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The association of co-morbid asthma and overweight/obese status with healthcare utilization and caregiver perception of health in children 4-17 years, an NHANES study

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Abstract:

Objective: Asthma and obesity are two of the most common chronic childhood illnesses. The purpose of this study was to better understand the relationship between co-morbid asthma and obesity in children aged 4 to 17 and whether it impacts the caregiver's perception of health and/or healthcare utilization.

Methods: This was a secondary analysis of the National Health and Nutrition Examination Surveys (NHANES) datasets from 2007-2018. Cumulative logistic regression models were used to analyze the caregiver's perception of health, received healthcare, and overnight hospital stay as dependent variables. Asthma and weight status were included as covariates, with adjustment for age, income, head of the household's education, gender, race, and insurance.

Results: The sample included 15,386 children. When looking at weight status in addition to asthma, compared to caregivers of children with current asthma and normal weight, caregivers of children with current asthma and with obesity are more likely to perceive their children as having worse health (OR = 1.73, 95%CI = [1.30, 2.32], p = 0.0003), and are more likely to have more frequent healthcare utilization but the results did not reach a statistical significance.

Conclusions: Caregiver's perception of overall health was worse in caregivers of those with co-morbid obesity/asthma than in caregivers of children with asthma alone. This indicates that caregivers of children with co-morbid asthma and obesity have insight into their children's condition and may be primed for discussion and counseling in the healthcare setting.

Keywords: asthma, health care utilization, increased weight status, obese, overweight, caregiver's perception of health

1. Introduction:

Asthma and obesity are the two most common chronic childhood conditions in the United States and have a significant impact on patients, families, and the healthcare infrastructure(1, 2). The magnitude of healthcare costs, the impact on the healthcare infrastructure, and the effect on society are profoundly high for both individual conditions(3-5). When a child has a dual diagnosis of both asthma and obese weight status, these effects are often compounded(6-8). Children with co-morbid asthma and obesity more frequently use their medications, have more frequent daytime asthma symptoms, and are more likely to be limited in their physical activity (3, 7, 9-11). Increased weight status is also associated with an increased number of school days missed, especially among children with asthma, and significantly reduced quality of life (12-14).

A better understanding of the caregivers's understanding of the child's condition is crucial to develop family-centered strategies and counseling efforts. This study uniquely analyzes how this dual diagnosis impacts both caregiver's perception of their child's health, as well as healthcare utilization variables (i.e. number of healthcare received by visiting a doctor or health professional in a clinical or doctor's office, number of overnight hospital stays, and emergency care visits) in the National Health and Nutrition Examination Surveys (NHANES). While there is a wealth of literature that demonstrates increased utilization in both children with asthma and children with obesity independently (3, 4, 15-17), there is less literature describing healthcare utilization parameters in this dual diagnosis population and the results are somewhat mixed(6, 18-21).

The primary aim of this study is to utilize the NHANES dataset to assess the relationship between weight status, the diagnosis of asthma, and caregiver's perception of health and healthcare utilization variables in children. We hypothesize that caregivers of children with dual

diagnoses perceived their children's health worse than the caregivers of children with neither diagnosis did, as well as worse than those of children with asthma alone. Additionally, we hypothesize that children with dual diagnoses would utilize healthcare more (more healthcare received, and more overnight hospitalizations) than children with neither diagnosis and with asthma alone. This study is one of few studies analyzing these relationships in this unique, growing patient population. To the best of our knowledge, it is the only study using a large, nationally representative dataset to explore the question of caregiver's perceptions of health in this unique population.

2. Methods:

2.1 Participants

Participants were all children ages 4-17 years enrolled in the NHANES dataset from 2007-2018 with a calculated body mass index (BMI). The NHANES is maintained by the Centers for Disease Control and Prevention (CDC) and assesses the health and nutritional status of adults and children in the US through a combination of structured questionnaires, physical exams, and laboratory data (22). Participants from a twelve-year period, encompassing six 2-year datasets from 2007-2018 (2007-2008, 2009-2010, 2011-2012, 2013-2014, 2015-2016, 2017-2018) were pooled together to create a single analytic file for the study. Pregnant females could not be excluded from the study because pregnancy-related questions in NHANES were only asked of females aged 20 and/or above since 2007. The study was reviewed and determined to be exempted from review by the Stony Brook University Institutional Review Board.

