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Association between vertigo, cognitive and psychiatric conditions in US children: 2012 National Health Interview Survey

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Abstract

Objectives—Small studies have suggested an association between vertigo and psychiatric comorbidity. The purpose of this study is to evaluate the associations between vertigo and cognitive and psychiatric conditions among a large sample of U.S. children.

Methods—We conducted a cross-sectional analysis of the 2012 National Health Interview Survey (NHIS) Child Balance Supplement administered to parents/caregivers of children aged 3–17 years. Multivariable logistic regression models were used to evaluate the association between vertigo and specific cognitive and psychiatric conditions.

Results—The 1-year prevalence of vertigo was 1.56% in this nationally-representative sample (N=10,823) of U.S. children aged 3–17 years. After adjusting for demographic and confounding health variables (otitis media and headaches/migraine), children with vertigo had significantly higher odds of attention deficit disorder (OR=1.73, 95%CI: 1.06–2.81), learning disability (OR=3.45, CI: 2.18), developmental delay (OR=2.59, CI: 1.34–4.98), intellectual disability (OR=6.60, CI: 2.60–16.79), and are more likely to utilize special education services (OR=2.46, CI: 1.48–4.10) relative to the rest of U.S. children. Children with vertigo also had higher odds of having difficulty with emotions, concentration, or behavior (OR=2.92, CI 1.85–4.61), and having a poor attention span (OR=1.68, CI: 1.01–2.80).

Conclusions—Vertigo is associated with significantly increased odds of cognitive and psychiatric comorbidity in U.S. children. These findings support the hypothesis that the vestibular system is important for normal cognitive and psychiatric development in children.

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Keywords

Vertigo; vestibular; pediatrics; psychiatry; cognition

1.1 INTRODUCTION

Dizziness and vertigo are not infrequent complaints among children. Several large population-based surveys in Finland, Scotland and the UK reported a 6–15% prevalence of these symptoms among children aged 5–15.[1–4] Vertigo is a specific kind of dizziness attributed to the vestibular system, and is defined as the sensation of rotary movement or spinning in the absence of true rotation. In children the most common causes of vertigo include vestibular migraine, benign paroxysmal vertigo of childhood (BPV), vestibular neuritis, and unknown or idiopathic.[5]

A number of studies have observed an association between vestibular dysfunction in children and indicators of cognitive ability, including school performance and the presence of learning disabilities. In a small Brazilian study, children with below-average school performance were more likely to have concurrent vestibular dysfunction compared to their peers.[6] Several other studies also reported an association between vestibular dysfunction and learning disabilities in children,[7–10] although there has been some question regarding the specificity of the vestibular tests used in these studies.[11] Animal studies and functional imaging experiments in humans have shown that vestibular information feeds into cortical networks that subserve visuospatial processing, spatial memory, and even numerical ability.[12–17] These neural connections could explain the observed associations between vestibular loss and poorer cognitive ability in children.

Vestibular disorders and vertigo have also been linked consistently to psychiatric conditions in adults, including depression and anxiety.[18–20] One reason for this link may be that the uncertainty surrounding the onset of vertiginous symptoms causes considerable anxiety.[21] Additionally, the substantial overlap in the neuroanatomical regions and neurotransmitters involved in regulating emotions and in processing vestibular information may underlie this association.[22–24] Small case-control studies in children have observed a higher prevalence of psychological distress among children with vertigo relative to asymptomatic children, although no large scale studies have measured rates of psychiatric disorders in children with vertigo.[25,26]

In this study, we evaluate the association between vertigo, cognitive function and psychiatric comorbidity using data from the National Health Interview Survey (NHIS). We investigated whether associations exist between vertigo and cognitive disorders including learning disability, attention deficit disorder (ADD), developmental delay, autism, and intellectual disability in children. We also examined whether an association exists between vertigo and psychiatric and emotional problems in children. These cognitive and psychiatric conditions exert a tremendous toll on children, their families and society, and identifying potentially modifiable risk factors may be of substantial public health benefit.

