Association Between Obesity and Eczema Prevalence, Severity and Poorer Health in US Adolescents

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Background: **Identification of modifiable risk factors for the development of eczema is of major public health significance.**

Objective: **This study aimed to determine the effects of obesity in adolescence on the prevalence, severity, and quality of life of patients with eczema.**

Methods: **We used the 2007-2008 National Survey of Children's Health, including a nationally representative sample of 45,897 adolescents aged 10 to 17 years. Caregiver report of eczema, health status, height, weight, number of health conditions, use of health services, and sociodemographics were assessed.**

Results: **The prevalences of overweight (20.3% vs 15.4%) and obesity (16.8% vs 15.4%) were increased in adolescents with eczema compared with adolescents without eczema (Rao-Scott χ^2, $P < 0.0001$). A body mass index for-age-percentile (BMIP) of 50 to 94 (logistic regression, odds ratio [OR], 1.61 [95% confidence interval (CI), 1.32–1.97]) and greater than or equal to 95 (1.46 [1.15–1.86]) was associated with higher odds of eczema compared with 5% to 49%. Moderate to severe eczema was higher with BMIP of 50 to 94 (41.2%; OR, 2.46 [95% CI, 1.73–3.51]) and greater than or equal to 95 (45.7%; 2.95 [1.73–3.51]) compared with 5 to 49 (22.2%). There was a significant interaction between race/ethnicity and BMIP in multivariate regression models of eczema severity, such that BMIP remained significant in Hispanics (OR, 3.24 [95% CI, 1.56–6.71]), non-Hispanic whites (3.64 [1.93–6.84]), Asians (57.17 [4.02–813.10]), Pacific Islanders/Alaskan Natives (90,336.3 [11,963.80–682,111.0]), and multiracial/other (3.99 [1.23–12.98]) but not in non-Hispanic blacks (1.88 [0.91–3.91]) and American Indians (2.12 [0.11–42.33]). Obese adolescents with eczema had higher odds of having only good (OR, 2.67 [95% CI, 1.56–4.56]) or fair (2.60 [1.35–5.03]) health compared with excellent overall health, had higher number of chronic health conditions (34.6% vs 18.0% with ≥2 conditions; $P \leq 0.003$), and used more health services than most children of the same age compared with nonobese children (31.2% vs 21.5%; $P = 0.01$).**

Conclusions: **Obesity in adolescence is associated with increased eczema prevalence and severity, poorer overall health, and increased chronic health conditions and health care utilization.**

The prevalence of childhood atopic dermatitis (AD) in the United States was 2% to 3% before 1960, 9% to 12% after 1970, and is now as high as 20%.[1,2] At the same time, the US prevalences of overweight and obesity in childhood have dramatically increased. Recently, several studies demonstrated an association between childhood obesity and AD.[3–6] Silverberg et al[4] (2011) performed a retrospective pediatric practice-based study and found that obesity, in particular obesity that starts in early childhood (0–5 years), was associated with increased prevalence and severity of eczema and increased pediatrician visits related to AD. Several international population-based studies have also demonstrated an association between adiposity/obesity and AD.[3,5,6] The previously mentioned studies that demonstrated associations between obesity and eczema were performed in predominantly racially/ethnic homogeneous cohorts. It is therefore unknown if the results of those studies are generalizable to the entire US population.

Elucidation of the impact of childhood obesity on the prevalence of AD may have significant public health ramifications. However, few US population-based studies have been performed

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J.I. Silverberg had full access to all the data in the study and takes responsibility for the integrity of the data and accuracy of the data analysis.

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to assess the impact of obesity on AD in childhood or adolescence. To best answer these questions, large-scale studies that use random sampling across all states and districts and include children of all races, ethnicities, and household income strata are needed.

Race/ethnicity and socioeconomic status are important predictors of obesity and metabolic syndrome.[7] Race/ethnicity and socioeconomic status have also been shown to be associated with higher eczema prevalence. We hypothesized that there are differential effects of race/ethnicity and socioeconomic status on the association of obesity and eczema. However, in a study of 102,353 children aged 0 to 17 years from the 2003 National Survey of Children's Health (NSCH), eczema prevalence was associated with black race, higher education level, speaking English, and having a single mother living in the household and living in a metropolitan area, but not with body mass index (BMI).[8] Although this study was a US population-based study, the analyses examined raw BMI as opposed to BMI-for-age and sex percentiles, which are more commonly used in the pediatric and adolescent population. Furthermore, the analyses examined BMI for children aged 0 to 17 years. A subsequent validation study by the Centers for Disease Control and Prevention (CDC) revealed that self-reported height and weight, used for calculation of BMI, are valid only for children aged 10 to 17 years.[9] We therefore felt that a more detailed analysis was warranted that considered these points.

There are several additional questions about the role of obesity in atopic disease. Despite emerging evidence of the role of weight in early childhood eczema, there is a paucity of studies that demonstrate a relationship between obesity and eczema risk in adolescence. This is of particular importance because eczema in adolescence was found to be associated with greater disease severity compared with younger children.[10] Finally, it is unknown if obesity in children with eczema further predisposes them toward other atopic disorders, for example, asthma or food allergies. In the present study, we present a comprehensive analysis of the impact of obesity on eczema in US adolescents.

