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Eczema Is Associated with Childhood Speech Disorder: A Retrospective Analysis from the National Survey of Children's Health and the National Health Interview Survey

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Abstract

Objective—To determine if eczema is associated with an increased risk of a speech disorder.

Study design—We analyzed data on 354 416 children and adolescents from 19 US population-based cohorts: the 2003–2004 and 2007–2008 National Survey of Children's Health and 1997–2013 National Health Interview Survey, each prospective, questionnaire-based cohorts.

Results—In multivariate survey logistic regression models adjusting for sociodemographics and comorbid allergic disease, eczema was significantly associated with higher odds of speech disorder in 12 of 19 cohorts ($P < .05$). The pooled prevalence of speech disorder in children with eczema was 4.7% (95% CI 4.5%–5.0%) compared with 2.2% (95% CI 2.2%–2.3%) in children without eczema. In pooled multivariate analysis, eczema was associated with increased odds of speech disorder (aOR [95% CI] 1.81 [1.57–2.05], $P < .001$). In a single study assessing eczema severity, mild (1.36 [1.02–1.81], $P = .03$) and severe eczema (3.56 [1.70–7.48], $P < .001$) were associated with higher odds of speech disorder. History of eczema was associated with moderate (2.35 [1.34–4.10], $P = .003$) and severe (2.28 [1.11–4.72], $P = .03$) speech disorder. Finally, significant interactions were found, such that children with both eczema and attention deficit disorder with or without hyperactivity or sleep disturbance had vastly increased risk of speech disorders than either by itself.

Conclusions—Pediatric eczema may be associated with increased risk of speech disorder. Further, prospective studies are needed to characterize the exact nature of this association.

Eczema is a chronic inflammatory skin disorder with highest prevalence in childhood,¹ which causes significant suffering because of itch, sleep disturbance,² and decreased quality of life.³ Eczema is accompanied by profound systemic inflammation with activation of T-helper 2, 17, and 22 pathways.^{4–7} Systemic inflammation and/or the strong burden of atopic

dermatitis may contribute toward a variety of health conditions. Indeed, we and other investigators have previously found childhood eczema to be associated with multiple comorbidities, including obesity,^{8–10} hypertension,¹⁰ low bone mineral density,¹¹ increased risk of warts and extra-cutaneous infections,¹² asthma,¹³ allergic rhinitis,¹³ attention deficit disorder (ADD)/attention deficit hyperactivity disorder (ADHD),^{14,15} anxiety, depression, and conduct disorder.^{16,17}

Many studies have reported on the negative neurocognitive outcomes of various chronic diseases of childhood, particularly language ability. For example, chronic otitis media,^{18,19} congenital heart disease,²⁰ and chronic kidney disease^{21,22} have all been associated with poor language and verbal performance in children. However, few studies have examined the neurocognitive ability of pediatric patients with eczema. Recently, we found that pediatric patients with eczema reported higher levels of contact with therapists, including speech therapists²³ suggesting that eczema affects in some way the functional speech capability of children. Children with eczema have multiple risk factors for speech and language disorders, including sleep disturbance^{24,25} and ADHD.²⁶ We hypothesized that eczema is independently associated with increased risk of speech problems in children, particularly in severe eczema, sleep disturbance, and comorbid ADHD. The present study analyzed 19 US population-based cohorts to determine whether there is an association between eczema and speech disorders.

Methods

Data were assessed from 19 different cohorts including the National Survey of Children's Health (NSCH) 2003–2004 and 2007–2008 and the National Health Interview Survey (NHIS) from the years 1997–2013. All surveys are collected by the National Center for Health Statistics, and the specific characteristics of each are reviewed (Table I; available at www.jpeds.com). In sampled households with multiple children, 1 child was randomly chosen to be the subject of the interview. Common to all samples is a multistage area probability sampling design that factors in age, sex, race, ethnicity, household size, and educational attainment of the most educated household member, using data from the US Census Bureau. Sample weights were created by the National Center for Health Statistics allowing for frequency and prevalence estimates that are representative of each state's population of noninstitutionalized children. In this study, frequency and prevalence estimates presented in analyses of single samples reflect this complex weighting process. The similar sampling methodologies across the sample years allowed for weighted analysis of pooled results for NHIS (n = 17) and NSCH (n = 2), respectively. However, because of the differences in sampling methodology between NHIS and NSCH, sample weights for all 19 samples could not be combined in pooled analyses. Thus, in analyses of pooled weighted data of all 19 samples, meta-analysis of multivariate regression analysis effects were performed using a robust variance estimation method.²⁷ This study was approved by the institutional review board at Northwestern University.

Associations with Eczema and Speech Disorder

Associations of both pediatric eczema and speech disorder were examined in children aged 3–17 years from NHIS 1997–2013 and NSCH 2003 and children aged 2–17 years from NSCH 2007 including sex, age, race, household income, highest level of household/parental education, birthplace in the US, and insurance coverage.

Associations between caregiver-reported history of eczema (19 samples) and eczema severity (1 sample) and speech disorder were examined both for each individual cohort and in pooled analyses. Interactions between eczema and several comorbidities including ADD/ADHD, sleep disturbance, fatigue, and depression were examined for their effect on speech disorders. Contrast statements were used to determine the differential effect of each on the risk of speech disorder.