2.1 METHOD

The National Health Interview Survey (NHIS) is an annual household interview survey conducted by the National Center for Health Statistics (NCHS) to track health status among the non-institutionalized, civilian U.S. population. The survey has been continuously operating since 1957 with field staff supplied by the U.S. Census Bureau. Participants are selected using a complex stratification, multistage sampling, and a probability cluster sampling technique with over-sampling of minorities to improve the precision of statistical estimates. In addition to surveying adults, the NHIS administers health questions pertaining to a randomly chosen 'sample' child (≤17 years) in the household. Questions about the sample child are asked of an adult in the household who is knowledgeable about the child's health, usually a parent or other caregiver. With sponsorship from the National Institute on Deafness and Other Communication Disorders (NIDCD), the 2012 NHIS included a Child Balance Supplement, which was the first nationally-representative survey to include a broad range of questions on balance and dizziness problems in U.S. children aged 3–17. Data from the balance supplement are available from 10,954 children, of whom 10,823 have data on vertigo (113 unknown, not ascertained, 12 unknown, don't know, 6 unknown, refused). Participants provided informed consent, and participation was voluntary. The NHIS was evaluated and approved by the Research Ethics Review Board of the National Center for Health Statistics, and data are publically available online.[27]

2.2 Assessment of balance and vertigo

Questions about balance in the NHIS survey included 'During the past 12 months, has [child's name] been bothered by episodes of: 1) Vertigo, a spinning sensation like a Merry-Go-Round, 2) Poor balance, an unsteady or woozy feeling that makes it difficult to stand up or walk, 3) Problems with body or motor coordination or clumsiness, 4) Frequent falls, 5) Light-headedness, fainting, or feeling he/she is about to pass out, and 6) Any other type of balance or dizziness problems? We defined vertigo as a positive response to question 1. The other questions, about unsteadiness, clumsiness, falls, fainting, and 'other' balance problems are not specific for vestibular disease and were not included in the present analysis, and have been previously described.[28]

2.3 Assessment of cognitive function and psychiatric distress

Respondents were asked about cognitive diagnoses with the question: 'Has a doctor or healthcare provider ever diagnosed your child with: 1) autism, 2) attention deficit disorder, 3) learning disability, 4) developmental delay, 5) mental retardation' (referred to for the remainder of this paper as intellectual disability). Respondents were also asked if the child used special education services. Data on symptoms of cognitive impairment were elicited by asking respondents if their child's 'activities are limited by difficulty remembering or confusion.'

Questions regarding psychiatric and emotional distress were asked on a three-point scale: certainly true, somewhat true, and not true. Respondents were asked if, in the past six months, their child: 1) had difficulty with emotions, concentration, or behavior; 2) was often unhappy, depressed, or tearful; 3) often seemed worried; 4) had a good attention span and

finishes tasks; 5) was generally well-behaved. The answers to questions 1–3 were dichotomized as “certainly true” vs. “somewhat true” or “not true, while the answers to questions 4–5 were dichotomized as “not true” vs. “somewhat true” or “certainly true.” Respondents were asked if the child received special services due to an emotional problem.

2.4 Assessment of demographic and other health-related variables

Demographic data was obtained from the household adult respondent and included information on the child’s gender, race/ethnicity (White, Black, Asian, Other), and household income (in the categories ≤ $34,999, $35,000 - $74,999, $75,000 - $99,999, and ≥ $100,000). Respondents were also asked if their child had a history of three or more ear infections in the previous 12 months, or if they have had frequent or severe headaches or migraines in the past 12 months. A history of recurrent otitis media or headaches were included in all analyses given its potential role as confounders of the association between vestibular, cognitive and psychiatric function.

2.5 Statistical analysis

All analyses were weighted to account for the complex sampling methodology used by the NHIS, which allows for inferences generalizable to U.S. children aged 3–17. Multivariable logistic regression was used to estimate odds of cognitive and psychiatric conditions in children with vertigo compared to children without vertigo. All regression models were adjusted for age, sex, race/ethnicity, income, three or more ear infections in the previous 12 months, and headaches. In an attempt to account for other potential confounding comorbidities sensitivity analyses were performed adding to the model cerebral palsy, seizures in the past year, muscular dystrophy, deafness, trouble seeing, and Downs syndrome, and separately running the analysis again excluding those with these diagnoses. We also performed an age stratified analysis of those age 3–11, and 12–17. Statistical significance predefined as $p < 0.05$. All analyses were performed using STATA version 13 (Statacorp, College Station, TX).