METHODS

National Survey of Children's Health

We used data from the 2007–2008 NSCH survey of 91,642 households, which was designed to estimate the prevalence of various child health issues. The NSCH was sponsored by the Maternal and Child Health Bureau and the US Department of Health and Human Services. The National Center for Health Statistics conducted it using the State and Local Area Integrated Telephone Survey program with a goal of more than 1700 children per state. The telephone numbers were chosen at random, followed by identification of the households with 1 or more children younger than the age of 18 years. Subsequently, 1 child was randomly selected for interview. The survey results were weighted to represent the population of noninstitutionalized children nationally and in each state. Using the data from the US Bureau of the Census, population-based weights were adjusted for age, sex, race/ethnicity, household size, and educational attainment of the most educated household member to provide a data set that was more representative of each state's population of noninstitutionalized children younger than the age of 18 years. The National Center for Health Statistics of the Center for Diseases Control and Prevention oversaw sampling and telephone interviews. The weighted overall response rate was 46.7% without significant nonresponse bias by age.[11] The study was approved by the institutional review board at St Luke's-Roosevelt Hospital Center.

Eczema Prevalence

Atopic dermatitis/eczema prevalence was determined using the NSCH question, "During the past 12 months, have you been told by a doctor or other health professional that (child) had eczema or any kind of skin allergy?" Because the outcome was health care–diagnosed AD/eczema, we excluded all patients who responded "no" to the question, "During the past 12 months, did (child) see a doctor, nurse, or other health care professional for any kind of medical care, including sick-child care, well-child check-ups, physical exams, and hospitalizations?"

Eczema Severity

The severity of AD/eczema was determined using the NSCH question, "Would you describe (child's) eczema or skin allergy as mild, moderate, or severe?" Responses were encoded as an ordinal variable, where 1 is equal to mild, 2 is equal to moderate, and 3 is equal to severe.

BMI Classification

Body mass index classification for adolescents aged 10 to 17 years was determined by the NSCH using a combination of questions, "How much does (child) weigh now?" (in pounds) and "How tall is (child) now?" (in inches). The question about weight was asked to all parents. However, the question about height was only asked to parents of adolescents aged 10 to 17 years (n = 45,897) owing to concerns about parental underestimation of height and resultant overestimation of overweight/obesity prevalence among preschool-aged and elementary school–aged children.[9] As per the NSCH institutional review protocol, the identity of children with extreme height or weight measurements was protected by top coding to 95th percentile for even higher values or bottom coded to fifth percentile for even lower values. Body mass index was calculated by the following: (weight $\times$ 703)/height.[2] The BMI-for-age percentiles were determined using the CDC standards. The BMI data are presented as both *z* scores and percentiles. Obesity was defined as greater than or equal to the 95th BMI-for-age percentile (BMIP).

Health care Outcomes

The prevalence of comorbid asthma, allergic rhinitis, and food allergies as well as overall health and requirement of more services

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than other children of the same age were determined by survey responses. Nonresponders or "not known" responses were considered as missing data. Number of chronic health conditions is a derived variable from the NSCH, which represents the sum of all medical conditions elicited in the survey (see footnote to Table 4 for the list of conditions).

Data Processing and Statistical Methods

All data processing and statistical analyses were performed in SAS version 9.2. Analyses of survey responses were performed using survey procedures. Bivariate associations were tested using Rao-Scott χ^2 tests and logistic regression modeling. Multivariate logistic regression models included age, sex, race/ethnicity, and household income. Selection of these potentially confounding variables was based on our a priori hypothesis of racial/ethnic and/or socioeconomic differences for the association between BMI and eczema, as well as previous analyses from the NSCH[10]; potential for confounding was confirmed in bivariate analyses. The analysis of eczema prevalence was performed by binomial logistic regression with health care diagnosis of AD as the binary-dependent outcome. The analysis of eczema severity was performed by binomial logistic regression with presentation of odds ratios (OR) and 95% confidence intervals (CIs) for moderate to severe versus mild eczema. This approach was used over ordinal logistic regression because the data did not meet the proportional odds assumption (score test, $P < 0.01$). The analyses of the prevalences of other atopic disorders (ie, asthma, hay fever, and food allergy) were also performed by binomial logistic regression with health care diagnosis of these disorders as the binary-dependent outcomes. For models of atopic disease, sensitivity analyses were also performed to determine if higher BMI confers additional risk for atopic disease above and beyond the risk of AD. Complete data analysis was performed, that is, patients with missing data were excluded from analyses.

The distribution of BMI-for-age z scores was significantly skewed and neither met assumptions of normality (Kolmogorov-Smirnov test, $P < 0.01$) nor goodness of fit for logistic regression models (Hosmer-Lemeshow, $P \leq 0.03$). The BMI-for-age z scores were therefore treated as ordinal variables for all analyses and divided into symmetric bins ($z < -1.65$, $-1.65 \leq z < 0$, $0 \leq z < 1.65$, $1.65 < z$). These bins correspond to less than 5 (underweight), 5 to 49 (normal weight), 50 to 94 (upper normal-overweight), and greater than or equal to 95 BMI-for-age percentiles (obese), respectively. Sensitivity analyses were performed by constructing models with and without adolescents that had top- and bottom-coded height and weight values. There were no significant differences of association between BMI-for-age z scores/obesity and eczema/other atopic outcomes between these 2 approaches. Therefore, only models that include all adolescents are presented in this article.

Correction for multiple-dependent tests ($\kappa = 31$) was performed by controlling for the false discovery rate with the approach of Benjamini and Hochberg[12] and yielded a critical P value threshold of 0.03.