Statistical Analyses

All data analyses and statistical processes were performed using the SURVEY procedures in SAS v 9.4 (SAS Institute, Cary, North Carolina). Weighted population-based frequencies and prevalences were assessed for each study (PROC SURVEYFREQ). Multivariate survey logistic regression models were constructed for individual samples and pooled years of NSCH or NHIS accounting for the surveys' complex weighting. The dependent variable in each model was the history of speech disorder in the past year. The independent variables were either 1-year history of eczema (ie, active eczema in the past year [yes/no] or eczema severity [no eczema/mild/moderate/severe]). Age (2–6/7–11/12–17 years), sex (male/female), race/ethnicity (non-Hispanic Caucasian/non-Hispanic African American/Hispanic/multiracial or other), household income (0%–99%/100%–199%/200%–399%/400%+ federal poverty level), level of education of the highest member of the family/highest level of parental education (less than high school/high school or graduate equivalence degree/more than high school), insurance status (yes/no), birthplace (US/outside US), lifetime history of asthma (yes/no), and 1-year history of hay fever (yes/no) and digestive allergy (yes/no) were included as covariates. In addition, there was concern that diagnosis of comorbidity was related to overall increased healthcare utilization. Thus, a second multivariate model was created to examine the effect of eczema on speech disorder when controlling for number of outpatient visits per year. The aOR and 95% CI were determined. Two-way interactions between covariates were assessed and noted if significant ($P < .01$) and modified the effect size by 20%.

Our a priori hypothesis was that psychological and sleep dysfunction occurring in eczema is particularly associated with speech disorder. History of ADD/ADHD was assessed in all samples, whereas depression and number of nights of adequate sleep per week were assessed in NSCH 2007–2008. Fatigue and insomnia were assessed in NHIS 2007 and 2012, and daytime sleepiness was assessed in NHIS 2012 only. These variables and interaction terms with history of eczema were included in multivariate models. Estimates of effect size for significant interactions between the 2 variables were conducted for each level of the covariates using contrast statements. The various questions used in this study to assess eczema, speech disorder, depression, ADD/ADHD, and sleep disturbance are presented (Table II; available at www.jpeds.com).

Complete data analysis was performed in that subjects with missing data were excluded. The frequency of missing values from each study is presented (Table III; available at www.jpeds.com). Analysis of missing value patterns for speech disorder found that missing values were not more likely to occur in various age groups, racial and ethnic groups, family income levels, or education levels.

Results

Data were analyzed on 354 416 US children and adolescents age 2–17 years, including those of all racial/ethnic groups, sex, levels of household income, and birthplaces. The pooled prevalence of eczema from all 19 samples was 10.1% (95% CI 10.0%–10.2%) (Table IV; available at www.jpeds.com). In pooled, bivariate logistic regression models, eczema was positively associated with female sex, and African American and multiracial race. In contrast, eczema was inversely associated with older age (7–11 years, 12–17 years), Hispanic ethnicity, less than high school level of household education, foreign birthplace, and lack of insurance coverage.

The US pooled prevalence of speech disorder was found to be 2.4% (95% CI 2.4%–2.5%; Table IV). In bivariate logistic regression models, speech disorder was positively associated with African American race, Hispanic ethnicity, lower household income, and lower levels of household education. Speech disorder was inversely associated with female sex, older age, multiracial race, foreign birthplace, and lack of insurance coverage.

Association between Eczema and Speech Disorder

In bivariate models, eczema was significantly associated with speech disorder in 16 of 19 samples ($P < .05$, data not shown). In multivariate models adjusting for race/ethnicity, age, sex, household income, highest level of parental education, insurance coverage, US birthplace, lifetime history of asthma, and 1-year history of hay fever and food allergy, the association between eczema and speech disorder remained significant in 12 samples (Table V).

The pooled US prevalence of speech disorder was 4.7% (4.5%–5.0%) in children with eczema and 2.2% (2.2%–2.3%) in children without eczema (Table V). In pooled multivariate analysis, eczema was associated with significantly higher odds of speech disorder (pooled aOR [95% CI] using robust variance method, 1.81 [1.57–2.05], $P < .001$). Multivariate modeling of the pooled NHIS 1997–2013 data alone found eczema to be associated with significantly higher odds of speech disorder (1.71 [1.50–1.96], $P < .001$). Likewise, multivariate modeling of the pooled NSCH 2003–2004 and 2007–2008 data found eczema to be associated with significantly higher odds of speech disorder (1.53 [1.29–1.81], $P < .001$). The association between eczema and speech disorder occurred at all ages (aOR [95% CI] for 2–6 years: 1.73 [1.12–2.67], $P = .01$; 7–12 years: 1.50 [1.12–2.01], $P = .007$; 13–17 years: 1.90 [1.17–3.07], $P = .009$).

Analysis for confounders was performed by assessing each covariate separately with eczema as predictors of speech dysfunction in the years when the association did not remain significant in multivariate models. The association remained significant in 2013, 2007, 2003,

and 1999 with the inclusion of every covariate individually, with the exception of the inclusion of asthma or digestive allergy for the year 2003. The association was not significant in 2011, 2009, and 2002 with the inclusion of the covariates individually.

The associations of eczema and outpatient healthcare visits as predictors of speech disorder were also examined for each sample. In 14 of 19 samples, the associations between eczema and speech disorder remained significant ($P < .05$) when adjusting for number of outpatient healthcare visits. The associations did not remain significant in the years 2002, 2003, 2007, 2009, and 2011.

A single interaction among the covariates of the 19-study pooled multivariate model was found between food allergy and eczema. In multivariate models, higher odds of speech disorder were found in children with eczema alone (1.71 [1.59–2.83], $P < .001$) and food allergy alone (1.99 [1.79–2.22], $P < .001$) compared with children without either condition. However, the highest odds of speech disorder were found in children with both eczema and food allergy (2.58 [2.27–2.93], $P < .001$).

Associations between Eczema and Speech Disorder Based on Severity

The 2007–2008 NSCH assessed the caregiver-reported severity of eczema. In multivariate models, mild eczema (1.36 [1.02–1.81], $P = .03$) and severe eczema (3.56 [1.70–7.48], $P < .001$) compared with no eczema were associated with significantly higher odds of speech disorders (Table VI). The 2007–2008 NSCH also assessed the caregiver-reported severity of speech disorder. In multivariate models, eczema was associated with significantly higher odds of moderate (2.35 [1.34–4.10], $P = .003$) and severe speech disorder (2.28 [1.11–4.72], $P = .03$) (Table VII).