3.1 RESULTS

The prevalence of vertigo stratified by age, sex, race/ethnicity and household income level in U.S. children aged 3–17 surveyed in NHIS is shown in Table 1. Overall, 1.56% of children aged 3–17 had vertigo in the past year, equivalent to 951,000 U.S. children. The 1-year prevalence of vertigo was 0.29% in pre-school children aged 3–5, 0.93% in children aged 6–11, and 2.82% in adolescents aged 12–17 ($p < 0.0001$). The prevalence of vertigo by each year of age shows (Figure 1) an overall increase in prevalence with age, peaking at age 15. The prevalence of vertigo did not vary significantly by sex, or family income, but the prevalence of vertigo was different in different racial/ethnic backgrounds (Table 1). With respect to potential medical confounding factors, children with vertigo had a 35% prevalence of frequent or severe headaches or migraines, compared to 6% of all U.S. children ($p < 0.0001$). Additionally, 10% of children with vertigo had three or more ear infections in the previous 12 months, compared to 4.4% of all children ($p = 0.0053$) (Table 1).

The prevalence of several cognitive diagnoses was higher among children with vertigo compared to children without vestibular vertigo (Table 2). Specifically, in multivariable logistic regression analyses adjusted for age, sex, race/ethnicity, income, three or more ear infections in the previous 12 months, and headaches, children with vertigo were significantly more likely to have attention deficit disorder (ADD) (OR=1.73, 95% CI: 1.06 – 2.81), learning disability (OR=3.45, 95% CI: 2.18 – 5.45), developmental delay (OR=2.59, 95% CI: 1.34 – 4.98), and intellectual disability (OR=6.60, 95% CI: 2.60 – 16.79) compared to children without vertigo. Additionally, children with vertigo were significantly more likely to use special education services (OR=2.46, 95% CI: 1.48 – 4.10). With respect to symptoms of cognitive impairment, children with vertigo were significantly more likely to have their activities limited by difficulty remembering or confusion (OR=32.07, 95% CI: 13.18 – 78.00).

The prevalence of psychiatric and emotional conditions was also higher in children with vertigo compared to other children (Table 2). Children with vertigo were significantly more likely to have difficulty with emotions, concentration, or behavior (OR=2.92, 95% CI: 1.85 – 4.61), and were significantly more likely to have a poor attention span (OR=1.68, 95% CI: 1.01 – 2.80). There were no significant differences between children with and without vertigo with respect to other emotional or psychiatric outcomes, including being often unhappy/depressed/tearful, often worried, or not well-behaved (Table 2).

In secondary sensitivity analysis we found similar results when additional potential confounders were included in the model, and when children with these comorbidities were excluded from the analysis (Table 3). In young children aged 3–11 there were significant associations between vertigo and learning disability, developmental delay, and intellectual disability (Table 3). In older children aged 12–17 there were significant associations between vertigo and ADD, learning disability, intellectual disability, use of special education services, activities limited by difficulty remembering or confusion, and difficulty with emotions, concentration, and behavior (Table 3).

4.1 DISCUSSION

Using data from the 2012 National Health Interview Survey, we observed that children with vertigo had a significantly higher odds of a number of important cognitive conditions, including an 7-fold increased odds of intellectual disability, a 3-fold increased odds of developmental delay, a 3-fold increased odds of learning disability, and a 2-fold increased odds of ADD. We additionally observed that children with vertigo had a 3-fold increased odds of having ‘difficulty with emotions, concentration, or behavior’ relative to the rest of US children. Children with vertigo were also 2-fold more likely to have a poor attention span.