RESULTS

Determinants of BMI in Adolescents Aged 10 to 17 Years

There were 45,897 adolescents aged 10 to 17 years, of which 38,409 (83.7%) had a health care interaction within the preceding year; 37,754 (98.3%) of these had available BMI data. When considered as a continuous variable, the median (interquartile range [IQR]) BMI-for-age z score was 0.44 (1.64) overall and was higher in adolescents with eczema than without (median, 0.67 [IQR, 1.41] vs 0.40 [1.65]; Kruskal-Wallis test, $P < 0.0001$). To model BMI in logistic regression models, BMI-for-age z scores were divided into 4 symmetrically binned groups (see Methods).

Overall, almost one third of adolescents were either overweight (16.1%) or obese (15.5%). In particular, the prevalences of overweight (20.3% vs 15.4%) and obesity (16.8% vs 15.4%) were increased in adolescents with eczema compared with adolescents without eczema (Rao-Scott χ^2 test, $P < 0.0001$; Fig. 1). There was a significant overrepresentation of higher BMI-for-age classification in male sex, younger age, Hispanics and African Americans, and lower household income (Rao-Scott χ^2 test, $P < 0.0001$; Table 1). These variables were therefore included in multivariate logistic regression models later.

BMI and Eczema Prevalence

Eczema prevalence was significantly associated with increased BMI. Adolescents with BMI-for-age percentiles of 50 to 94 (logistic regression, OR, 1.61 [95% CI, 1.32–1.97]; $P < 0.0001$) and greater than or equal to 95 (1.46 [1.15–1.86]; $P = 0.002$) had significantly higher odds of eczema when compared with fifth to 49th percentile (Table 2). These associations remained significant in multivariate models that included age, sex, race/ethnicity, and household income ($P \leq 0.009$). However, there was no significant increase of

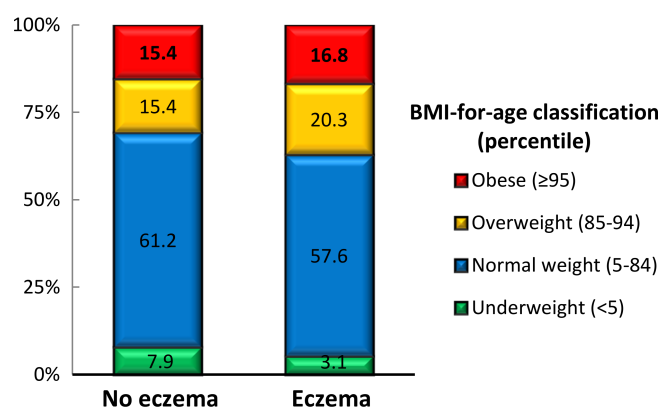

Figure 1. Childhood eczema is associated with increased prevalence of overweight and obesity. The BMI-for-age z scores/percentiles were divided into underweight ($z < -1.65$; <5%), normal weight ($-1.65 \leq z < 0$; 5%–49%), upper normal weight and overweight ($0 \leq z < 1.65$; 50%–94%), and obesity ($1.65 < z$; ≥95%). Data are presented as the prevalence (in percent).

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TABLE 1. Determinants of Adiposity in US Adolescents (N = 37,754)

	BMI-for-Age Percentile								
	≤5 (Underweight) (n = 2334)		5–49 (n = 11,656)		50–94 (n = 18,782)		≥95 (Obese) (n = 4982)		
Variable*	Frequency	Percent (95% CI)	Frequency	Percent (95% CI)	Frequency	Percent (95% CI)	Frequency	Percent (95% CI)	*P*†
Sex									
Male	1290	8.3 (7.1–9.4)	5309	25.1 (23.6–26.6)	9894	48.5 (46.7–50.3)	3203	18.2 (16.8–19.5)	<0.0001
Female	1040	6.3 (5.3–7.3)	6330	32.7 (31.0–34.4)	8869	48.3 (46.4–50.2)	1776	12.7 (11.3–14.0)	
Age, y									
10–11	805	13.8 (11.4–16.2)	1793	21.4 (19.2–23.7)	3592	43.3 (40.6–46.0)	1476	21.5 (19.3–23.7)	<0.0001
12–13	583	6.9 (5.4–8.4)	2530	26.7 (24.5–28.9)	4503	49.9 (47.4–52.5)	1200	16.5 (14.4–18.6)	
14–15	421	4.3 (3.4–5.3)	3227	31.5 (29.2–33.9)	5209	50.8 (48.3–53.2)	1206	13.4 (11.8–15.1)	
16–17	525	4.7 (3.8–5.7)	4106	35.0 (32.6–37.4)	5478	49.3 (46.7–51.9)	1100	11.0 (9.4–12.7)	
Race/ethnicity									
Non-Hispanic white	1495	5.8 (5.2–6.4)	8759	33.0 (31.6–34.4)	13,131	48.8 (47.4–50.3)	2874	12.3 (11.3–13.3)	<0.0001
Hispanic	401	12.7 (9.5–16.0)	947	20.0 (17.0–23.1)	1793	46.6 (42.1–51.1)	671	20.6 (17.0–24.2)	
Non-Hispanic black	190	5.5 (3.8–7.2)	840	21.4 (18.7–24.2)	2104	49.3 (46.2–52.5)	951	23.7 (21.2–26.3)	
Asian	40	16.0 (4.4–27.6)	157	42.1 (27.7–56.5)	168	35.0 (22.6–47.4)	34	6.9 (2.0–11.8)	
Native Hawaiian/ Pacific Islander	9	12.4 (1.5–23.2)	26	18.3 (9.6–27.0)	61	52.6 (39.6–65.5)	20	16.8 (6.4–27.2)	
Multiracial/other	136	6.0 (4.0–7.9)	691	30.6 (26.2–35.0)	1088	52.1 (47.3–56.9)	282	11.3 (8.6–14.1)	
Household income,% family poverty level									
0–99	352	12.1 (9.3–14.9)	771	19.1 (16.5–21.6)	1749	45.2 (41.7–48.8)	889	23.6 (20.8–26.4)	<0.0001
100–199	370	7.3 (5.3–9.2)	1413	23.6 (20.7–26.5)	2917	49.2 (46.1–52.4)	1061	19.9 (17.4–22.4)	
200–399	694	5.7 (4.6–6.7)	3874	28.9 (26.9–30.9)	6413	50.5 (48.1–52.8)	1670	15.0 (13.3–16.7)	
≥400	918	6.7 (5.5–7.8)	5598	36.5 (34.6–38.4)	7703	47.3 (45.4–49.3)	1362	9.5 (8.1–10.8)	