2.2 Measures

2.2.1 Outcome measures

The primary outcome measure was the caregiver perception of children's overall health. Secondary outcome measures included the number of times the child received healthcare, the number of times the child had an overnight hospital stay in the past year, and emergency care visits for children with asthma. All outcome measures were self-reported NHANES survey questions administered either to a proxy person (usually the parents or primary caregiver). According to NHANES survey information "a proxy respondent must be a family member or legal guardian 18 years old or older. For children (birth to 15 years old), the preferred proxy respondent is the most knowledgeable about the child (usually the mother or father)" (23).

The caregiver perception of his/her child's overall health was recorded with a response to the question of "Would you say sample person's health in general is ..." with the response choices as follows: excellent, very good, good, fair, and poor. This question was answered by a proxy for children younger than 16 years old.

The number of times the person received healthcare over the past year was captured using the question "During the past 12 months, how many times have you/has a sample person seen a doctor or other health care professional about health?" Overnight hospitalizations,, visits to hospital emergency rooms, home visits, or telephone calls were not included in the category of 'number of times person received healthcare'. The responses were categorized as follows: 0, 1, 2-3, 4-5, 6-7, 8-9, 10-12, 13-15, and 16 or more.

To capture overnight hospitalizations, the question "How many different times did you/sample person stay in any hospital overnight or longer during the past 12 months?" was asked. The responses were categorized as follows: 0, 1, 2-3, 4-5, 6-7, 8-9, 10-12, 13-15, 16 or more.

Another healthcare utilization outcome “emergency care visit” was measured using the question “During the past 12 months, have you/has sample person had to visit an emergency room or urgent care center because of asthma?”. The question was only asked if children still having asthma and the dichotomous response was recorded as either yes or no.

2.2.2. Covariates

One of the primary covariates was the presence of a diagnosis of asthma. In the NHANES, the asthma status is determined by two self-report survey questions “Has a doctor or other health professional ever told you/sample person that you have/sample person has asthma?”. When answered “Yes”, survey participants were asked another question: “Do you still have asthma?”. Then the participants were divided into three groups based on their answers to these two questions. 1. Current, who answered “Yes” to both questions; 2. Past, who was diagnosed with asthma but does not still have asthma; and 3. Never, who was not diagnosed with asthma at any point.

Another covariate in the analysis was BMI category using BMI percentile categorized as normal weight (less than the 85th percentile for age and gender), overweight (between the 85th and 95th percentile for age and gender), and obese (greater than or equal to the 95th percentile for age and gender) based on CDC parameters that have clinical relevance(22). Obesity was further divided into moderate and severe obesity to evaluate the effects of obesity severity. Participants with BMI in the range of 100-119% of the 95th percentile were categorized as the “moderate” obesity group and participants with BMI $\geq$ 120% of the 95th percentile were categorized in the “severe” obesity group (24). Anthropometrics for NHANES subjects were collected in Mobile Examination Centers (MEC) by trained health technicians with regularly calibrated equipment in accordance with the NHANES Anthropometry Procedures Manual(23). Because the NHANES

does not provide BMI percentile information, a publicly available SAS® program for CDC growth charts was used to assign each child a BMI percentile using the variables of age in months, sex, height or recumbent length, and weight(25).

Other covariates for the analyses included child's age, gender (male/female), race/ethnicity (non-Hispanic White, non-Hispanic African-American, Hispanic and other), health insurance status (insurance or no insurance), ratio of family income to poverty, the educational attainment of the head of household (less than high school, high school or GED or some college, college graduate and above). Of note, race/ethnicity is a single variable in the NHANES dataset. The information for the above covariates were obtained from the *Demographic, Medical Conditions*, and *Health Insurance Surveys* sections of the NHANES survey(26).

