approach leveraged mutually exclusive diagnostic groups in which the ASD-only group excluded children with ASD+ADHD, making our results difficult to compare to other studies that grouped children with ASD and ASD+ADHD together. Finally, this study did not examine the vastly heterogenous language and cultural differences within Hispanic families that have been shown to contribute to the likelihood of being diagnosed with ASD[32]. The etiology of ASD and ADHD is thought to be complex with a strong genetic component that is independent of race/ethnicity[34]. Thus, observed differences in diagnostic rates or odds across the socioeconomic strata are likely related to broader health disparities or social inequities in access to healthcare. Our observations of lower odds of ADHD-only and ASD+ADHD for all minority groups reflect a possible disparity in access to referral and diagnostic services for ADHD that is supported by prior work in this area[35,36].

Diagnostic odds across parental education levels and income illustrate complex associations. Families with the lowest educational attainment experience lower odds of an ASD-only diagnosis. We hypothesize that this may be related to the link between parental education and healthcare disparities. Families in lower educational strata may experience decreased access to healthcare services and thus, may be less likely to receive a diagnosis for their child from a medical professional. Children from families in the middle educational strata, with a high school diploma or some college, show higher odds of ADHD-only compared to college-educated families. This finding could again be related to genetic underpinnings of ADHD, with adults with ADHD (who are more likely to have children with ADHD) generally achieving lower levels of education[37]. The finding that the odds of ADHD-only diagnoses are not significantly different among families with the lowest and highest education could reflect an interaction between healthcare disparities and familial liability. Families with lower education may experience decreased access to diagnostic services, as well as increased familial liability for ADHD, whereas families with higher education may experience increased access to diagnostic services but decreased familial liability for ADHD. More targeted studies may be able to disentangle these effects.

Regarding income, the lowest income group showed increased odds of ASD-only and ASD+ADHD diagnoses compared to the highest income group. This contrasts with literature showing lower odds of ASD in low-income families[15,18]. From a heritability perspective, studies have shown that adults with ADHD and ASD make less income compared to adults without these disorders[38,39]; likewise, both ASD and ADHD run in families, with parents with ASD-features also more likely to have children with ASD [39]. Families with fewer resources, evidenced by lower income, may be at the greatest risk not only for ASD-only, but for the more severe presentation of ASD+ADHD and later intervention. This points to the need for greater supports and earlier interventions for lower income families[38,40]. Moreover, families with a history of ADHD and/or ASD, especially those with lower income, should be targeted for increased screenings to ensure equitable access to care.

Overall, our findings point to an important factor associated with comorbid ASD+ADHD – lower income. Interestingly, the odds of comorbid ASD+ADHD were lower for non-white children (except for Hispanic children). These findings may reflect the complex dynamics

among race, income, and education. We find that children are more likely to be diagnosed with ASD+ADHD at the lowest range of the economic strata, compared to the highest range. This is consistent with literature showing that clinical severity of those with ASD, including comorbid diagnoses (i.e., ASD+ADHD), is related to family resources with fewer resources being associated with increased severity[41]. When controlling for resource-related variables in models that predict diagnosis from race/ethnicity, however, it appears that minority status is associated with *lower* odds of ASD+ADHD. This same pattern was observed for ADHD-only diagnoses, suggesting that this finding may be driven by lower likelihood of minoritized children to be diagnosed with ADHD, regardless of a comorbid ASD diagnosis. There are at least three possible interpretations of this finding. First, it could be that decreased ADHD diagnoses among minoritized children reflect barriers in access to healthcare, even when there is also an ASD diagnosis present. Second, it could be related to the higher prevalence of mental health stigma in Black and other non-white populations[42], contextualized by systemic racism, resulting in minoritized families being less likely to seek out ADHD diagnoses. Finally, previous work has shown that minoritized children with behavior challenges are more likely to be diagnosed with conduct disorder or disruptive behavior disorder instead of ADHD when compared to white children[35,36]. These potential explanations should be explored in future research.

It is interesting that the factors associated with ASD+ADHD did not consistently follow the same pattern of findings for ASD-only group. Particularly, educational attainment had a clear differential effect on ASD-only versus ASD+ADHD where, for the lowest educational group, the odds of ASD-only were significantly lower. This point merits further research and can possibly be explained by additional risk factors that were not included in the data for this study.