**Missing data were encountered in 655 (1.7%) for BMI, 0 (0.0%) for age, 1973 (5.1%) for race/ethnicity, 55 (0.1%) for sex, and 0 (0.0%) for household income in adolescents aged 10 to 17 years. There were no significant differences of nonresponders for history of eczema across age, race/ethnicity, sex, or household income strata.*
†Rau-Scott χ^2 tests.

eczema prevalence in adolescents with BMI-for-age percentile of less than 5.

To exclude the effects of the previously established and potentially confounding association between obesity and race/ethnicity, we also constructed a multivariate model that excluded any adolescents of black/African American or American Indian race/ethnicity. The association between eczema prevalence and BMI-for-age percentiles of 50 to 94 (OR, 1.61 [95% CI, 1.28–2.04]; $P < 0.0001$) and greater than or equal to 95 (1.35 [1.08–1.82]; $P = 0.02$) remained significant. Similarly, we also constructed a multivariate model that excluded any adolescents with history of asthma to exclude potentially confounding of the association between obesity and asthma. The association between eczema prevalence and BMI-for-age percentiles of 50 to 94 (OR, 1.60 [95% CI, 1.25–2.06]; $P = 0.0002$) and greater than or equal to 95 (1.41 [1.02–1.94]; $P = 0.03$) remained significant.

BMI and Moderate to Severe Eczema

Obesity was associated with increased eczema severity. The prevalence of moderate to severe eczema was significantly higher in adolescents with BMI-for-age percentiles of 50 to 94 (41.2%; OR, 2.46 [95% CI, 1.73-3.51]; $P < 0.0001$) and greater than or equal to 95 (45.7%; 2.95 [1.73–3.51]; $P < 0.0001$) when compared with the referent group of 5 to 49 (22.2%; Table 2). However, there was no association between underweight and moderate to severe eczema ($P = 0.16$).

There was a significant linear interaction between race/ethnicity and BMI-for-age *z* score in models of severe eczema. Contrast statements were used to estimate the interactive effects of BMI-for-age *z* score and race/ethnicity. The association between race/ethnicity, BMI-for-age *z* score, and severe eczema remained significant in all Hispanics (OR, 3.24 [95% CI, 1.56–6.71]; $P = 0.002$), non-Hispanic whites (3.64 [1.93–6.84]; $P < 0.0001$), Asians (57.17 [4.02–813.10]; $P = 0.003$), Pacific Islanders/Alaskan Natives (90,336.3 [11,963.80–682,111.0]; $P < 0.0001$), and multiracial/other (3.99 [1.23–12.98]; $P = 0.02$) but not in non-Hispanic blacks (1.88 [0.91–3.91]; $P = 0.09$) and American Indians (2.12 [0.11–42.33]; P 0.62). There were no other significant interactions between BMI, sex, age, or household income (data not shown).

Obesity and Health Outcomes and Utilization in Adolescents With Eczema

Adolescents with eczema who were obese reported poorer overall health than those who were not obese (self-reported excellent health, 34.0% vs 49.9%; Table 3). Obesity was associated with higher odds

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TABLE 2. Association Between Increased BMI-for-Age *z* Score and Eczema Prevalence in Adolescents

BMI for Age		Eczema Prevalence (n = 38,373)							
		No Eczema (n =34,265)		Eczema* (n = 4108)					
z Scores	Percentiles	Freq	Percent (95% CI)	Freq	Percent (95% CI)	OR (95% CI)	*P*	aOR (95% CI)	*P*
<−1.65	<5 (underweight)	2143	93.9 (92.0–95.7)	189	6.0 (4.2–7.8)	0.70 (0.49–1.01)	0.05	0.71 (0.49–1.02)	0.06
−1.65–0	5–49	10,553	91.6 (90.4–92.8)	1091	8.4 (7.2–9.6)	1.00 (ref)	—	1.00 (ref)	—
0–1.65	50–94	16,651	87.1 (85.7–88.4)	2112	12.8 (11.5–14.2)	1.61 (1.32–1.97)	<0.0001	1.60 (1.31–1.97)	<0.0001
≥1.65	≥95 (obese)	4315	88.2 (86.3–90.1)	665	11.8 (9.9–13.7)	1.46 (1.15–1.86)	0.002	1.41 (1.09–1.82)	0.009