Association between Eczema, Psychological and Sleep Disturbance, and Speech Disorder

Interactions between eczema and psychological and sleep disturbance were also examined as associations with speech disorder. The pooled prevalence of speech disorder in children and adolescents with either eczema (3.8% [3.6%–4.0%]) or ADD/ADHD (6.7% [6.4%–7.0%]) were higher than in those without either disorder (1.8% [1.8%–1.9%]). An even higher prevalence of speech disorder occurred in those with both eczema and ADHD (12.6% [11.4%–13.7%]). In pooled multivariate models, eczema (1.59 [1.47–1.71]) and ADD/ADHD (3.87 [3.61–4.14]) were associated with higher odds of speech disorder (Table VIII). However, children with both eczema and ADD/ADHD had even higher odds of speech disorder than either condition alone (6.00 [5.31–6.77]) ($P < .001$ for all).

In NSCH 2007–2008, eczema alone was associated with higher odds of speech disorder (1.58 [1.23–2.04], $P < .001$). Childhood depression with (3.10 [1.37–7.01], $P = .006$) and without (3.73 [2.45–5.68], $P < .001$) eczema had even higher odds of speech disorder.

In NSCH 2007–2008, 0–3 adequate nights of sleep alone (1.37 [1.00–1.87], $P = .049$) but not eczema alone (1.26 [0.94–1.70], $P = .13$) was associated with higher odds of speech disorder in multivariate models. However, children with both eczema and 0–3 adequate nights of sleep per week had dramatically higher odds of speech disorder (5.85 [2.72–12.53], $P < .001$).

In NHIS 2007 and 2012, eczema (1.70 [1.10–2.62], $P = .02$) and insomnia (4.43 [2.71–7.25], $P < .001$) were associated with higher odds of speech disorder in multivariate logistic regression models. However, children with both eczema and insomnia had even higher odds of speech disorder (5.93 [2.97–11.82], $P < .001$).

In NHIS 2012, eczema (1.86 [1.10–3.14], $P = .02$) but not caregiver-reported daytime sleepiness (2.18 [0.97–4.94], $P = .06$) was associated with higher odds of speech disorder in multivariate logistic regression models. However, children with both eczema and daytime sleepiness had dramatically increased odds of speech disorder (6.21 [2.44–15.80], $P < .001$).

In NHIS 2007 and 2012, eczema alone (1.82 [1.19–2.78], $P = .006$) was associated with higher odds of speech disorder. However, children with fatigue with (5.71 [2.77–12.17], $P < .001$) and without (5.68 [3.31–9.74], $P < .001$) eczema had even higher odds of speech disorder.

Discussion

In the present study, we analyzed data from 19 US population-based samples and found that pediatric eczema is associated with increased odds of speech disorder at all ages. In addition, our sociodemographic findings are consistent with previous studies showing higher risk for eczema in females,^{28–30} African Americans,¹ and more highly educated families.¹ In a single sample that assessed for eczema severity, severe eczema was associated with even higher odds of speech disorder than mild or moderate disease; mild disease was still also associated with increased speech disorder compared with children that had no eczema. Eczema was also associated with higher odds of moderate and severe speech disorder. Eczema without psychological and sleep dysfunction, including ADD/ADHD and depression was associated with modestly increased risk of speech disorder. However, eczema accompanied by these psychological diseases, fatigue, and sleep disturbance was associated with dramatically higher odds of speech disorder. Together, these results suggest that a subset of children with eczema have higher odds of speech disorder.

It is possible that children with eczema might have increased detection of speech disorders because of increased healthcare interaction. To address this, we created multivariate models that controlled for number of healthcare interactions and the association remained significant in 14 of 19 cohorts. Thus, we believe that these associations are not merely because of increased healthcare interaction. Regardless, increased utilization for speech disorders and other comorbidities in children with eczema¹³ may pose a previously unrecognized public-health burden. Future longitudinal studies using clinical cohorts are needed to confirm these findings.

Several previous studies have examined possible interplay between eczema and speech disorder. A 2013 case-control study of 41 children examined the associations between sleep and neurocognitive function in children with eczema compared with children without eczema.³¹ Their investigation found that children with eczema had lower scores on all neurocognitive measures including verbal comprehension and word reasoning, though their testing did not specifically examine language functionality. Sleep architecture, assessed by

parental report and polysomnography, did not significantly affect neurocognitive outcomes. Another previous study, assessing data from the 1995 Australian Health Survey on 12 388 children aged 0–14 years, examined the disease and socioeconomic associations of childhood speech disorders.³² Although their investigation found that children with speech disorders reported a higher number of comorbid health conditions than children without speech disorders, they found no significant difference in the prevalence of eczema between children with and children without speech disorders. Of note, they did not examine the relationship between speech disorders and eczema while controlling for sociodemographics and comorbid allergic disease nor did they examine any impact that sleep had on the development of speech disorders.

We theorize that the mechanism behind the association between eczema severity and speech disorder is likely multi-factorial, related to the effects of chronic disease during childhood development and chronic sleep deprivation. Sleep deprivation during the formative years of child development may interfere with the memory functions required for early language mastery.^{25,33} A 2007 study found that children with shorter sleep duration had 3.1 times the risk of low performance on a standardized vocabulary test, indicating a role for proper sleep duration in language acquisition.²⁴ However, the present study demonstrates that although children with both eczema and sleep disturbance have vastly increased risk of speech disorder, even those with eczema and no sleep disturbance conditions had increased risk. It is possible that eczema, even without tangible complaints of sleep loss, inflicts developmental stress that impacts language development. It is also possible that eczema affects language development in the same manner of other childhood chronic disease. If so, it may be that other chronic disorders of childhood also increase the risk of speech disorder. Conversely, it could be that speech disorder occurs first in development and inflicts distress that increases a child's predisposition toward itch and is eventually recognized as eczema.