The use of parent reported diagnosis as the primary outcome variable in this study warrants important discussion. Gathering parent report of child diagnoses is a cost-effective way to establish prevalence rates in a large population, as having clinicians confirm diagnoses through direct assessment or medical record review can be a time and resource intensive process. However, parent report is not a robust proxy for the prevalence of these disorders. It is possible that parents misremember their child's diagnosis and providers may not communicate diagnoses clearly. Further, it is important to consider sociodemographic factors that influence healthcare access and diagnosis seeking. Barriers to healthcare exist for racial minorities and families of lower SES. For example, racial minority and lower income families may be less likely to obtain, and therefore report, a diagnosis due to barriers such as cost, and lack of translators for non-English speaking families. On the other hand, families with higher levels of education and income may be more likely to seek out a diagnosis of ASD or ADHD. Thus, this data may underestimate diagnostic prevalence differentially across groups.

This paper limited the sample to children who were between the ages of 5 and 17 at the time of data collection. Thus, this study does not consider young children or adults with either disorder. Further, although statistically significant, results of this study yielded some very small to small effect sizes based on Cohens *d*[43]. It is important to acknowledge that effect sizes should be interpreted based on context of current study methods, existing literature in

the field, and potential health and policy limitations. Further research is needed to replicate these findings.

This study investigated income by separating participants into four categories based on the federal poverty line. However, household income is a largely complex topic and future studies should consider including other variables that contribute to household income, including housing costs and measures of household composition such as the OECD equivalization scale[44]. Given the response rate for the NSCH, which ranges from 37–44%, it is possible that individuals who responded to the questionnaire differ from individuals who did not respond, which may introduce unintentional bias to the dataset. However, many studies that use the NSCH report similar response rates, and data from these studies continue to be used to inform policy by providing population-based information about these disorders[45,46]. In addition, data for this study was taken from a United States based survey and thus may not generalize to other countries. Due to the nature of parent reported diagnoses, it is also possible that children who were misdiagnosed with ASD, or ADHD, or diagnosed later in life, were missed by this survey. Finally, this study did not explore some variables that may have shed light on some of our findings (e.g., English proficiency).

Conclusion

This study points to specific sets of risk factors for receiving a diagnosis of ASD-only, ADHD-only, and ASD+ADHD. Children from racial and ethnic minorities had lower odds of receiving any of the three diagnoses, with the exception Hispanic children who were reported to have higher odds of an ASD-only diagnosis compared to white children. Lower parent household income was associated with ASD-only and ASD+ADHD diagnoses and birth characteristics were associated with all three diagnoses. These findings further our understanding of disparities in diagnoses of ASD, ADHD, and ASD+ADHD and can contribute to future research agendas and guidelines for equitable care for children of diverse backgrounds and further specification the relationship between ASD and ADHD.