BMI for Age		Eczema Severity (n = 4100)							
		Mild (n = 2711)		Moderate to Severe† (n = 1389)					
z Scores	Percentiles	Freq	Percent (95% CI)	Freq	Percent (95% CI)	OR (95% CI)	*P*	aOR (95% CI)	*P*
<−1.65	<5 (underweight)	124	67.9 (53.7–82.0)	64	32.0 (17.9–46.1)	1.65 (0.82–3.30)	0.16	1.40 (0.64–3.05)	0.40
−1.65–0	5–49	780	77.7 (73.1–82.2)	309	22.2 (17.7–26.7)	1.00 (ref)	—	1.00 (ref)	—
0–1.65	50–94	1383	58.4 (52.6–64.2)	725	41.2 (35.3–47.0)	2.46 (1.73–3.51)	<0.0001	2.35 (1.66–3.31)	<0.0001
≥1.65	≥95 (obese)	390	54.2 (45.7–62.6)	274	45.7 (37.3–54.2)	2.95 (1.73–3.51)	<0.0001	2.59 (1.64–4.10)	<0.0001

Missing data were encountered in 655 (1.7%) for BMI, 36 (0.1%) for eczema, 0 (0.0%) for age, 1973 for race/ethnicity (5.1%), 55 for sex (0.1%), and 0 (0.0%) for household income in adolescents aged 10 to 17 years. There were no significant differences of nonresponders for history of eczema or eczema severity across age, race/ethnicity, sex, or household income strata.

Note: Logistic regression models were constructed with BMI-for-age z score as a continuous variable. However, the Hosmer-Lemeshow goodness-of-fit test was significant (P = 0.02) and BMI-for-age z score was therefore modeled as an ordinal variable.

**Binary logistic regression models were constructed with history of eczema in the past 12 months (yes/no) as the dependent (outcome) variable.*

†Binomial logistic regression models were constructed with eczema severity dichotomized into mild versus moderate to severe as the dependent (outcome) variable. The independent (explanatory) variable was BMI-for-age z scores (ordinal). Odds ratios and 95% CI were determined. Adjusted OR was determined from multivariate models by including sex, current age, sex, race/ethnicity, and household income as categorical variables. There were no significant interactions between BMI-for-age z scores and age, sex, or household income. There was a significant linear interaction between BMI-for-age z score and race/ethnicity. However, there was no significant effect modification between estimates from individual contrast statements and the interaction term was therefore omitted from the final model.

aOR indicates adjusted OR.

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TABLE 3. Association Between Eczema, Obesity, and Poorer Health Outcomes in Adolescents

Health Outcome in Adolescents With Eczema (n = 4057)	Not Obese (n = 3392)		Obese (n = 665)					
	Freq	Percent (95% CI)	Freq	Percent (95% CI)	OR (95% CI)	*P*	aOR (95% CI)	*P**
Overall health								
Excellent	1819	49.9 (45.4–54.3)	230	34.0 (25.4–42.7)	1.00 (ref)	—	1.00 (ref)	—
Very good	997	29.8 (25.8–33.9)	217	29.8 (22.8–36.9)	1.46 (0.91–2.36)	0.12	1.44 (0.88–2.35)	0.15
Good	429	14.8 (11.6–18.1)	150	27.0 (19.7–34.40)	2.67 (1.56–4.56)	0.0003	2.34 (1.33–4.14)	0.003
Fair	119	4.6 (2.9–6.2)	59	8.1 (4.8–11.4)	2.60 (1.35–5.03)	0.004	2.29 (1.11–4.74)	0.03
Poor	26	0.9 (0.3–1.5)	9	1.0 (0.0–2.07)	1.68 (0.46–6.16)	0.44	1.46 (0.33–6.48)	0.62
No. comorbid chronic conditions								
None	1979	56.9 (52.5–61.4)	298	44.3 (35.9–52.7)	1.00 (ref)	—	1.00 (ref)	—
1	774	25.1 (21.0–29.2)	160	21.2 (15.2–27.1)	1.08 (0.69–1.71)	0.73	1.03 (0.65–1.64)	0.89
2	263	5.9 (4.4–7.3)	75	13.3 (7.3–19.2)	2.91 (1.57–5.38)	0.0007	2.68 (1.43–5.05)	0.002
3+	376	12.1 (9.2–15.0)	132	21.3 (14.4–28.2)	2.26 (1.33–3.86	0.003	2.04 (1.18–3.54)	0.01
More services than most children of same age	728	21.5 (17.9–25.1)	222	31.2 (24.4–38.1)	1.66 (1.13–2.43)	0.01	1.46 (0.99–2.16)	0.06
Health Outcome in Adolescents Who Are Obese (n = 5906)	**No Eczema (n = 5159)**		**Eczema (n = 747)**					
	Freq	**Percent (95% CI)**	**Freq**	**Percent (95% CI)**	**OR (95% CI)**	***P***	**aOR (95% CI)**	***P****
Overall health								
Excellent	2262	90.9 (88.2–93.7)	257	9.1 (6.3–11.8)	1.00 (ref)	—	1.00 (ref)	—
Very good	1662	89.5 (87.0–92.0)	252	10.5 (8.0–13.0)	1.18 (0.77–1.81)	0.45	1.27 (0.81–1.99)	0.29
Good	963	85.8 (81.7–89.9)	170	14.2 (10.1–18.3)	1.66 (1.03–2.67)	0.03	1.77 (1.07–2.94)	0.026
Fair	254	85.2 (78.6–91.7)	63	14.8 (8.3–21.4)	1.75 (0.94–3.24)	0.08	2.06 (1.13–3.76)	0.02
Poor	41	93.4 (86.7–100.0)	12	6.6 (0.0–13.3)	0.70 (0.22–2.23)	0.55	0.87 (0.26–2.91)	0.82
No. comorbid chronic conditions								
None	3373	92.4 (90.5–94.2)	339	7.6 (5.8–9.5)	1.00 (ref)	—	1.00 (ref)	—
1	979	87.7 (84.4–91.1)	184	12.3 (8.9–15.6)	1.69 (1.12–2.54)	0.01	1.66 (1.09–2.52)	0.01
2	344	80.4 (72.4–88.4)	82	19.6 (11.6–27.6)	2.94 (1.66–5.20)	0.0002	2.79 (1.57–4.96)	0.0005
3+	490	78.2 (71.1–85.3)	192	21.8 (14.7–28.9)	3.37 (2.06–5.50)	<0.0001	3.59 (2.22–5.82)	<0.0001
More services than most children of the same age	503	9.1 (7.3–10.9)	244	18.9 (14.8–22.9)	2.32 (1.65–3.27)	<0.0001	2.36 (1.67–3.32)	<0.0001