This study has raised several additional questions about the relationship between speech disorder and eczema. Using a population-based experimental model, we could not determine the permanence of speech symptoms. Given that the association between eczema and speech disorder was significant even in adolescence, it is possible that language development is irreversibly altered by chronic eczema during early childhood. There appears to be a period of heightened sensitivity for language learning in children.^{34,35} Some studies have suggested that language learning declines after age 4 years, though the exact end point of this heightened sensitivity is unknown.^{34,35} It may be that eczema and/or other chronic diseases impair language learning during this critical period, potentially resulting in persistent language or speech deficits. Alternatively, it is possible that speech function is a reversible symptom of relapsing and remitting disease. If the latter is true, affected children may have no speech symptoms between eczema flares. We were also unable to determine if strong therapeutic control of a child's eczema could in turn improve speech function or improvement in speech function with therapy could improve a child's symptoms of itch. Longitudinal, prospective studies could elucidate these points.

The strengths of this study include using 19 US population-based surveys of children, each with minimal selection bias and a large sample size, encompassing children of all ages, races/ethnicities, and socioeconomic statuses. The associations remained significant in all 16

studies in bivariate analyses and 12 studies in multivariate or confounder analyses. It is not entirely clear why the association did not remain significant in 3 of 19 years. Nevertheless, the results demonstrate a highly reproducible association between eczema and speech disorder. In addition, the use of multivariate logistic regression models allowed us to adjust for confounding sociodemographic variables and comorbid allergic disease. However, our study is not without weakness. Speech disorder history was determined by caregiver-report of physician diagnosis in NSCH and caregiver-report in NHIS and not verified by a physician or speech pathologist. In addition, the NHIS question assessing for speech disorder inquired about only child history of “stuttering or stammering” and the NSCH question inquired about “stuttering, stammering, or other speech problems,” introducing heterogeneity among positive respondents of the different surveys. Eczema history was similarly determined by caregiver-report of physician diagnosis in NSCH and caregiver-report in NHIS and not verified by a physician. We recently performed a multicenter study to validate the question employed in NSCH and found very good sensitivity, specificity, and positive predictive value.³⁶ Moreover, previous studies found good concordance between self-reported eczema and eczema diagnosed by medical examination.^{37,38} Thus, we believe that the case definition for eczema is valid. Finally, the cross-sectional design of our study prevents any conclusions from being made on causality. Perhaps there are unknown genetic or environmental factors that are responsible for both increased risk of sleep disturbance and problematic language development in certain eczema patients. Future prospective studies with objective determination of speech disorder and eczema severity could provide further information on precise etiology.

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Glossary

ADD	Attention deficit disorder
ADHD	Attention deficit hyperactivity disorder
NHIS	National Health Interview Survey
NSCH	National Survey of Children’s Health

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Survey characteristics

Table 1

Study	Size	Age (y)	Type	Languages	Assessments
NSCH 2003–2004	102 353	3–17	Telephone	English Spanish Mandarin Cantonese Vietnamese Korean	Caregiver-report
NSCH 2007–2008	91 642	2–17	Telephone	English Spanish Mandarin Cantonese Vietnamese Korean	Caregiver-report
NHIS 1997	14 290	3–17	Household	English Spanish	Caregiver-report
NHIS 1998	36 116	18–85		Spanish	
	13 645	3–17	Household	English	Caregiver-report
	32 440	18–85		Spanish	
NHIS 1999	12 910	3–17	Household	English	Caregiver-report
	30 801	18–85		Spanish	
NHIS 2000	13 376	3–17	Household	English	Caregiver-report
	32 374	18–85		Spanish	
NHIS 2001	13 579	3–17	Household	English	Caregiver-report
	33 326	18–85		Spanish	
NHIS 2002	12 524	3–17	Household	English	Caregiver-report
	31 044	18–85		Spanish	
NHIS 2003	12 229	3–17	Household	English	Caregiver-report
	30 852	18–85		Spanish	
NHIS 2004	12 424	3–17	Household	English	Caregiver-report
	31 326	18–85		Spanish	

Study	Size	Age (y)	Type	Languages	Assessments
NHIS 2005	12 523	3–17	Household	English	Caregiver-report
	31 428	18–85		Spanish	
NHIS 2006	9837	3–17	Household	English	Caregiver-report
	24 275	18–85		Spanish	
NHIS 2007	9417	3–17	Household	English	Caregiver-report
	23 393	18–85		Spanish	
NHIS 2008	8815	3–17	Household	English	Caregiver-report
	21 781	18–85		Spanish	
NHIS 2009	11 156	3–17	Household	English	Caregiver-report
	27 731	18–85		Spanish	
NHIS 2010	11 277	3–17	Household	English	Caregiver-report
	27 157	18–85		Spanish	
NHIS 2011	12 850	3–17	Household	English	Caregiver-report
	33 014	18–85		Spanish	
NHIS 2012	13 275	3–17	Household	English	Caregiver-report
	34 525	18–85		Spanish	
NHIS 2013	12 860	3–17	Household	English	Caregiver-report
	34 557	18–85		Spanish	