2.3 Statistical analysis

This study was a secondary data analysis of 6-cycle NHANES datasets from 2007-2018. NHANES uses a complex survey design to account for oversampling, non-response, and non-coverage. The survey is weighted to represent the U.S. Civilian non-institutionalized Census population(27). Therefore, all statistical analyses were performed by using sample weights and stratum collected and designed by NHANES. When combining 6 cycles of NHANES data from 2007–2018, the combined sample weights were computed by dividing the two-year cycle weights by 6 in the analysis following the NHANES guideline (28). Furthermore, cycle differences were tested for all outcome measures using cumulative logistic regression models. If no significant difference in outcomes was found across different years, the analyses will not be stratified by 6 cycles.

Descriptive statistics were calculated for asthma status, weight status, and other covariates (e.g. weighted means for continuous variables and weighted percentages for categorical

variables). We fit cumulative logistic regression for ordinal outcome measures, e.g. caregiver perception of health and healthcare utilization variables, to evaluate the associations with covariates. Compared to ordinary logistic regression, cumulative logistic regression will use information from all ordinal categories of the outcome measures and have a better model fitting, higher statistical power, and more precise estimation (29). Three cumulative logistic regression models were fit as follows: Model 1: the caregiver perception of health was included as the dependent variable. The proportional odds were estimated for the ratios of the probability of worse health divided by the probability of better health (e.g. $\text{Prob}[\text{poor}]/\text{Prob}[\text{fair, good, very good, excellent}]$, $\text{Prob}[\text{poor, fair}]/\text{Prob}[\text{good, very good, excellent}]$, $\text{Prob}[\text{poor, fair, good}]/\text{Prob}[\text{very good, excellent}]$ and so on (30). Since the survey question was asked to caregivers for children less than 16 years old, this model was limited to children aged 4-16 years old only. Model 2: number of times received healthcare was the dependent variable. Proportional odds were estimated for the ratios of the probability of more times received healthcare divided by the probability of fewer times. Model 3: number of times overnight hospital stay was the dependent variable. Proportional odds were also estimated for the ratios of the probability of more times overnight hospital stay divided by the probability of fewer times. For all three models, asthma and weight status were included as primary covariates. The odds ratios and 95% confidence intervals (CI) were calculated to compare asthma vs non-asthma, obese vs normal, and overweight vs normal weight. The interaction between asthma status and weight status was also included and tested for co-morbid effect, i.e. comparing children with asthma and obesity to children with non-asthma and normal weight. Gender, head of the household's education, race, age, ratio of family income to poverty, and insurance were also included in this model as

covariates. A secondary analysis was performed to evaluate the effects of moderate and severe obesity using cumulative logistic regression models similar to the above mentioned 3 models.

A subgroup analysis was performed for “whether had emergency care visit for asthma over the past year” using a binary logistic regression model. The analysis is limited to children still having asthma. Weight status was treated as the primary covariate. Gender, head of the household’s education, race, age, ratio of family income to poverty, and insurance were also included in the logistic regression model.

All statistical analyses were conducted using SAS v9.4 (the SAS Institute, Cary, NC). P-value less than 0.05 was considered statistical significance. When appropriate, p values will be adjusted with Bonferroni correction for multiple tests.

3. Results.

Six cycles of the NHANES survey data 2007-2018 were combined for analyses. The final sample size was 15,386 children aged 4 to 17 with the weighted sample size being 55,746,032. The characteristics of the sample are outlined in **Table 1**. The weighted mean age of the sample is 10.62 years (± 0.05) with 49.01% being female. The sample consisted of 53.81% non-Hispanic White, 22.78% Hispanic, 14.12% non-Hispanic Black, and 9.29% other non-Hispanic children. In terms of BMI, the percentage of children with normal, overweight, and obese status are 65.23%, 15.89%, and 18.90% respectively. We found that 10.69% of the weighted sample currently has asthma, and 6.61% of the weight sample had asthma in the past. No significant difference was found in all outcome measures across different years.

3.1 Weight status and asthma status associated with “caregiver perception of children’s overall health”

As shown in **Table 2**, when compared to caregivers of children having no asthma and normal weight, caregivers of children with obesity and current asthma are 5.99 times more likely to perceive their children as having worse health (OR = 5.99, 95%CI [4.64, 7.73], $p < 0.0001$). Caregivers of children with overweight status and current asthma also showed worse health perception compared to children with normal weight and never had asthma (OR = 2.83, 95%CI [2.07, 3.86], $p < 0.0001$). Similar results were found in children with past asthma and overweight/obese.