Missing data were encountered in 52 (1.2%) for BMI, 37 (0.9%) for overall health, 0 (0.0%) for number of chronic conditions, 31 (0.8%) for more services than most children of the same age, 0 (0.0%) for age, 189 (4.6%) for race/ethnicity, 5 (0.1%) for sex, and 0 (0.0%) for household income in adolescents aged 10 to 17 years. There were no significant differences of nonresponders for history of eczema across age, race/ethnicity, sex, or household income strata.

Number of chronic health conditions is a derived variable, which represents the sum of all medical conditions elicited in the survey (learning disability; attention deficit disorder or attention deficit hyperactivity disorder; depression; anxiety problems; behavioral or conduct problems, such as oppositional defiant disorder or conduct disorder; autism, Asperger disorder, pervasive developmental disorder, or other autism spectrum disorder; any developmental delay that affects his/her ability to learn; stuttering, stammering, or other speech problems; Tourette syndrome; asthma; diabetes; epilepsy or seizure disorder; hearing problems; vision problems that cannot be corrected with glasses or contact lenses; bone, joint, or muscle problems; and brain injury or concussion).

**Binomial and multinomial logistic regression models were constructed with health outcomes as the dependent (outcome) variables. Two different sets of models were constructed; (1) the independent (explanatory) variable was obesity (BMI-for-age z score, ≥1.65 or ≥95th percentile; binary) and subjects were limited to those who had eczema and (2) the independent (explanatory) variable was eczema (binary) and subjects were limited to those who were obese. Odds ratio and 95% CI for health outcomes were determined. Adjusted OR was determined from multivariate models by including sex, current age, race/ethnicity, and household income as categorical variables. Note: there were no significant interactions between BMI-for-age z score and other covariates in multivariate models.*

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of only good (OR, 2.67 [95% CI, 1.56–4.56]; $P = 0.0003$) or fair (2.60 [1.35–5.03]; $P = 0.004$) health when compared with nonobesity. Obesity was also associated with a higher number of chronic health conditions in adolescents with eczema (obese vs not obese, 34.6% vs 18.0% with ≥2 conditions; $P \leq 0.003$). These associations remained significant in multivariate logistic regression models. Finally, obese adolescents with eczema reportedly used more health services than most adolescents of the same age compared with those who were not obese (31.2% vs 21.5%; $P = 0.01$), but this association did not remain significant in multivariate models ($P = 0.06$).

Similarly, adolescents who were obese and had eczema were reported to have poorer overall health, had a higher number of chronic health conditions, and used more health services than those without eczema (Table 3).

Obesity and Other Atopic Disorders

Obesity in adolescence was associated with increased prevalence of asthma (OR, 1.58 [95% CI, 1.27–1.97]; $P < 0.0001$) and hay fever (1.21 [1.02–1.45]; $P = 0.03$) within the past 12 months but not with food allergies (1.26 [0.93–1.71]; $P = 0.14$; Table 4). In addition, obesity was associated with increased prevalence of at least 1 of the previously mentioned disorders (OR, 1.31 [95% CI, 1.13–1.52]; $P = 0.0004$) and the comorbid diagnosis of all 3 (2.33 [1.19–4.57]; $P = 0.01$) atopic disorders aside from eczema.

In adolescents with eczema, however, there were no significant differences of prevalence of comorbid asthma, hay fever, food allergies, or combinations thereof with obesity compared with nonobesity.

Similar results were found when the previously mentioned models were constructed using BMI-for-age z scores divided into quartiles by rank (data not shown).