Table II

Questions used in this study

Variables	Question	Surveys asked
Eczema	During the past 12 mo, have you been told by a doctor or other health professional that (child) had eczema or any kind of skin allergy?	NSCH 2003–2004 NSCH 2007–2008
Eczema	During the past 12 mo, has (child) had any of the following conditions: Eczema or any kind of skin allergy?	NHIS 1997–2013
Eczema (parents)	During the past 12 mo, have you had dermatitis, eczema, or any other red, inflamed skin rash?	NHIS 2010
Eczema (parents)	During the past 12 mo, have you been told by a doctor or other health professional that you had eczema or any kind of skin allergy?	NHIS 2012
Eczema severity	Would you describe (his/her) eczema or skin allergy as mild, moderate, or severe?	NSCH 2007–2008
Speech Disorder	Has a doctor or other healthcare provider ever told you that (child) had stuttering, stammering, or other speech problems? Does (child) currently have speech problems?	NSCH 2007–2008
Speech disorder severity	Would you describe (his/her) speech problems as mild, moderate, or severe?	NSCH 2007–2008
Speech disorder	During the past 12 mo, that is since (date) have you been told by a doctor or other health care professional that (child) had any of the following conditions: stuttering, stammering, or other speech problems?	NSCH 2003–2004
Speech disorder	During the past 12 mo, has (child) had any of the following conditions: stuttering or stammering?	NHIS 1997–2013
Ever asthma history	Has a doctor or other health professional ever told you that (child) had asthma?	NSCH 2003–2004 NSCH 2007–2008 NHIS 1997–2013
Hay fever	During the past 12 mo, have you been told by a doctor or other health professional that (child) had hay fever or any kind of respiratory allergy?	NSCH 2003–2004 NSCH 2007–2008
Hay fever	During the past 12 mo, has (child) had any of the following conditions: Hay fever?	NHIS 1997–2013
Food allergy	During the past 12 mo, have you been told by a doctor or other health professional that (child) had any kind of food or digestive allergy?	NSCH 2003–2004 NSCH 2007–2008
Food allergy	During the past 12 mo, has (child) had any of the following conditions: any kind of food or digestive allergy?	NHIS 1997–2013
ADHD	Has a doctor or other health care provider ever told you that (child) had ADD or ADHD?	NSCH 2003–2004 NSCH 2007–2008
ADHD	Has a doctor or health professional ever told you that (child) had ADHD or ADD?	NHIS 1997–2013
Depression	Has a doctor or other health care provider ever told you that (child) had depression?	NSCH 2007–2008
Nights of adequate sleep	During the past week, on how many nights did (child) get enough sleep for a child (his/her) age?	NSCH 2007–2008
Fatigue	During the past 12 mo, has (child) had fatigue or lack of energy?	NHIS 2007
Fatigue	During the past 12 mo, has (child) had fatigue or lack of energy more than three days?	NHIS 2012
Insomnia	During the past 12 mo, has [child] had insomnia or trouble sleeping?	NHIS 2007
Insomnia	During the past 12 mo, has [child] regularly had insomnia or trouble sleeping?	NHIS 2012
Daytime sleepiness	During the past 12 mo, has [child] regularly had excessive sleepiness during the day?	NHIS 2012

Table III

Frequency of missing values for variables used in the study

Study	Variables	Freq (%)
NSCH 2003–2004	Stuttering	69 (0.07)
	Eczema	176 (0.18)
	Asthma	218 (0.22)
	Hay fever	326 (0.32)
	Food allergy	187 (0.19)
	ADHD	398 (0.39)
	Age	0 (0.00)
	Race/ethnicity	1416 (1.40)
	Sex	80 (0.07)
	Household income	9414 (9.20)
	Highest level of education in the household	432 (0.42)
	US birthplace	22 (0.02)
	Insurance coverage	169 (0.17)
NSCH 2007–2008	Stuttering	65 (0.07)
	Stuttering severity	9 (0.33)
	Eczema	99 (0.11)
	Eczema severity	25 (0.03)
	Nights of sleep	634 (0.70)
	Asthma	117 (0.13)
	Hay fever	187 (0.21)
	Food allergy	140 (0.15)
	ADHD	185 (0.20)
	Depression	129 (0.15)
	Age	0 (0.00)
	Race/ethnicity	1546 (1.68)
	Sex	110 (0.12)
	Household income	0 (0.0) *
	Highest level of education in the household	4346 (4.74)
	US birthplace	961 (1.05)
	Insurance coverage	183 (0.20)
	Adequate nights of sleep	634 (0.70)
NHIS 1997–2013	Stuttering	121 (0.07)
	Eczema	1029 (0.50)
	Asthma	348 (0.17)
	Hay fever	1484 (0.72)
	Food allergy	1140 (0.55)
	ADHD	387 (0.21)
	Age	0 (0.00)
	Race/ethnicity	301 (0.1)

Study	Variables	Freq (%)
	Sex	0 (0.0)
	Household income	38 476 (18.6)
	Highest level of education in the household	1409 (0.68)
	US birthplace	830 (0.40)
	Insurance coverage	1444 (0.7)
	Fatigue (2007 and 2012)	9 (0.05)
	Insomnia (2007 and 2012)	11 (0.06)
	Daytime sleepiness (2012)	5 (0.05)

Freq, frequency.

* Multiple imputations of missing values, generated by the National Center for Health Statistics, were used. Missing values were encountered in 9.2% of subjects in the raw datasets.

Table IV

Associations of eczema and speech disorders in children (n = 354 416)