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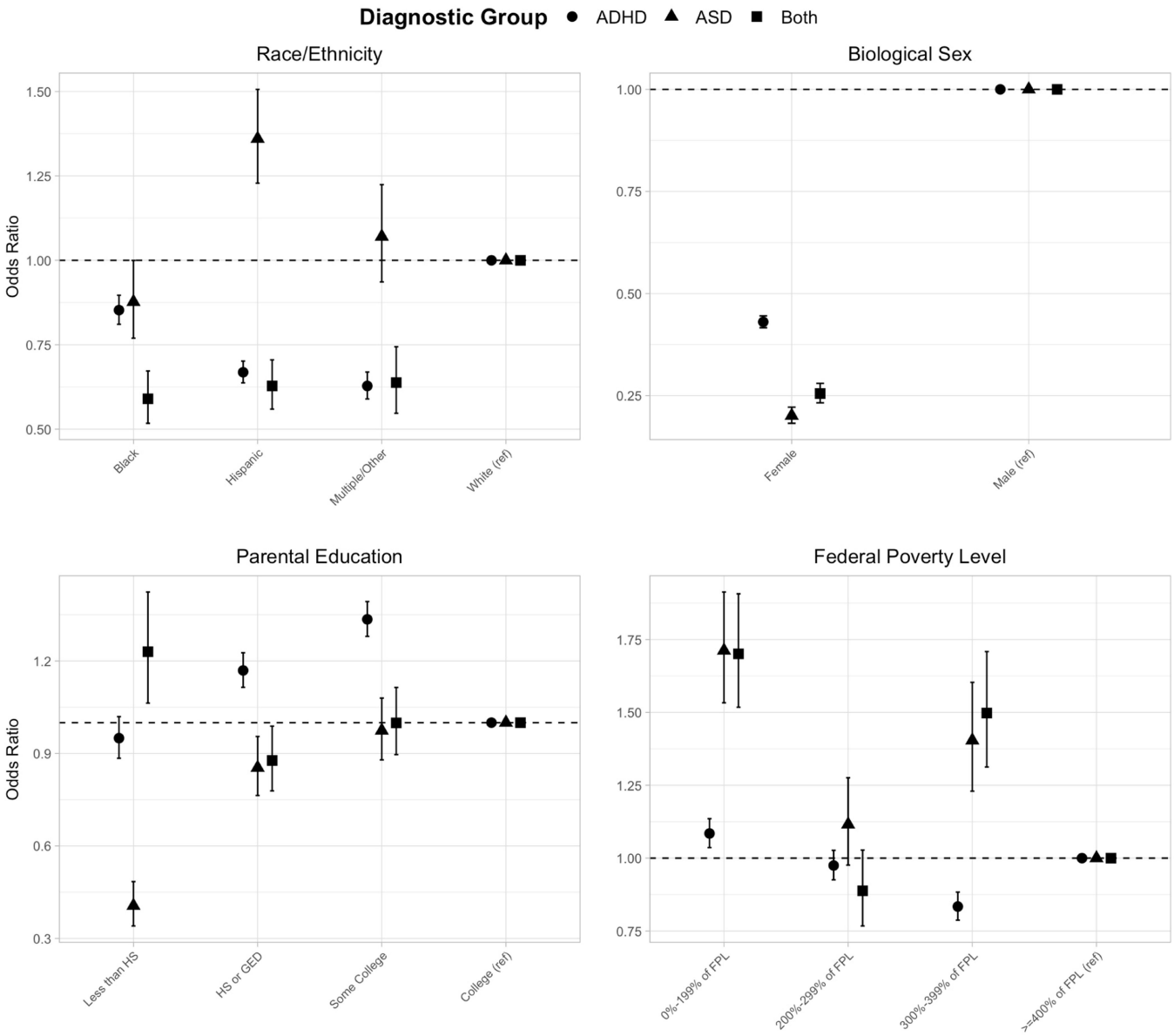

Figure 1: Results for Sociodemographic and Socioeconomic Variables from the Multivariable Mixed Effects Multinomial Logistic Regression Model

The solid horizontal line represents an odds ratio (OR) of one. Dotted horizontal lines represent the value for small effect sizes, and ORs above and below the dotted lines (on the positive and negative sides, respectively) correspond to small effect sizes. Dashed horizontal lines represent the value for medium effect sizes, and ORs above and below the dashed lines (on the positive and negative sides, respectively) correspond to medium effect sizes. Finally, long dashed horizontal lines represent the value for large effect sizes, and ORs above and below the long dashed lines (on the positive and negative sides, respectively) correspond to large effect sizes.