DISCUSSION

Using a US population-based sample, we demonstrated an association between increased BMI and eczema in adolescents; that is, adolescents who were either in upper normal/overweight (50th–94th BMI-for-age percentile) or obese (≥95th percentile) had greater eczema prevalence and severity. Adolescents with both eczema and obesity had poorer overall health, more chronic health conditions, and greater health care utilization than adolescents with either obesity or eczema alone. The present study includes a nationally representative cohort with adequate sampling of all

TABLE 4. Association Between Obesity, Asthma, and Hay Fever in All Adolescents but not in Adolescents With Eczema (n = 37,719)

	All Adolescents							
	Not Obese (n = 32,739)		Obese (n = 4980)					
Atopic Disorder Within the Past 12 mo	Freq	Percent (95% CI)	Freq	Percent (95% CI)	OR (95% CI)	*P*	aOR (95% CI)	*P**
Asthma	3315	10.2 (9.4–11.0)	766	16.2 (13.7–18.7)	1.72 (1.40–2.11)	*<0.0001*	1.58 (1.27–1.97)	*<0.0001*
Hay fever	7128	19.9 (18.9–21.0)	1235	22.9 (20.0–25.7)	1.19 (1.00–1.41)	0.05	1.21 (1.02–1.45)	*0.03*
Food allergies	1520	4.1 (3.6–4.5)	255	5.3 (3.9–6.7)	1.31 (0.97–1.77)	0.08	1.26 (0.93–1.71)	0.14
≥1 of the previously mentioned disorders	11,904	35.5 (34.1–36.8)	2174	42.1 (38.8–45.4)	1.32 (1.14–1.54)	*0.0002*	1.31 (1.13–1.52)	*0.0004*
All 3 of the previously mentioned disorders	235	0.5 (0.4–0.7)	50	1.1 (0.4–1.8)	2.13 (1.10–4.13)	*0.03*	2.33 (1.19–4.57)	*0.01*
	Adolescents With Eczema†							
	Not Obese (n = 3392)		**Obese (n = 665)**					
	Freq	**Percent (95% CI)**	**Freq**	**Percent (95% CI)**	**OR (95% CI)**	***P***	**aOR (95% CI)**	***P****
Asthma	714	21.8 (18.1–25.4)	171	26.2 (19.5–33.0)	1.27 (0.85–1.92)	0.25	1.06 (0.69–1.63)	0.80
Hay fever	1405	42.2 (37.7–46.7)	291	43.9 (35.6–52.1)	1.07 (0.73–1.57)	0.73	1.03 (0.70–1.52)	0.89
Food allergies	461	11.1 (9.1–13.2)	94	15.7 (10.1–21.4)	1.52 (0.95–2.44)	0.09	1.40 (0.86–2.27)	0.18
≥1 of the previously mentioned disorders	1811	53.2 (48.7–57.6)	389	62.8 (54.7–71.0)	1.49 (1.01–2.21)	0.046	1.37 (0.92–2.05)	0.12
All 3 of the previously mentioned disorders	190	5.1 (3.5–6.7)	44	7.0 (3.0–11.0)	1.40 (0.69–2.81)	0.35	1.22 (0.58–2.57)	0.60

**Binomial and multinomial logistic regression models were constructed with atopic disorders as the dependent (outcome) variables. The independent (explanatory) variable was obesity (BMI-for-age z score, ≥1.65 or ≥95th percentile; binary). Odds ratio and 95% CI for health outcomes were determined. Adjusted OR was determined from multivariate models by including sex, current age, race/ethnicity, and household income as categorical variables. Note: there were no significant interactions between BMI-for-age z score and other covariates in multivariate models.*

†Missing data were encountered in 52 (1.2%) for BMI, 4 (0.1%) for asthma, 5 (0.1%) for hay fever, 9 (0.2%) for food allergy, 0 (0.0%) for age, 189 (4.6%) for race/ethnicity, 5 (0.1%) for sex, and 0 (0.0%) for household income in adolescents aged 10 to 17 years. There were no significant differences of nonresponders for history of eczema across age, race/ethnicity, sex, or household income strata.

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racial and ethnic groups, which allowed for examination of interactions between race/ethnicity and BMI in models of eczema severity. Body mass index was significantly associated with moderate to severe eczema in Hispanics, non-Hispanic whites, Asians, Pacific Islanders/Alaskan Natives, and multiracial/others but not in American Indians or African Americans/blacks. There may be racial/ethnic differences with respect to the pathogenesis of and/or risk factors for AD. Further studies are warranted to study the impact of obesity on AD severity in different racial/ethnic groups.

Previous studies found an association between overweight and/or obesity and eczema in young children and adolescents.[3–6,13] However, the population-based nature of the survey allows for a better estimate of the effects of obesity on eczema throughout the United States and broader sampling of all racial/ethnic groups compared with previous studies using hospital- or practice-based samples. Silverberg et al[4] (2011) found that early onset (ages 0–5 years) and prolonged duration (>2.5 years) of obesity were associated with increased odds of developing AD in the pediatric outpatient setting. Murray et al[13] (2011) demonstrated that increased BMI-for-age *z* score was significantly associated with increased odds of physician-diagnosed eczema at age 5 and 8 years in a UK birth cohort. The patient cohorts from those studies were predominantly non-Hispanic whites. A study of Japanese schoolchildren aged 7 to 15 years found that increased BMI was associated with AD.[3] The present study confirms these findings and demonstrates similar results across multiple racial/ethnic and other demographic groups. In contrast, analysis of the 2003 NSCH revealed no association between eczema and raw BMI in children aged 0 to 17 years.[8] The differences observed in the present study are due to the use of BMI-for-age and sex percentiles and limiting the analyses to aged 10 to 17 years, where self-reported BMI is validated. In fact, reanalysis of the 2003 NSCH using the CDC BMI-for-age and sex percentiles in adolescents aged 10 to 17 years similarly revealed significant associations between being upper normal/overweight (50th-94th BMI-for-age percentile) or obese (≥95th percentile) and eczema prevalence (data not shown).