When looking at weight status in addition to asthma, compared to caregivers of children with current asthma and normal weight, caregivers of children with current asthma and obesity are more likely to perceive their children having worse health (OR = 1.73, 95%CI = [1.30, 2.32], $p = 0.0003$). Similarly, caregivers of children with past asthma and obesity are more likely to perceive their children having worse health (OR = 2.05, 95%CI = [1.32, 3.18], $p = 0.002$).

In addition, we evaluated the association between overnight hospital stay and caregiver’s perceived health using the cumulative logistic regression with the inclusion of overnight hospital stay as the only independent variable. As expected, more overnight hospital stays are significantly associated with worse perceived health (OR=1.27, 95% CI 1.21-1.33, $p<0.0001$). However, there is no significance in the associations between children with normal weight and never had asthma and children with obesity and current asthma.

3.2 Weight status associated with the number of times received healthcare and overnight hospital stay.

For number of times received healthcare over the past year (**Table 3**), children with current asthma and obesity are more likely to receive more healthcare compared to those having no asthma with normal weight (OR = 3.69, 95% CI [2.92, 4.67], $p < 0.0001$). Similarly, children with current asthma and overweight, children with past asthma and obesity are more likely to receive more healthcare compared to children with normal weight and never had asthma. Children with co-morbid current asthma and obesity showed having more frequent healthcare utilization than children with current asthma and normal weight (OR = 1.16, 95% CI [0.87, 1.55], $p = 0.31$), but without a statistical significance.

For overnight hospital stays (**Table 4**), children with current asthma and obesity are more likely to spend more overnight hospital stays than children with normal weight and never had asthma (OR = 2.84, 95%CI [1.55, 5.21], $p = 0.001$). Children with co-morbid current asthma and obesity also showed having more nights spent overnight as hospital patients than children with current asthma and normal weight (OR = 1.10, 95% CI [0.64, 1.90], $p = 0.73$), but did not show statistical significance.

3.3 Weight status and emergency care among children still having asthma

For emergency care visits for children still having asthma, no significance was observed between weight status. Non-Hispanic Black children are more likely to have emergency care visit than non-Hispanic White (OR = 1.99, 95% CI[1.35, 2.94], adj. $p = 0.001$). Children with older age is also significantly associated with less likelihood of emergency care visit (OR = 0.95, 95% CI[0.91, 0.99], $p = 0.02$).

3.4 Effects of moderate obesity and severe obesity

As shown in Supplemental Table 1, caregivers of children with severe obesity more likely perceived worse overall health than caregivers of children with moderate obesity did, e.g.

current asthma + severe obesity OR=7.71 vs current asthma + moderate obesity OR=5.29, both p values <0.0001. Similar pattern was observed for number of times received healthcare, e.g. current asthma + severe obesity OR=5.20 vs current asthma + moderate obesity OR=3.70, both p values <0.0001. However, severe obesity was not associated with number of times overnight hospital stay, e.g. current asthma +severe obese OR=2.08, p value =0.10.

4. Discussion:

The study uniquely examined the healthcare variable of caregiver's perception of child health, finding that, in addition to both increased weight status (overweight and obese status) and asthma diagnosis independently being associated with a worse caregiver health perception, those caregivers of children with co-morbid diagnoses of obesity and asthma viewed their children's health as worse than those with normal weight and asthma. However, caregivers of children with asthma and overweight status did not perceive their children's health as worse than their normal counterparts. Perhaps indicating some type of weight "threshold" point where caregivers were able to notice more of a problem with their child's weight and its relative influence on their health.

Interestingly, many previous studies of parents/caregivers of both children with asthma and children with obesity have demonstrated limited insight into their child's condition (31-35). One fundamental difference is the specific question that these studies asked the parents. In the studies by Lundahl,Rietmeijer, and Ling, parents are asked specifically about weight classification. In the studies by Carroll and Silva, parents were asked more specific questions about asthma severity (parents underestimated) and control (parents overestimated).study

analyzes the caregiver's perception of the child's overall health which might be easier to perceive than the specifics noted in the other studies.