A growing body of literature has shown compelling associations between vertigo and vestibular dysfunction and cognitive impairment in adults.[12–14,29–31] Our findings suggest that vertigo may influence cognitive circuits in children as well, validating and extending prior smaller studies.[6–11] The vestibular system is anatomically connected to widespread regions of the cerebral cortex involved in cognition and emotion, including the

hippocampus and amygdala.[15,17] Patients with vestibular disease have been shown to have reduced hippocampal volumes on MRI,[13] and impairments in the cognitive domains of visuo-spatial processing, memory and attention.[32–34] Vertigo or altered vestibular function in children may contribute to impaired information processing, particularly of spatial information, leading to greater difficulties performing every-day and higher-level cognitive tasks. Moreover, children with vestibular dysfunction have been shown to have reading impairment due to reduction of static and dynamic visual acuity.[35] Impairment in the fundamental skill of reading may in turn lead to poor school performance, and perhaps to clinical diagnoses such as learning disability and ADD. Alternatively, the adverse emotional and psychiatric effects of vertigo in children may contribute to cognitive impairment.

The findings of increased rates of difficulty with emotions, concentration, behavior, and poor attention span confirm and extend the results of two smaller studies that showed a higher prevalence of psychological distress (specifically symptoms of depression, anxiety and behavioral problems) in children with vertigo.[25,26] An association between vertigo or vestibular dysfunction and psychiatric disease has been well established in adults. Individuals with vertigo have higher rates of anxiety, depression, panic attacks, and general psychological distress than individuals without vertigo.[22–24,36–38] Moreover, the emotional distress due to vestibular disease may in turn lead to cognitive impairment.[39]

The prevalence of vertigo of in this sample (1.56%) is lower than that reported in prior studies, which ranged from 6–15%.[1–4] This difference could be partially accounted for by the different populations and age groups studied (US, Finland, UK, and Scotland, ages 3–17, 1–15, 5–15, and 10, respectively). Additionally, each study utilized different questions to ascertain vertigo. In Finland, the word for vertigo is the same as that for dizziness, which may explain the higher reported prevalence in that group. [1] In the studies of children from Scotland, the screening question reported on is for ‘dizziness attacks’, after interviewing a sample of children who reported dizziness attacks, the authors report a prevalence of paroxysmal vertigo of 2.6%, which is closer to that reported in the present study.[2,4] In a sample of 10 year olds in the UK dizziness was reported by 5.7%, but on further questioning only 59% of those reported the dizziness was like ‘objects turning or spinning around you’, suggesting the vertigo prevalence was closer to 3.4%.[3] These differences in methodology and reported prevalence highlight the difficulty in assessing vertigo, which even in adults can be difficult to assess, and is even more difficult to evaluate in children who may not have the language or descriptive skills required to provide a good history.

We performed sensitivity analyses to further evaluate potential confounders and neurologic comorbidities in the model, including seizures, Downs syndrome, cerebral palsy, muscular dystrophy, deafness, and difficulty seeing, and then a separate analysis excluding children with these comorbidities, which demonstrated similar results to our original model. This suggests the associations between vertigo and the outcomes of interest are not driven by children with these comorbities, although we are limited in this analysis by the available variables, which do not include concussion, traumatic brain injury, stroke, or other potential neurologic confounders. Subgroup analysis of children 3–11 and 12–17 was also performed given these groups may have different causes of vertigo. We found younger children age 3–11 with vertigo were more likely to have learning disability, intellectual disability, and

developmental delay, but not other comorbidities including ADD, difficulty remembering or confusion, and difficulty with emotions, concentration, and behavior, which were seen in older children aged 12–17. This may be due to differences in the causes of vertigo between the age groups, or differences in how caregivers interpret the symptoms of their children.

Determining the cause of vertigo for patients in this self-reported survey is difficult. Prior literature found vestibular migraine accounted for approximately 24–40% of vertigo in children[5], and demonstrated approximately 80% of children with vestibular migraine report resolution or improvement in their symptoms with appropriate therapy[40]. Referral of children to a dizziness and balance specialist is important to not just appropriately diagnose and treat symptoms, but also potentially prevent important downstream effects of those symptoms, such as the cognitive and psychiatric sequelae presented here.