Variables	Eczema		Speech disorders	
	% Prev (95% CI)	Pooled OR (95% CI)	% Prev (95% CI)	Pooled OR (95% CI)
Overall	10.1 (10.0–10.2)	-	2.4 (2.4–2.5)	-
Sex				
Male	9.8 (9.6–9.9)	1.00 [ref]	3.3 (3.2–3.4)	1.00 [ref]
Female	10.6 (10.5–10.8)	1.10 (1.08–1.13)	1.5 (1.5–1.6)	0.45 (0.43–0.48)
Age (y)				
2–6	12.3 (12.1–12.5)	1.00 [ref]	3.8 (3.7–3.9)	1.00 [ref]
7–11	10.4 (10.2–10.6)	0.82 (0.80–0.85)	2.8 (2.7–2.9)	0.72 (0.69–0.76)
12–17	8.5 (8.4–8.7)	0.66 (0.65–0.68)	1.4 (1.4–1.5)	0.37 (0.35–0.39)
Race				
Caucasian	9.8 (9.6–9.9)	1.00 [ref]	2.3 (2.2–2.3)	1.00 [ref]
Black/African American	14.3 (14.0–14.6)	1.54 (1.50–1.59)	3.2 (3.0–3.4)	1.43 (1.35–1.52)
Hispanic	8.1 (7.9–8.3)	0.82 (0.79–0.84)	2.5 (2.3–2.6)	1.09 (1.03–1.15)
Multiracial/other	11.4 (10.9–11.9)	1.19 (1.13–1.25)	1.6 (1.4–1.8)	0.70 (0.62–0.80)
Household income (%FPL)				
0–99	10.7 (10.4–11.0)	0.97 (0.93–1.01)	4.2 (4.0–4.4)	2.45 (2.29–2.62)
100–199	10.2 (10.0–10.5)	0.92 (0.89–0.96)	3.1 (2.9–3.2)	1.76 (1.65–1.89)
200–399	10.5 (10.3–10.6)	0.97 (0.94–1.00)	2.2 (2.1–2.3)	1.26 (1.19–1.35)
400	10.9 (10.7–11.0)	1.00 [ref]	1.7 (1.7–1.9)	1.00 [ref]
Highest level of household education				
<High school	7.1 (6.8–7.3)	0.61 (0.59–0.64)	3.3 (3.1–3.5)	1.49 (1.39–1.59)
High school or GED	8.9 (8.6–9.1)	0.78 (0.76–0.81)	2.7 (2.6–2.8)	1.20 (1.13–1.26)
>High school	11.0 (10.9–11.1)	1.00 [ref]	2.3 (2.2–2.3)	1.00 [ref]
Birthplace in the US				
No	6.1 (5.8–6.5)	0.56 (0.53–0.60)	1.6 (1.4–1.8)	0.64 (0.57–0.72)
Yes	10.4 (10.3–10.5)	1.00 [ref]	2.5 (2.4–2.6)	1.00 [ref]
Insurance coverage				
No	7.2 (6.9–7.5)	0.66 (0.63–0.69)	2.0 (1.8–2.1)	0.78 (0.72–0.85)
Yes	10.5 (10.4–10.6)	1.00 [ref]	2.5 (2.5–2.6)	1.00 [ref]

Prev, prevalence; FPL, federal poverty level; GED, general educational development; Ref, reference.

Pooled prevalence of eczema or speech disorder in NSCH 2003–2004, NSCH 2007–2008, and NHIS 1997–2013. Binary logistic regression models were constructed with eczema or speech disorder as the dependent variables and sex, age, race, household income, highest level of household education, US vs foreign birthplace, and insurance coverage as the independent variables. Because of differences in sampling methodology between NHIS and NSCH, sample weights could not be combined, and, thus, unweighted estimates of prevalence and effect size are presented.

Table V

Association between eczema and speech disorders in children and adolescents

Study	No speech disorders			Speech disorders			P value
	Freq	% Prev (95% CI)	Freq (%)	% Prev (95% CI)	aOR (95% CI)		
NHIS 1997							
No eczema	10 594	98.4 (98.1–98.6)	175	1.6 (1.4–1.9)	1 [ref]	-	
Eczema	845	96.6 (95.2–97.9)	35	3.4 (2.1–4.8)	1.72 (1.05–2.82)	.03	
NHIS 1998							
No eczema	10 090	98.5 (98.3–98.8)	153	1.5 (1.2–1.8)	1 [ref]	-	
Eczema	783	97.0 (95.5–98.4)	22	3.0 (1.6–4.5)	1.88 (1.04–3.39)	.04	
NHIS 1999							
No eczema	9764	98.6 (98.4–98.9)	135	1.4 (1.1–1.7)	1 [ref]	-	
Eczema	676	96.8 (95.1–98.4)	24	3.2 (1.6–4.9)	1.91 (0.99–3.68)	.056	
NHIS 2000							
No eczema	10 034	98.8 (98.6–99.1)	134	1.2 (1.0–1.4)	1 [ref]	-	
Eczema	737	96.1 (94.6–97.7)	32	3.9 (2.3–5.4)	2.64 (1.59–4.39)	<.001	
NHIS 2001							
No eczema	10 148	99.0 (98.7–99.2)	116	1.1 (0.8–1.3)	1 [ref]	-	
Eczema	848	96.6 (95.2–97.9)	33	3.4 (2.1–4.8)	3.02 (1.80–5.05)	<.001	
NHIS 2002							
No eczema	9329	98.5 (98.2–98.8)	142	1.5 (1.2–1.8)	1 [ref]	-	
Eczema	853	97.9 (96.8–98.9)	23	2.1 (1.1–3.2)	1.04 (0.56–1.91)	.91	
NHIS 2003							
No eczema	9087	98.7 (98.4–99.0)	123	1.3 (1.0–1.6)	1 [ref]	-	
Eczema	863	97.7 (96.5–98.8)	22	2.4 (1.2–3.5)	1.49 (0.81–2.74)	.20	
NHIS 2004							
No eczema	9118	98.3 (98.0–98.7)	147	1.7 (1.4–2.0)	1 [ref]	-	
Eczema	886	95.9 (94.3–97.5)	36	4.1 (2.5–5.7)	1.97 (1.18–3.27)	.009	
NHIS 2005							
No eczema	9195	98.4 (98.1–98.7)	138	1.6 (1.3–1.9)	1 [ref]	-	
Eczema	936	96.4 (94.9–97.8)	36	3.6 (2.2–5.1)	1.75 (1.05–2.92)	.03	

