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Journal of Asthma

Publication details, including instructions for authors and subscription information:

<http://www.informaworld.com/smpp/title~content=t713597262>

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Online Publication Date: 01 September 2009

To cite this Article Ahmad, Naveed, Biswas, Swati, Bae, Sejong, Meador, Karen E. S., Huang, Rong and Singh, Karan P. (2009) 'Association between Obesity and Asthma in US Children and Adolescents', *Journal of Asthma*, 46:7, 642 — 646

To link to this Article: DOI: 10.1080/02770900802503123

URL: <http://dx.doi.org/10.1080/02770900802503123>

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ORIGINAL ARTICLE

Association between Obesity and Asthma in US Children and Adolescents

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Background. To explore the association between obesity and asthma in US children and adolescents with adjustment of other structural and behavioral factors. **Method.** Prevalence and associated risk factors of asthma were explored in 102,273 children and adolescents in the National Survey of Children's Health (2003–2004). Subgroup analysis was performed for subjects of 0–6 year-old, 7–12 year-old, and 13–17 year-old. Crude and adjusted odds ratios for the potential risk factors were examined in univariate and multivariate logistic regressions. **Results.** The overall prevalence of obesity was 24.5% and that of asthma was 12.5%. The adjusted odds ratio of asthma with obesity remains significantly bigger than 1 for children in the 7–12 and the 13–17 year-old age-groups. Gender and race were significantly associated with asthma in all age groups. The two parent family structure showed significant protectiveness against asthma with children in the 0–6 year-old age group. Poverty was positively associated with asthma in the 7–12 years old age group. Having a smoker in the household increased the odds of asthma by 29% and 23.5% in the 0–6 and 13–17 year-old age-groups, respectively. Higher education level of the parents and access to healthcare showed positive association with asthma in the 13–17 year-old age group. **Conclusion.** Gender and race were significantly associated with asthma. In the 13–17 year-old age-groups, obesity, household education level, healthcare coverage, and household smoking were positively associated with asthma. Further studies should characterize how the family structure and household education level influence childhood asthma in 0–6 and 13–17 year-old age-groups respectively.

Keywords childhood asthma, overweight, obesity, National Survey of Children's Health

INTRODUCTION

Childhood obesity is a leading healthcare problem in the U.S. and in most developed countries with its increasing prevalence, severity, and appearance at younger ages (1). Many studies have reported a dramatic increase in obesity in both adults and children, and according to Hadley et al., childhood overweight and obesity now affect 3 in 10 or 30% of our nation's youth (2). Obesity is associated with many health problems including orthopedic, neurological, pulmonary, gastrointestinal, and endocrine conditions (3).

Asthma is another emerging health care problem. According to the Centers for Disease Control and Prevention (CDC), asthma is considered the most common chronic childhood disease (54 per 1000 children) in the U.S. (4). Some known factors of childhood asthma include male sex, parental history of asthma, low birth weight, early respiratory infections, and exposure to indoor allergens, tobacco smoke, and outdoor pollutants (5, 6).

Some recent studies explored the association between obesity and asthma. Using Behavioral Risk Factor Surveillance System database, Strine et al. reported that obese adults were 70% more likely to have asthma and 60% more likely to make asthma-related emergency rooms visits than those who were not obese (7). Saha et al. found that overweight boys and girls were 3.1 and 1.8 times more likely to have asthma than their peers of normal weights, respectively (8). A study by Bidad et al. on 2,900 students 11 to 17 years of age in Tehran, Iran, showed asthma prevalence to be more frequent in males as well as in obese students (9). Conversely, some studies did not demonstrate this association such as a case

control study by Vignolo et al. on children and adolescents of 2 to 16 years of age in Genoa, Italy (10), and in a population-based study by Vydykhan et al. on Canadian children 4 to 11 years of age (11).

The controversy on the association between asthma and obesity warrants further investigation, especially in US populations where these two health-care problems are prevalent. Given the seriousness of asthma and potential for asthma prevention or improvement, the association between asthma and obesity is investigated in this article with the National Survey of Child Health (NSCH) database, a representative sample of all children in US.