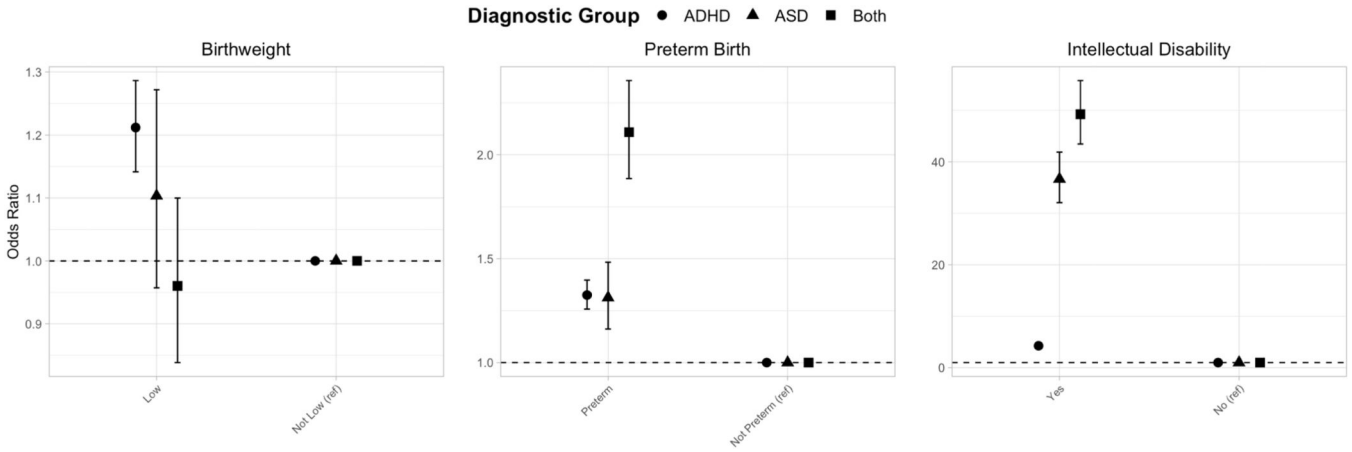

Figure 2: Results for Clinical Variables from the Multivariable Mixed Effects Multinomial Logistic Regression Model

The solid horizontal line represents an odds ratio (OR) of one. Dotted horizontal lines represent the value for small effect sizes, and ORs above and below the dotted lines (on the positive and negative sides, respectively) correspond to small effect sizes. Dashed horizontal lines represent the value for medium effect sizes, and ORs above and below the dashed lines (on the positive and negative sides, respectively) correspond to medium effect sizes. Finally, long dashed horizontal lines represent the value for large effect sizes, and ORs above and below the long dashed lines (on the positive and negative sides, respectively) correspond to large effect sizes.

Table 1

Descriptive Statistics for Independent Variables and Diagnostic Groups

Variable \ N (%)	Overall	ADHD Only	ASD Only	ADHD+ASD	Neither ADHD-ASD
Biological Sex					
Female	34279 (49.1)	2437 (31.9)	224 (18.3)	233 (22.3)	31385 (51.9)
Male	36634 (50.9)	4971 (68.1)	883 (81.7)	906 (77.7)	29874 (48.1)
Race/Ethnicity					
Hispanic	7722 (24.1)	706 (18.6)	140 (31.1)	117 (20.8)	6759 (24.7)
White	50342 (53.0)	5548 (59.8)	740 (46.8)	840 (59.3)	43214 (52.2)
Black	4173 (12.7)	495 (14.5)	68 (12.0)	64 (12.6)	3546 (12.5)
Asian	3426 (4.4)	91 (0.9)	61 (4.2)	33 (2.1)	3241 (4.8)
American Indian/Alaska Native	411 (0.4)	52 (0.5)	9 (0.5)	9 (0.5)	341 (0.4)
Native Hawaiian/Other Pacific Islander	177 (0.1)	11 (0.0)	4 (0.3)	0 (0.0)	162 (0.2)
Multiple Races	4163 (4.6)	462 (5.4)	80 (4.9)	72 (4.6)	3549 (4.5)
Other	499 (0.7)	43 (0.4)	5 (0.3)	4 (0.1)	447 (0.7)
Highest Parental Education					
Less than HS	1549 (9.0)	162 (7.2)	18 (6.4)	38 (13.2)	1331 (9.2)
HS or GED	9193 (19.7)	1112 (21.3)	136 (22.2)	171 (20.0)	7774 (19.5)
Some College	16689 (22.6)	2102 (27.0)	290 (24.6)	332 (22.2)	13965 (22.1)
College	43482 (48.8)	4032 (44.5)	663 (46.8)	598 (44.7)	38189 (49.3)
Federal Poverty Level					
0–199%	17996 (40.8)	2220 (43.1)	344 (49.3)	413 (50.1)	15019 (40.2)
200–299%	11191 (15.2)	1220 (15.4)	182 (13.2)	169 (10.4)	9620 (15.3)
299–399%	10529 (12.0)	966 (10.3)	157 (12.6)	174 (13.5)	9232 (12.2)
Greater than 400%	31197 (32.0)	3002 (31.2)	424 (25.0)	383 (25.9)	27388 (32.3)
Preterm Status					
Not Preterm Birth	62881 (88.1)	6262 (84.2)	920 (83.7)	909 (76.5)	54790 (88.8)
Preterm Birth	8032 (11.9)	1146 (15.8)	187 (16.3)	230 (23.5)	6469 (11.2)
Birthweight Status					
Low Birthweight	5797 (9.2)	751 (11.8)	139 (11.7)	160 (14.6)	4747 (8.8)
Not Low Birthweight	65116 (90.8)	6657 (88.2)	968 (88.3)	979 (85.4)	56512 (91.2)
Intellectual Disability Status					
No	70067 (98.8)	7256 (97.8)	930 (84.8)	933 (79.6)	60948 (99.5)
Yes	846 (1.2)	152 (2.2)	177 (15.2)	206 (20.4)	311 (0.5)
Variable \ Mean (Std. Dev.)	**Overall**	**ADHD Only**	**ASD Only**	**ADHD+ASD**	**Neither ADHD-ASD**
Age	11.0 (3.7)	11.9 (3.4)	10.4 (3.8)	11.7 (3.3)	10.9 (3.8)