Additionally, while there are studies of parental perception of health status in children with asthma and those with increased weight status independently, there is limited literature about caregiver perception of their child's health when there is a co-morbid diagnosis. One such study by Musaad et al found that parents of children with dual diagnoses do not recognize their child's weight status. This study was limited to a single study cohort and was for children ages 2-5 years of age(38). Our study has a different age range, is nationally representative and has a larger sample size due to the nature of the NHANES dataset. Bianchi-Hayes et al found that only 31% of dual diagnosis caregivers believed that their child's weight contributed to the severity of their child's asthma (39).

Children with independent diagnoses of obesity and asthma spend more nights at hospital than patients without these diagnoses. A similar trend was seen in our previous study of NHANES data examining routine place of healthcare for children by weight status after adjusting for covariates (40). However, interestingly, when comparing children with dual diagnoses to asthma alone this did not show significance. This result likely reflects the complicated relationship between these diagnoses, healthcare utilization variables, and other socioeconomic factors as many of the relationships that were seen in the unadjusted logistic regression models disappeared after adjusting for relevant covariates. This is somewhat inconsistent with previous literature, demonstrating that this is an area that needs to be further studied from multiple angles. Gross et al found increased length of stay and increased severity of asthma exacerbations children with dual diagnoses. Bettenhauser et al found more mixed results in their population of inpatient with asthma, finding that healthcare utilization variables were not

associated with increased weight status in this group(18). Which is similar to our finding that when examining weight status alone, not association was found with overnight hospital stay and emergency care visit. Both studies analyzed healthcare utilization variables in single inpatient populations that are not necessarily as generalizable as NHANES data which is weighted to be reflective of the US population.

There are several limitations to this study. One limitation of our study was the survey nature of the outcome variables. While anthropometric data is based on measured, objective variables (height, weight), the healthcare utilization variables and the presence of an asthma diagnosis are based on self-reported data from caregivers, subject to recall bias. Another limitation was that for anthropometric measures we chose to focus solely on measured BMI and did not analyze other secondary variables such as waist circumference or percent body fat. Additionally, while the NHANES uses sample weighting to get a nationally represented sample, it is possible that certain groups may be under or overrepresented in the data. While this study could not exclude potentially pregnant adolescents from the analysis, as that information was not available,, the small number of potential adolescents impacted by this variable would not have influenced the overall results.

In conclusion, caregivers of children with co-morbid increased weight status and asthma perceive their child's health to be worse than caregivers of children with asthma alone. This indicates that caregivers of children with this important co-morbid diagnosis have insight into their child's conditions. Family-centered motivational interviewing interventions geared toward caregivers of children with co-morbid asthma and increased weight status merit consideration.

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Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

All data used in this article were retrieved from NHANES database. Requests for material should be made to the corresponding authors.

Competing interests

The authors declare that they have no competing interests.

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Table 1. Characteristics of 4 to 17-year Old Children in the Survey Sample

Variable	Median (SE)	Weighted Mean (SE)	
BMI Percentile	70.58 (0.62)	64.14 (0.38)	
Age	10.24 (0.09)	10.62 (0.05)	
Ratio of family income to poverty	2.15 (0.08)	2.29 (0.05)	
	Frequency	Weighted Frequency	Weighted %
Never Asthma	12646	46036227	82.68%
Ever Asthma¹			
Current Asthma ²	1760	5961815	10.69%
Past Asthma ³	965	3685099	6.61%
BMI Category			
Normal	9755	36365686	65.23%
Overweight	2477	8846242	15.89%
Obese	3154	10534103	18.90%
Female	7520	27320849	49.01%
Race			
Hispanic	5194	12698803	22.78%
Non-Hispanic White	4343	29998322	53.81%
Non-Hispanic Black	3772	7870832	14.12%
Other non-Hispanic	2077	5178074	9.29%
Head of the Household Education Attainment			
Less than high school degree	3926	10748097	19.95%
High School grade/GED or Some college/ AA degree	7743	27795622	51.59%
College graduate or above	3178	15331544	28.46%
Insurance (yes)	13973	51347324	92.26%

(Total N= 15386, weighted N= 55746032)

¹ Participants answered “Yes” to the survey question: “Has a doctor or other health professional ever told that you have asthma?”.