METHODS

Data

This study used data from the National Survey of Children's Health (NSCH) collected in years 2003–2004. The NSCH was a population-based, cross-sectional telephone survey with a complex multi-cluster, probability sampling design (12). The NSCH was sponsored by the Maternal and Child Health Bureau in partnership with the National Center for Health Statistics as a part of the CDC (13). A random-digit dial sample of households with children was selected for each of 50 states and the District of Columbia. One child was randomly selected from all children in each identified household to be a subject of the survey. The respondent was the parent or guardian who knew the most about the child's health and health care. These interviews were conducted in English and Spanish, and data were collected on a total of 102,353 children of ages less than or equal to 17 years. The weighted

overall response rate was 55.3%. Detailed information about the design of the NSCH is available at www.nschdata.org.

Analyses

The primary binary outcome (dependent) variable used in this study was “diagnosed asthma,” which was ascertained through one survey question to the parent, “Has a doctor or health professional ever told you that selected child has asthma?” The primary independent (explanatory) variable of interest was obesity status of the child. It was calculated by NSCH and was determined by body mass index (BMI) based on the reported weight and height. Cutoff criteria for obesity and overweight was based on the 2000 CDC BMI-for-age-growth charts for the United States, and it was gender- and age-specific for children. Subjects were classified into underweight (≤ 5 th percentile), normal weight (> 5 th and < 85 th percentile), at risk of overweight (≥ 85 th and < 95 th percentile), and overweight (≥ 95 th percentile). For this present study, this variable was recoded into a dichotomous variable: obese (≥ 95 th percentile) and non-obese (< 95 th percentile). Several other independent variables were included in the model based on their previously reported association with obesity and/or asthma (3, 7, 8). These variables, all of which are categorical, included gender, race/ethnicity (white, black, Hispanic, other), highest level of education attained by anyone in the household is more than high school (Yes, No), family structure of two parents who could be biological/adopted/step (Yes, No), categorical poverty level based on Department of Health and Human Services Federal Poverty guidelines ($< 100\%$, 100% to $< 200\%$, 200% to $< 300\%$, 300% to $< 400\%$, $\geq 400\%$), health care coverage, which includes prepaid plans such as HMOs or government plans such as Medicaid (Yes, No); and smoking cigarettes, cigars, or pipe tobacco by anyone in the household (Yes, No).

Population-based estimates were obtained by using sampling weights to each sampled child for whom an interview was completed. Frequency tables were constructed to show both raw numbers and weighted estimates. The associations between the diagnosis of asthma and each of the independent variables were investigated by crude odds ratio and adjusted odds ratio. Adjusted odds ratios were obtained from the logistic regression model, with all of the above independent variables included in the model. 95% confidence intervals were calculated for both crude and adjusted odds ratios. Missing values were treated as invalid. All two-way interactions between independent variables were tested using Wald's test in the logistic regression model. All statistical analyses were performed using SPSS 15.0 - complex sampling design module (SPSS Inc, Chicago, IL), which take into account complex survey design of the data.

RESULTS

A total of 102,273 subjects between the ages of 0 to 17 years were included in the study. The descriptive statistics for all variables are given in Table 1. About half of them (51.1%) were male. The racial/ethnic composition included 60.7% non-Hispanic white, 14.4% non-Hispanic black, and 17.6% Hispanic or Latino. The weighted prevalence of obesity was 24.5%, and the weighted prevalence of asthma was 12.5%. About two thirds (65.7%) of the household had a highest

TABLE 1.— Study sample description: The unweighted overall sample size is 102,273.