This study has several important limitations. All data were gathered from interviews, which were completed by parents or caregivers, not the children themselves. There was no objective measurement of vestibular or cognitive function, and psychiatric diagnoses based on clinical criteria were not available. Children with cognitive or psychiatric conditions may be more likely to report somatic symptoms such as vertigo compared to their peers. Even with our secondary analysis excluding children with comorbid neurologic conditions it is impossible to account for all potential confounders and the results may be due to the effects of unmeasured variables. Further, the NHIS is a cross-sectional study, which cannot support causal inferences.

5.1 Conclusions

Vertigo is not uncommon in children, and is associated with significantly increased odds of important cognitive and psychiatric comorbidity. These findings support the hypothesis that peripheral vestibular inputs are important for normal cognitive and emotional development, and that an early insult to the vestibular system may lead to cognitive deficits that manifest in childhood and are lifelong.[39] Alternatively, cognitive impairment may contribute to symptoms of vertigo, or there may be complex bi-directional influences between vestibular and cognitive function, as has been suggested in the adult literature.[21] Further research using prospective pediatric cohorts will be required to establish the causal direction of the association between vertigo and cognitive and psychiatric impairment, and potentially determine whether treatment may forestall or prevent these morbid conditions in children.

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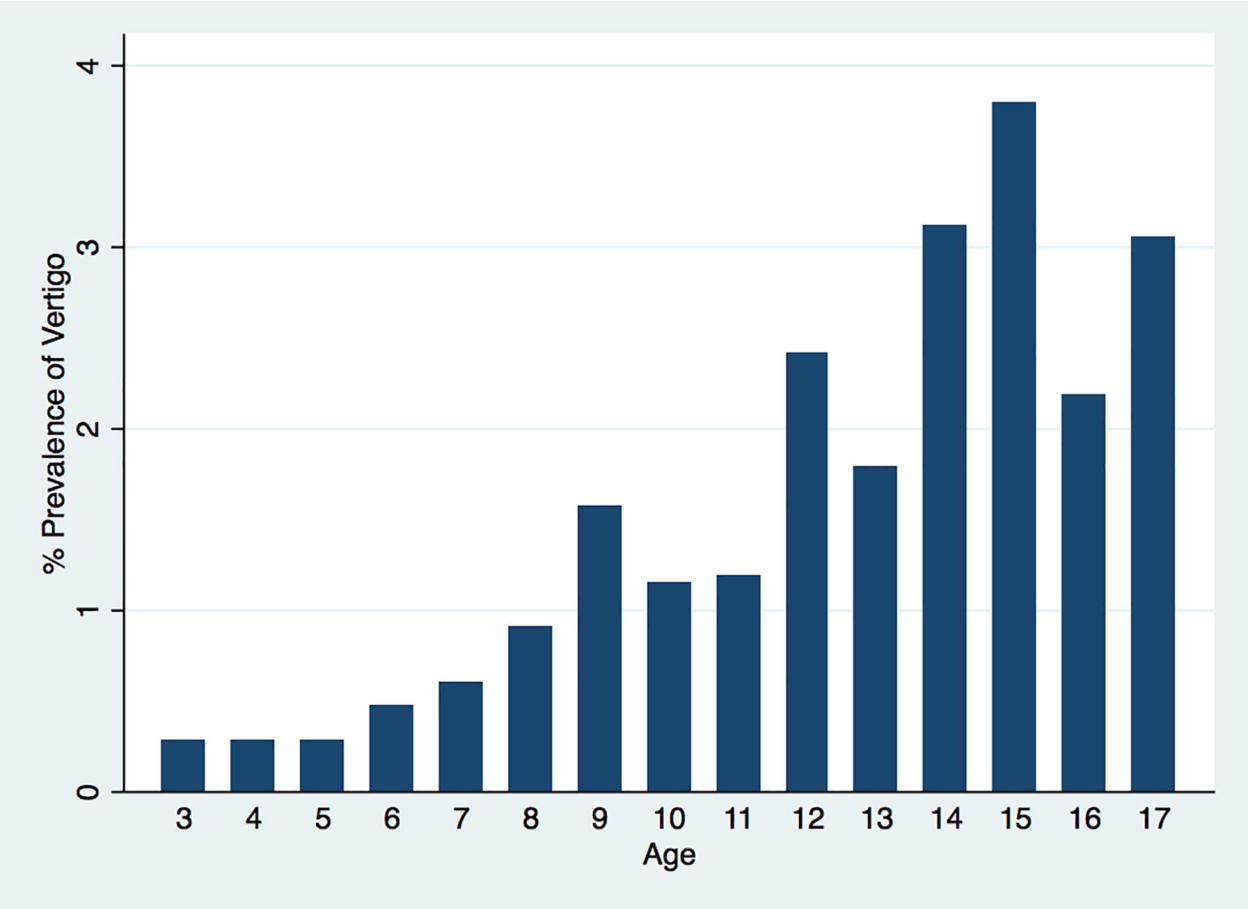