² Participants answered “Yes” to question in ¹ and “Yes” to the second question: “Do you still have asthma?”.

³ Participants answered “Yes” to question in ¹ and “No” to the second question: “Do you still have asthma?”.

Table 2. Weight and asthma status associated “caregiver perceived overall health” (N = 12041)

Covariate	Odds Ratio	95% Confidence Interval	p-value
Never Asthma + Normal weight	Reference		
Past Asthma + Overweight	1.76	(1.19, 2.60)	0.005*
Current Asthma + Overweight	2.83	(2.07, 3.86)	<.0001*
Past Asthma + Obese	2.91	(1.91, 4.43)	<.0001*
Current Asthma + Obese	5.99	(4.64, 7.73)	<.0001*
Current Asthma + Normal weight	Reference		
Current Asthma + Overweight	0.82	(0.58, 1.16)	0.26
Current Asthma + Obese	1.73	(1.30, 2.32)	0.0003*
Past Asthma + Normal weight	Reference		
Past Asthma + Overweight	1.24	(0.80, 1.93)	0.34
Past Asthma + Obese	2.05	(1.32, 3.18)	0.002*

Odds ratios were estimated based on a cumulative weighted logistic regression model including “caregiver perceived overall health” as the dependent variable and asthma status, weight status, ratio of family income to poverty, education, gender, race, age and insurance as covariates.

* P value remained significant after Bonferroni correction.

Table 3. Weight and asthma status associated with “number of times received healthcare over the past year” (N = 13684)

Covariate	Odds Ratio	95% Confidence Interval	p-value
Never Asthma + Normal weight	Refence		
Past Asthma + Overweight	1.57	(1.12, 2.21)	0.01
Current Asthma + Overweight	3.30	(2.60, 4.20)	<.0001*
Past Asthma + Obese	1.73	(1.19, 2.50)	0.004*
Current Asthma + Obese	3.69	(2.92, 4.67)	<.0001*
Current Asthma + Normal weight	Refence		
Current Asthma + Overweight	1.04	(0.80, 1.35)	0.77
Current Asthma + Obese	1.16	(0.87, 1.55)	0.31
Past Asthma + Normal weight	Refence		
Past Asthma + Overweight	0.91	(0.63, 1.31)	0.61
Past Asthma + Obese	1.00	(0.66, 1.53)	0.99

Odds ratios were estimated based on a cumulative weighted logistic regression model including “number of times received healthcare over the past year” as the dependent variable and asthma status, weight status, ratio of family income to poverty, education, gender, race, age and insurance as covariates.

* P value remained significant after Bonferroni correction.

Table 4. Weight and asthma status associated with “number of times overnight hospital stay over the past year” (N = 13708)

Covariate	Odds Ratio	95% Confidence Interval	p-value
Never Asthma + Normal weight	Reference		
Past Asthma + Overweight	1.11	(0.48, 2.55)	0.80
Current Asthma + Overweight	1.19	(0.61, 2.32)	0.61
Past Asthma + Obese	2.12	(1.17, 3.85)	0.01
Current Asthma + Obese	2.84	(1.55, 5.21)	0.001*
Current Asthma + Normal weight	Refence		
Current Asthma + Overweight	0.46	(0.23, 0.91)	0.026
Current Asthma + Obese	1.10	(0.64, 1.90)	0.73
Past Asthma + Normal weight	Reference		
Past Asthma + Overweight	0.79	(0.36, 1.71)	0.54
Past Asthma + Obese	1.51	(0.62, 3.64)	0.36

Odds ratios were estimated based on a cumulative weighted logistic regression model including “number of times overnight hospital stay” as the dependent variable and asthma status, weight status, ratio of family income to poverty, education, gender, race, age and insurance as covariates.

* P value remained significant after Bonferroni correction.