It is noteworthy that in the present study, the effect sizes were modest for the association between obesity and AD but considerably higher for AD severity. The previously mentioned studies of Silverberg et al[4] and Murray et al[13] found considerably larger effect sizes for the association between AD prevalence and obesity; the former study[4] found the strongest association in younger children. Thus, obesity seems to play a stronger role as an exacerbating factor for AD in adolescents.

Less is known about the impact of obesity on AD in adults. A single study of AD in adults found that obesity is associated with increased odds of AD, defined by personal history of eczema, family history of any atopic disorders, and positive skin prick atopy testing, but not with eczema or atopy alone.[14] The present study suggests that overweight and obesity are associated with both greater prevalence and severity of adolescent AD. We recently demonstrated that the AD that occurs in adolescence is associated with increased disease severity and other atopic disorders.[10] It seems that obesity is associated with more severe and persistent disease. Future longitudinal studies are needed to confirm these intriguing findings.

We found that obesity in adolescents was associated with increased odds of asthma but not with hay fever and food allergies. However, in adolescents with eczema, obesity did not confer additional risk of other atopic disorders. Some authors have suggested that overweight and obesity in early childhood may guide the immature immune system toward a proatopic or inflammatory state; thus, obesity predisposes to either condition independently.[4,15] Alternatively, obesity may specifically trigger or exacerbate eczema and, in turn, predispose toward asthma as part of the "atopic march."[16]

It is interesting that obesity and eczema together were associated with even poorer overall health and increased health care utilization than eczema alone. Previous studies demonstrated impaired quality of life in both AD[17–21] and childhood obesity.[22–25] These data suggest an additional public health burden of childhood obesity by exacerbating disease and potentially increasing health care expenditures from AD.

The present study found the prevalence of overweight and obesity in adolescents to be 15.4% and 16.2%, respectively. These estimates are consistent with the recent estimates from the 2009–2010 National Health and Nutrition Examination Survey of 15.2% for overweight and 18.4% for obesity in adolescents aged 12 to 19 years.[26] Childhood and adolescent obesity rates have significantly increased over the past decade.[26] Thus, it is possible that the increasing prevalence of obesity is driving the increasing prevalence of AD observed in multiple international studies (reviewed in DaVeiga[22] study). The mechanisms of the association between obesity and AD are not known. Obesity seems to have multiple effects on the innate immune system, for example, toll-like receptors,[27–30] inflammatory cytokine pathways (eg, tumor necrosis factor α, interleukin 6, interferon gamma, and interleukin 2).[31–35] An intriguing study by Nagel et al[36] found a disease-specific association between AD and low adiponectin levels, which tends to occur in obesity.[37] However, an inherent limitation to a cross-sectional study design is that we cannot determine whether obesity is a risk factor for AD and/or vice versa. It may be that chronic inflammation and functional quality-of-life impairment from AD predispose toward obesity. Future studies of the mechanism of association between obesity and AD are needed.

The strengths of this study include being large-scale, US population-based study with adequate sampling of multiple racial/ethnic and other demographic groups and prevalence estimates that are reflective of the entire US population, use of the CDC BMI-for-age and sex percentiles, as well as controlling for confounding demographic variables in multivariate models. However, the study also has some limitations. The NSCH question for eczema asked about "eczema or any other kind of skin allergy." This rather broad question may result in overestimates of prevalence for AD per se by inclusion of other entities such as allergic contact

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dermatitis, but such entities are relatively uncommon compared with AD in pediatric age groups. Previous studies similarly used single questions using parental recall of physician-diagnosed eczema that have been validated.[38,39] Thus, the results of the survey with this question are likely meaningful and accurate. Responses for the question related to eczema severity were guided as mild, moderate, or severe, which might direct respondents toward the latter answer choices. Future studies are needed to validate self-report of health care diagnosis of eczema prevalence and eczema severity. Previous studies from the NSCH validated parental report of BMI in adolescents aged 10 to 17 years but not in younger children. Thus, the impact of obesity in the first decade of life could not be assessed. Future population-based studies are necessary to determine if obesity has more profound or perhaps different effects in younger children. We excluded any subjects who did not have health care interactions in the preceding year to limit the effects of health care access as a bias for the association between obesity and eczema. Nevertheless, this does not fully absolve the potential bias related to health care access. There was a small subset (<0.1%) of subjects that were nonresponders for history of eczema and eczema severity, which might introduce reporting bias. However, the nonresponse rates were very low and there were no differences of nonresponse across age, race/ethnicity, sex, or household income strata. Finally, because this study is cross sectional, it is not possible to determine the direction of association between obesity and AD. Obesity may precede and be a risk factor for AD, or AD and its sequelae may be risk factors for obesity. Alternatively, there may be another factor that commonly predisposes to both AD and obesity. Future longitudinal cohort studies are required to confirm the direction of association between AD and obesity in the US population.

The present study found that obesity is associated with increased prevalence and severity of and poorer health outcomes from AD. This study identifies adolescents with AD as a high-risk group for obesity and its sequelae. Future studies are needed to verify these points. Cohort studies are also needed to determine the temporal relationship between elevated BMI and AD development.

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