	Unweighted N (weighted % $\pm$ S.E.)
Gender	
Male	52,554 (51.1% $\pm$ 0.3)
Female	49,719 (48.9% $\pm$ 0.3)
Race/ethnicity	
White non-Hispanic	70,104 (60.7% $\pm$ 0.3)
Black non-Hispanic	9,586 (14.4% $\pm$ 0.2)
Hispanic or Latino	13,375 (17.6% $\pm$ 0.2)
Other	7,890 (7.3% $\pm$ 0.2)
Age groups	
0–6 years	38,372 (38.2% $\pm$ 0.3)
7–12 years	32,004 (33.6% $\pm$ 0.3)
13–17 years	31,977 (28.3% $\pm$ 0.2)
Asthma diagnosis	12,202 (12.5% $\pm$ 0.2)
Obese (≥ 95 th percentile of BMI)	18,612 (24.5% $\pm$ 0.3)
Households with highest level of education being more than high school	76,022 (65.7% $\pm$ 0.3)
Two-parent family structure	74,380 (72.1% $\pm$ 0.3)
Poverty level	
($< 100\%$)	11,307 (17.8% $\pm$ 0.3)
(100% - $< 200\%$)	18,850 (22.8% $\pm$ 0.3)
(200% - $< 300\%$)	17,828 (17.5% $\pm$ 0.2)
(300% - $< 400\%$)	15,712 (15.1% $\pm$ 0.2)
($\geq 400\%$)	29,242 (26.7% $\pm$ 0.2)
Health care coverage (yes/no)	94,300 (91.2% $\pm$ 0.2)
Cigarettes, cigars, or pipe tobacco use at the household? (yes/no)	26,947 (29.5% $\pm$ 0.3)

education level of more than high school, and 72.1% of children were living in two-parent family (biological, adopted, or step).

A cross-table of obesity and asthma prevalence after weighing is given in Table 2. In obese and non-obese groups, approximately 16.4% and 12.9% have asthma, respectively, and the odds ratio for association between asthma and obesity is 1.33 (95% CI: 1.22–1.44). This suggests a plausible association between asthma and obesity. In our further analyses, it was found that the age of the subjects had a significant interaction with the obesity status and gender. Therefore, the whole data were stratified into three age groups for further analyses. No other two-way interaction was found to be significant. Tables 3 to 4 provide crude and adjusted odds ratios of all independent variables with asthma for the age groups 1 (0–6 years of age), 2 (7–12 years of age), and 3 (13–17 years of age), respectively. Both the crude and adjusted odds ratios suggest that obese children are more likely to have asthma as compared to non-obese children in age groups 2 and 3. However, this association was not seen in age group

TABLE 2.—Cross-tabulation of asthma diagnosis with obesity.

Age group	Asthma % (95% C.I.)
0–6 years	
Obese	13.0 (11.8–14.3)
Non-obese	10.0 (9.1–10.9)
6–12 years	
Obese	19.0 (17.4–20.8)
Non-obese	13.3 (12.5–14.1)
13–17 years	
Obese	19.8 (17.6–22.2)
Non-obese	14.2 (13.5–15.0)
All age groups (0–17 years)	
Obese	16.4 (15.5–17.4)
Non-obese	12.9 (12.5–13.4)

TABLE 3.—Factors associated with **asthma in 0 to 6 years (group 1)** NSCH study subjects: bivariate Chi-square Test and logistic regression with the dependent variable asthma diagnosis and unweighted sample size 13,984.

Variable	Crude odds ratio (95% C.I.)	Adjusted odds ratio (95% C.I.)
Obese (≥ 95 th percentile/ < 95 th percentile)	1.352 (1.164–1.569)	1.101 (0.905–1.339)
Gender (male/female)	1.767 (1.546–2.020)	1.910 (1.587–2.298)
Race-ethnicity (black/white)	2.255 (1.905–2.669)	1.714 (1.274–2.305)
(Hispanic/white)	1.139 (0.942–1.378)	1.062 (0.780–1.445)
(Other/white)	1.471 (1.100–1.966)	1.233 (0.836–1.820)
Household highest level of education (more than high school / 12 years or less)	0.751 (0.654–0.862)	0.841 (0.672–1.052)
Family structure type (two-parent / single mother or other)	0.577 (0.498–0.669)	0.709 (0.558–0.900)
Poverty level ($< 100\%$ / $\geq 400\%$)	1.850 (1.515–2.259)	1.056 (0.748–1.490)
(100% – $< 200\%$ / $\geq 400\%$)	1.826 (1.495–2.230)	1.210 (0.902–1.622)
(200% – $< 300\%$ / $\geq 400\%$)	1.405 (1.144–1.725)	1.134 (0.868–1.482)
(300% – $< 400\%$ / $\geq 400\%$)	1.468 (1.165–1.849)	1.225 (0.912–1.644)
Health care coverage (yes/no)	1.634 (1.218–2.192)	1.435 (0.975–2.113)
Use of cigarettes, cigars, or pipe tobacco in the household (yes/no)	1.362 (1.158–1.603)	1.291 (1.050–1.587)

1 children. Males were more likely to have asthma in all age groups; moreover, the younger the age group, the stronger was this association. Blacks were more likely to have asthma as compared to whites with the greatest difference seen in age group 1 where blacks were about 70% more likely to have asthma than whites. Hispanic and other race/ethnicity did not differ significantly from the white race.