Fig. 1.
Prevalence of vertigo in US children by age: 2012 National Health Interview Survey

Table 1:

Demographic characteristics of vestibular vertigo in US children 3–17, 2012 Child Balance Supplement to the NHIS

	All 3–17 year olds		Vertigo	
Sample Size	**n = 10,823**		**n = 171**	
Population weighted	**61.7 Million**		**951k**	
	%	**%**[a]	**95% CI**	**Chi^2 p value**
Overall Prevalence		1.56	1.29 – 1.88	
Age				
3 to 5	20.0	0.29	0.11 – 0.75	< 0.0001
6 to 11	39.7	0.93	0.65 – 1.34	
12 to 17	40.2	2.82	2.27 – 3.48	
Sex				
Male	51.1	1.57	1.20 – 2.06	0.9229
Female	48.9	1.55	1.18 – 2.02	
Race/Ethnicity				
White	74.6	1.75	1.41 – 2.16	0.009
Black	14.2	0.85	0.49 – 1.50	
American Indian	1.4	4.09	1.52 – 10.51	
Asian	4.7	0.13	0.0002 – 0.92	
Mixed race	4.9	1.48	0.59 – 3.62	
Hispanic	23.7	1.88	1.32 – 2.67	
Family Income				
$0 – $35k	32.3	1.9	1.38 – 2.62	0.0992
$35k – $75k	29.8	1.76	1.31 – 2.36	
$75k – $100k	13.3	1.07	0.58 – 1.96	
$100k+	24.6	1.11	0.72 – 1.72	
Frequent or severe headaches	6.0	35.01[b]	26.59 – 44.50	< 0.0001
Three or more ear infections	4.4	9.86[b]	5.40 – 17.33	0.0053

NHIS - National Health Interview Survey

[a] Percentages reported are the prevalence of vertigo in each respective group

[b] Percentages reported are the prevalence of the symptom in children with vertigo

Table 2:

Prevalence and odds ratios of various co-morbid conditions and outcomes of all children and children with vertigo in the US, NHIS 2012

	US Children Without Vertigo		US Children With Vertigo			
	Prevalence		Prevalence		1.5%	
	%	95% CI	%	95% CI	OR	95% CI
Cognitive Conditions						
Autism	1.29	1.06 – 1.58	2.46	0.45 – 12.22	1.92	0.33 – 11.26
ADD	9.39	8.71 – 10.12	21.41	14.57 – 30.32	1.73*	1.06 – 2.81
Learning disability	7.64	7.01 – 8.33	31.08	22.67 – 40.96	3.45***	2.18 – 5.45
Developmental delay	4.77	4.30 – 5.30	13.44	8.09 – 21.51	2.59**	1.34 – 4.98
Intellectual disability	1.06	0.85 – 1.31	9.02	4.53 – 17.15	6.60***	2.60 – 16.79
Special education	8.40	7.75 – 9.10	22.84	15.43 – 32.44	2.46***	1.48 – 4.10
Activities limited by difficulty remembering or confusion	0.39	0.28 – 0.56	13.25	7.41 – 22.56	32.07**	13.18 – 78.00
Emotional/ Psychiatric Conditions						
Receive emotional services	2.73	2.37 – 3.14	6.72	3.42 – 12.77	1.84	0.87 – 3.88
Difficulty with emotions, concentration, or behavior	15.05	14.16 – 15.99	41.98	32.87 – 51.68	2.92***	1.85 – 4.61
Poor attention span	11.36	10.53 – 12.26	22.60	15.47 – 31.78	1.68*	1.01 – 2.80
Often worried	5.34	4.71 – 6.04	12.51	7.51 – 20.10	1.78	0.96 – 3.30
Not well behaved	3.20	2.79 – 3.67	6.49	3.20 – 12.73	1.67	0.74 – 3.75
Often unhappy, depressed, or tearful	3.10	2.66 – 3.62	3.75	1.67 – 8.19	0.86	0.35 – 2.11