Study	No speech disorders			Speech disorders			P value
	Freq	% Prev (95% CI)	Freq (%)	% Prev (95% CI)	aOR (95% CI)		
NHIS 2006							
No eczema	7136	98.5 (98.2–98.9)	109	1.5 (1.1–1.8)	1 [ref]	-	
Eczema	763	95.9 (94.1–97.7)	27	4.1 (2.4–5.9)	2.69 (1.52–4.78)	<.001	
NHIS 2007							
No eczema	6889	98.6 (98.2–98.9)	96	1.4 (1.1–1.8)	1 [ref]	-	
Eczema	654	97.2 (95.8–98.5)	23	2.8 (1.5–4.2)	1.70 (0.95–3.05)	.07	
NHIS 2008							
No eczema	6420	98.4 (98.1–98.8)	105	1.6 (1.2–1.9)	1 [ref]	-	
Eczema	733	96.7 (95.3–98.1)	34	3.3 (1.9–4.7)	1.92 (1.08–3.42)	.03	
NHIS 2009							
No eczema	7976	98.2 (97.9–98.6)	145	1.8 (1.4–2.1)	1 [ref]	-	
Eczema	1008	97.2 (95.8–98.6)	35	2.8 (1.4–4.2)	1.50 (0.78–2.89)	.22	
NHIS 2010							
No eczema	7969	98.1 (97.7–98.5)	152	1.9 (1.5–2.3)	1 [ref]	-	
Eczema	1058	96.4 (95.0–97.7)	39	3.6 (2.3–5.0)	1.67 (1.04–2.68)	.04	
NHIS 2011							
No eczema	9078	98.0 (97.6–98.4)	174	2.0 (1.6–2.4)	1 [ref]	-	
Eczema	1244	97.1 (96.1–98.1)	44	3.0 (2.0–4.0)	1.08 (0.66–1.76)	.77	
NHIS 2012							
No eczema	9484	98.4 (98.1–98.7)	168	1.6 (1.3–1.9)	1 [ref]	-	
Eczema	1236	95.8 (94.4–97.2)	56	4.2 (2.8–5.6)	1.86 (1.20–2.90)	.006	
NHIS 2013							
No eczema	9242	98.2 (97.9–98.6)	177	1.8 (1.4–2.2)	1 [ref]	-	
Eczema	1214	96.9 (95.7–98.1)	38	3.1 (1.9–4.3)	1.45 (0.88–2.40)	.15	
NSCH 2003–2004							
No eczema	74 967	96.8 (96.6–97.0)	2175	3.2 (3.0–3.4)	1 [ref]	-	
Eczema	7595	93.0 (91.9–94.0)	462	7.0 (6.0–8.1)	1.60 (1.31–1.96)	<.001	
NSCH 2007–2008							
No eczema	69 910	96.7 (96.4–97.0)	2103	3.3 (3.0–3.6)	1 [ref]	-	
Eczema	9277	93.2 (92.0–94.4)	578	6.8 (5.6–8.0)	1.50 (1.17–1.93)	.002	

Study	No speech disorders			Speech disorders			P value
	Freq	% Prev (95% CI)	Freq (%)	% Prev (95% CI)	aOR (95% CI)		
Pooled NSCH							
No eczema	144 877	96.7 (96.5–96.9)	4278	3.3 (3.1–3.5)	1 [ref]	-	
Eczema	16 872	93.1 (92.3–94.0)	1040	6.9 (6.0–7.7)	1.53 (1.29–1.81)	<.001	
Pooled NHIS							
No eczema	151 411	98.4 (98.4–98.5)	2389	1.6 (1.5–1.6)	1 [ref]	-	
Eczema	15 337	96.5 (96.2–96.8)	559	3.5 (3.2–3.8)	1.71 (1.50–1.96)	<.001	
Pooled NSCH and NHIS [*]							
No eczema	296 288	97.8 (97.7–97.8)	6667	2.2 (2.2–2.3)	1 [ref]	-	
Eczema	32 209	95.3 (95.0–95.5)	1599	4.7 (4.5–5.0)	1.81 (1.57–2.05)	<.001	

Freq, frequency; *Prev*, prevalence; *Ref*, reference.

Binary logistic regression models were constructed with speech disorder as the dependent variable and eczema as the independent variable. Multivariate models included eczema, sex, age, race, household income, highest level of household education, US vs foreign birthplace, insurance coverage, ever history of asthma, and 1-year history of hay fever and food allergy as the independent variables. aORs and 95% CIs were estimated.

^{*} Because of differences in sampling methodology between NHIS and NSCH, sample weights could not be combined. Meta-analysis of multivariate regression analysis effects were performed using a robust variance estimation method.

Table VI

Association between speech disorders and eczema severity in NSCH 2007–2008

Eczema severity	Speech disorders							
	No (n = 79 258)				Yes (n = 2676)			
	Freq	Percent	(95% CI)		Freq	Percent	(95% CI)	
None	69 910	96.7	(96.4–97.0)	2095	1.00	[ref]	1.00	[ref]
Mild	6364	94.5	(93.2–95.7)	340	1.71	(1.31–2.23)	1.36	(1.02–1.81)
Moderate	2389	93.0	(90.9–95.1)	172	2.20	(1.57–3.09)	1.45	(0.95–2.20)
Severe	508	83.4	(75.1–91.4)	64	5.79	(3.15–10.7)	3.56	(1.70–7.48)

Ref. reference.

Binary logistic regression models were constructed with speech disorder as the dependent variable and eczema severity as the independent variable. Multivariate models included eczema, sex, age, race, household income, highest level of household education, US vs foreign birthplace, insurance coverage, ever history of asthma, and 1-year history of hay fever and food allergy as the independent variables. aORs and 95% CIs were estimated.

Table VII
Association between eczema and severity of speech disorders in NSCH 2007–2008

Eczema											
Severity of speech disorders	No (n = 72 013)					Yes (n = 9855)					P value
	Freq	Percent	(95% CI)	Freq	Percent	(95% CI)	OR	(95% CI)	aOR	(95% CI)	
None	69 910	96.7	(96.4–97.0)	9277	93.2	(92.0–94.5)	1.00	[ref]	1.00	[ref]	-
Mild	1260	1.9	(1.7–2.1)	297	3.1	(2.4–3.9)	1.73	(1.31–2.27)	1.38	(0.86–2.22)	.19
Moderate	585	1.0	(0.8–1.2)	178	2.6	(1.7–3.6)	2.71	(1.80–4.09)	2.35	(1.34–4.10)	.003
Severe	250	0.4	(0.3–0.5)	102	1.0	(0.7–1.3)	2.42	(1.58–3.69)	2.28	(1.11–4.72)	.03

Ref. reference.

Binary logistic regression models were constructed with eczema as the dependent variable and severity of speech disorder as the ordinal independent variable. Multivariate models included sex, age, race, household income, highest level of household education, US vs foreign birthplace, insurance coverage, ever history of asthma, and 1-year history of hay fever and food allergy as the independent variables. aORs and 95% CIs were estimated.