Two-parent family structure played a protective role in age group 1. In this family structure, the odds of asthma decreased about 30% when compared to family structures of single mother or other types. Education level of the household did not appear to be associated with asthma in age groups 1 and 2, but it was associated with higher odds of asthma in adolescents. The prevalence of asthma was also not significantly different among adolescents of different poverty levels. The only significant difference was seen in age group 2 where children from less than 100% of poverty level reported higher prevalence of asthma as compared to the children who came from more than 400% of poverty level.

The odds ratios of health care coverage on diagnosis of asthma were greater than 1 in all three age groups, but only the odds ratio in age group 3 reached statistical significance. The health care coverage in age group 3 increased the odds of asthma by 54%. Household use of cigarettes, cigars, or pipe tobacco increased the odds of asthma by 29% in age group 1 and 23.5% in age group 3.

DISCUSSION

In this study nearly every fourth child was obese and every eighth child was diagnosed with asthma. These rates are by themselves alarming, given that they are coming from such a large representative sample of the U.S. population. The results of this study corroborate with most previous studies on

TABLE 4.—Factors associated with **asthma in 7 to 12 years age (group 2)** NSCH study subjects: bivariate Chi-square Test and logistic regression with the dependent variable asthma diagnosis and unweighted sample size 26,131.

Variable	Crude odds ratio (95% C.I.)	Adjusted odds ratio (95% C.I.)
Obese (≥ 95 th percentile/ < 95 th percentile)	1.529 (1.344–1.739)	1.331 (1.159–1.528)
Gender (male/female)	1.662 (1.484–1.861)	1.736 (1.538–1.960)
Race-Ethnicity (black/white)	1.644 (1.405–1.925)	1.488 (1.238–1.789)
(Hispanic/white)	0.858 (0.724–1.016)	1.017 (0.817–1.266)
(Other/white)	1.217 (0.960–1.542)	1.073 (0.826–1.395)
Household highest level of education (More than high school / 12 years or less)	0.981 (0.868–1.109)	1.074 (0.926–1.245)
Family structure type (two-parent/single mother or other)	0.784 (0.698–0.882)	0.943 (0.815–1.091)
Poverty level ($< 100\%$ / $\geq 400\%$)	1.373 (1.143–1.649)	1.353 (1.081–1.693)
(100% – $< 200\%$ / $\geq 400\%$)	1.053 (0.896–1.237)	1.090 (0.909–1.307)
(200% – $< 300\%$ / $\geq 400\%$)	1.066 (0.900–1.263)	1.072 (0.896–1.282)
(300% – $< 400\%$ / $\geq 400\%$)	0.955 (0.805–1.133)	0.949 (0.795–1.133)
Health care coverage (yes/no)	1.633 (1.317–2.024)	1.268 (0.981–1.638)
Use of cigarettes, cigars, or pipe tobacco in the household? (yes/no)	1.146 (1.019–1.288)	1.127 (0.991–1.281)

relationships between asthma and obesity, and the data collected from this large study add more credibility to the prior studies. In addition, this research expands current knowledge by examining these associations separately in three age groups of children.

Mannino et al. found a higher rate of self-reported asthma in boys, and in blacks compared to whites (14). Our study supports these findings in all three age groups. Furthermore, these associations are strongest in the 0 to 6 years age group,

TABLE 5.—Factors associated with **asthma in 13 to 17 years age (group 3)** NSCH study subjects: bivariate Chi-square Test and logistic regression with the dependent variable asthma diagnosis and unweighted sample size 27,407.