All p-values <0.0001, NH = Non-Hispanic, HS = High School, GED = General Educational Development, Std. Dev. = Standard Deviation

Table 2

Results from Univariate Mixed Effects Multinomial Logistic Regression Models

	Type III P-Value	ADHD Only	ASD Only	ADHD+ASD	Neither ADHD-ASD
Biological Sex					
Female	<0.0001	0.43 (0.42–0.45)	0.21 (0.19–0.23)	0.27 (0.24–0.29)	REF
Male		REF	REF	REF	REF
Race/Ethnicity					
Hispanic	<0.0001	0.70 (0.67–0.74)	1.42 (1.29–1.56)	0.82 (0.74–0.90)	REF
NH Black		0.95 (0.91–1.00)	1.13 (0.99–1.27)	0.84 (0.75–0.95)	REF
NH Other/Multiple Race		0.63 (0.60–0.68)	1.04 (0.91–1.19)	0.63 (0.55–0.74)	REF
NH White		REF	REF	REF	REF
Highest Parental Education					
Less than HS	<0.0001	0.91 (0.86–0.97)	0.75 (0.64–0.87)	1.67 (1.50–1.91)	REF
HS or GED		1.18 (1.13–1.23)	1.24 (1.12–1.36)	1.14 (1.03–1.26)	REF
Some College		1.34 (1.29–1.39)	1.20 (1.09–1.31)	1.12 (1.02–1.24)	REF
College		REF	REF	REF	REF
Federal Poverty Level					
0–199%	<0.0001	1.08 (1.04–1.12)	1.65 (1.51–1.81)	1.60 (1.46–1.75)	REF
200–299%		1.01 (0.96–1.06)	1.14 (1.01–1.30)	0.86 (0.75–0.99)	REF
299–399%		0.85 (0.81–0.90)	1.37 (1.21–1.56)	1.39 (1.22–1.57)	REF
Greater than 400%		REF	REF	REF	REF
Preterm Status					
Not Preterm Birth	<0.0001	REF	REF	REF	REF
Preterm Birth		1.46 (1.40–1.53)	1.56 (1.41–1.73)	2.44 (2.23–2.67)	REF
Birthweight Status					
Low Birthweight	<0.0001	1.36 (1.29–1.43)	1.41 (1.25–1.58)	1.75 (1.58–1.95)	REF
Not Low Birthweight		REF	REF	REF	REF
Intellectual Disability Status					
No	<0.0001	REF	REF	REF	REF
Yes		4.36 (3.85–4.93)	35.10 (30.98–39.78)	51.18 (45.52–57.53)	REF

Type III P-Value is associated with an omnibus test for all the levels of the variable, NH = Non-Hispanic, HS = High School, GED = General Educational Development, Std. Dev. = Standard Deviation