Logistic regression adjusted for age, sex, race, income, frequent or severe headaches or migraines and three or more ear infections in the previous 12 months

ADD - attention deficit disorder

NHIS - National Health Interview Survey

OR - Odds Ratio

* 0.05

** 0.01

*** 0.001

Table 3:

Secondary analyses of vertigo, cognitive, and psychiatric comorbidities in US children: NHIS 2012

	Model 1: Expanded model		Model 2: Excluding children with select comorbidities		Model 3: Age 3–11		Model 4: Age 12–17	
Cognitive Conditions	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Autism	1.41	(0.19 – 10.57)	2.22	(0.31 – 15.85)	0.21	(0.03 – 1.69)	3.19	(0.54 – 18.92)
ADD	1.66*	(1.04 – 2.68)	1.80*	(1.09 – 2.96)	0.91	(0.31 – 2.64)	2.18**	(1.25 – 3.79)
Learning disability	3.08***	(1.95 – 4.88)	3.06***	(1.87 – 5.02)	3.03*	(1.18 – 7.77)	3.77***	(2.19 – 6.48)
Developmental delay	2.06	(0.96 – 4.40)	2.86**	(1.41 – 5.80)	3.84*	(1.32 – 11.18)	2.15	(0.96 – 4.81)
Intellectual disability	5.83**	(2.01 – 16.89)	6.91***	(2.51 – 19.03)	11.20**	(2.10 – 59.61)	5.39**	(1.91 – 15.19)
Special education	2.15**	(1.27 – 3.63)	2.18**	(1.23 – 3.87)	2.32	(0.90 – 5.94)	2.61**	(1.38 – 4.92)
Activities limited by difficulty remembering or confusion	3.29	(3.29 – 3.29)	2.79	(2.79 – 2.79)	1.07	(0.20 – 5.70)	5.93***	(2.30 – 15.28)
Emotional/ Psychiatric Conditions								
Receive emotional services	1.69	(0.75 – 3.81)	2.57***	(1.56 – 4.23)	2.07	(0.56 – 7.66)	1.82	(0.73 – 4.56)
Difficulty with emotions, concentration, or behavior	2.84***	(1.80 – 4.50)	2.24*	(1.03 – 4.87)	2.64	(0.94 – 7.41)	3.17***	(1.94 – 5.18)
Poor attention span	1.61	(0.95 – 2.73)	1.79*	(1.06 – 3.03)	2.1	(0.83 – 5.28)	1.59	(0.88 – 2.88)
Often worried	0.87	(0.36 – 2.10)	0.78	(0.27 – 2.23)	1.17	(0.30 – 4.65)	0.78	(0.25 – 2.45)
Not well behaved	1.25	(0.79 – 1.98)	1.48	(0.92 – 2.39)	1.03	(0.40 – 2.64)	1.39	(0.80 – 2.41)
Often unhappy, depressed, or tearful	1.58	(0.69 – 3.59)	1.60	(0.70 – 3.65)	2.44	(0.55 – 10.86)	1.49	(0.56 – 3.97)

Logistic regressions adjusted for age, sex, race, income, frequent or severe headaches or migraines and three or more ear infections in the previous 12 months

Model 1: Expanded model also includes seizures, cerebral palsy, Down syndrome, muscular dystrophy, deafness, and vision loss

Model 2: Excludes from analysis children who have seizures, cerebral palsy, Down syndrome, muscular dystrophy, deafness, and vision loss

Model 3: Limited to children ages 3–11

Model 4: Limited to children ages 12–17

ADD - attention deficit disorder

NHIS - National Health Interview Survey

OR - Odds Ratio

* 0.05

** 0.01

*** 0.001