Variable	Crude odds ratio (95% C.I.)	Adjusted odds ratio (95% C.I.)
Obese (≥ 95 th percentile/ < 95 th percentile)	1.486 (1.271–1.738)	1.414 (1.190–1.680)
Gender (male/female)	1.151 (1.029–1.287)	1.185 (1.052–1.335)
Race-ethnicity (black/white)	1.314 (1.110–1.557)	1.382 (1.137–1.680)
(Hispanic/white)	0.902 (0.736–1.105)	1.252 (0.997–1.572)
(other/white)	1.172 (0.922–1.490)	1.133 (0.873–1.470)
Household highest level of education (more than high school / 12 years or less)	1.213 (1.073–1.371)	1.351 (1.157–1.577)
Family structure type (two-parent/single mother or other)	0.903 (0.797–1.023)	0.945 (0.820–1.089)
Poverty level ($< 100\%$ / $\geq 400\%$)	0.989 (0.818–1.195)	1.040 (0.825–1.311)
(100% – $< 200\%$ / $\geq 400\%$)	0.982 (0.829–1.164)	1.006 (0.841–1.204)
(200% – $< 300\%$ / $\geq 400\%$)	0.999 (0.850–2.090)	1.009 (0.852–1.195)
(300% – $< 400\%$ / $\geq 400\%$)	1.024 (0.873–1.202)	1.011 (0.859–1.190)
Health care coverage (yes/no)	1.655 (1.276–2.147)	1.541 (1.136–2.090)
Use of cigarettes, cigars, or pipe tobacco in the household? (yes/no)	1.170 (1.042–1.315)	1.235 (1.088–1.401)

probably due to the fact that children in this age group are least exposed to other environmental factors that might affect asthma etiology. This supports a genetic association model as proposed by Turki et al. (15). In some other studies the asthma hospitalization was found to be the highest among the youngest children and the ones from poor communities (16, 17). In our study the poverty level was significant only in the 7 to 12 years age group. It is not clear why only this age group is more vulnerable to poverty but one reason could be that children in this age group start going to school, and they have a greater exposure to the environment. Therefore, poor housing conditions and unhygienic surroundings could have a greater contribution to asthma in this age group.

Another interesting finding was the association of single parent family structure with asthma in 0 to 6 years age group. A plausible explanation may be the fact that children in this age group are very much dependent on their caregivers, and the two parent family structures provided a protective effect for the development of asthma. Conversely, the households with the highest level of education greater than 12th grade showed a higher rate of asthma in 13- to 17-year-old children when compared to households with highest level of education being 12th grade or less. This could be attributed to the greater awareness of the problem in the higher education group. Similarly, children in the same age group showed a higher rate of diagnosed asthma when they had some type of health insurance compared to the ones with no insurance (although not statistically significant), which could be attributed to greater access to healthcare.

The association of smoking with asthma is very well reported in previous studies. Strine et al. showed a 10% higher incidence of asthma in current smokers. Overall they found that asthma-related emergency rooms visits were 60% higher among smokers (7). Our study showed a significant association of household smoking with asthma in 0 to 6 years and 13 to 17 years age groups. The earlier finding is clearly due to passive smoking but the later finding could be partially due to active smoking.

Several explanations have been suggested for the association between asthma and obesity. Xu et al. (18) and Camargo et al. (19) suggested shared genetic factors that cause both the asthma and obesity; Visser et al. (20) and Varner (21) proposed that the obesity-related inflammation caused asthma; Chinn et al. (22) and Chen et al. (23) referred that unhealthy life style caused both conditions. Owing to the observational nature and limited information in the NSCH survey study, our study is not able to address the mechanism of the association. Other limitations of the study include self-reported (by parent) asthma diagnosis and obesity, weight/BMI not provided in continuous scale, non-response bias, and the proportion of active smoking in age group 13 to 17 being unknown. Some other known risk factors for asthma such as parental history and early stressors and infections could not be evaluated because of the secondary nature of the analysis.

In summary, this nationally representative database demonstrates that obesity is strongly associated with childhood asthma and that this association is stronger among boys and blacks (compared with whites). The influence of poverty level, healthcare coverage, and household smoking on childhood asthma varies depending on the age-group of the child. Future work should carefully consider these age differences

in all studies of risk factors for childhood asthma, particularly those focusing on the role of obesity per se. Furthermore, the role of household education level and family structure, on asthma, also need to be further investigated. Ideally, future studies would use a prospective cohort study design with actual measurement of weight and height, and validation of asthma diagnosis. The data from our study add to existing evidence that childhood obesity is associated with several other diseases and suggest a new avenue for asthma management and prevention.

Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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