Table VIII

Association between eczema, psychiatric or sleep disturbance, and speech disorder

		Speech disorder							
		No (n = 79 258)				Yes (n = 2676)			
Eczema	Psychiatric or sleep disturbance	Freq	Percent (95% CI)	Freq	Percent (95% CI)	OR (95% CI)	P value	aOR (95% CI)	P value
ADHD *									
No	No	274 808	98.2 (98.1–98.2)	5109	1.8 (1.8–1.9)	1.00 [ref]	-	1.00 [ref]	-
No	Yes	20 832	93.3 (93.0–92.6)	1498	6.7 (6.4–7.0)	3.87 (3.65–4.10)	<.001	3.87 (3.61–4.14)	<.001
Yes	No	29 211	96.2 (96.0–96.4)	1163	3.8 (3.6–4.0)	2.14 (2.01–2.28)	<.001	1.59 (1.47–1.71)	<.001
Yes	Yes	2928	87.4 (86.3–88.6)	421	12.6 (11.4–13.7)	7.74 (6.96–8.60)	<.001	6.00 (5.31–6.77)	<.001
Depression									
No	No	67 454	97.2 (97.1–97.3)	1930	2.8 (2.7–2.9)	1.00 [ref]	-	1.00 [ref]	-
No	Yes	2412	93.8 (92.8–94.7)	160	6.2 (5.3–7.2)	3.68 (2.45–5.52)	<.001	3.73 (2.45–5.68)	<.001
Yes	No	8784	94.5 (94.0–95.0)	513	5.5 (5.1–6.0)	2.17 (1.73–2.73)	<.001	1.58 (1.23–2.04)	<.001
Yes	Yes	472	88.7 (86.0–91.4)	60	11.3 (8.6–14.0)	4.33 (2.30–8.13)	<.001	3.10 (1.37–7.01)	.006
Nights of adequate sleep per wk									
No	4–7	50 132	97.1 (96.8–97.5)	1309	2.9 (2.5–3.2)	1.00 [ref]	-	1.00 [ref]	-
No	0–3	4836	96.7 (95.8–97.5)	150	3.3 (2.5–4.2)	1.16 (0.87–1.54)	.31	1.37 (1.00–1.87)	.049
Yes	4–7	5864	95.1 (94.0–96.3)	294	4.9 (3.7–6.0)	1.72 (1.31–2.26)	<.001	1.26 (0.94–1.70)	.13
Yes	0–3	683	85.7 (77.6–93.7)	57	14.3 (6.3–22.4)	5.62 (2.88–10.94)	<.001	5.85 (2.72–12.53)	<.001
Insomnia (NHIS 2007 and 2012)									
No	No	15 037	98.7 (98.5–98.9)	207	1.3 (1.1–1.5)	1.00 [ref]	-	1.00 [ref]	-
No	Yes	729	94.5 (92.4–96.6)	41	5.5 (3.4–7.6)	4.42 (2.84–6.88)	<.001	4.43 (2.71–7.25)	<.001
Yes	No	1594	97.2 (96.2–98.1)	54	2.8 (1.9–3.8)	2.22 (1.51–3.26)	<.001	1.70 (1.10–2.62)	.02
Yes	Yes	181	90.9 (86.4–95.5)	20	9.1 (4.5–13.6)	7.63 (4.29–13.58)	<.001	5.93 (2.97–11.82)	<.001
Daytime sleepiness (NHIS 2012)									
No	No	8558	98.5 (98.2–98.8)	142	1.5 (1.2–1.8)	1.00 [ref]	-	1.00 [ref]	-
No	Yes	323	97.1 (94.9–99.3)	10	2.9 (0.7–5.1)	1.94 (0.86–4.37)	.11	2.18 (0.97–4.94)	.06
Yes	No	1033	96.4 (95.0–97.8)	41	3.6 (2.2–5.0)	2.45 (1.57–3.82)	<.001	1.86 (1.10–3.14)	.02
Yes	Yes	89	90.8 (83.3–98.4)	10	9.2 (1.6–16.7)	6.57 (2.60–16.60)	<.001	6.21 (2.44–15.80)	<.001
Fatigue (NHIS 2007 and 2012)									

		Speech disorder							
		No (n = 79 258)				Yes (n = 2676)			
Eczema	Psychiatric or sleep disturbance	Freq	Percent	(95% CI)	Freq	Percent	(95% CI)	OR	(95% CI)
No	No	15 060	98.7	(98.5–98.9)	212	1.3	(1.1–1.5)	1.00	[ref]
No	Yes	707	94.0	(91.6–96.5)	36	6.0	(3.5–8.4)	4.94	(3.07–7.93)
Yes	No	1582	97.2	(96.3–98.1)	54	2.8	(1.9–3.7)	2.26	(1.55–3.30)
Yes	Yes	194	91.2	(86.6–95.7)	20	8.8	(4.3–13.4)	7.55	(4.20–13.58)
								5.81	(2.77–12.17)
									<.001

Ref, reference.

Binary logistic regression models were constructed with speech disorder as the dependent variable. Eczema (NSCH 2003–2004 and 2007–2008 and NHIS 1997–2013), ADD/ADHD (NSCH 2003–2004 and 2007–2008 and NHIS 1997–2013), depression (NSCH 2007–2008 only), number of adequate nights of sleep per week (NSCH 2007–2008), insomnia (NHIS 2007 and 2012), daytime sleepiness (NHIS 2012), and fatigue (NHIS 2007 and 2012) were the independent variables. Multivariate models included sex, age, race, household income, highest level of household education, US vs foreign birthplace, insurance coverage, ever history of asthma, and 1-year history of hay fever and food allergy as the independent variables. aORs and 95% CIs were estimated.

* Samples weights between NSCH and NHIS could not be combined. Unweighted prevalence and prevalence odds ratio estimates are presented.