

ORIGINAL RESEARCH

Childhood Obesity and In-Hospital Asthma Resource Utilization

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OBJECTIVE: To examine the relationship between pediatric obesity and inpatient length of stay (LOS), resource utilization, readmission rates, and total billed charges for in-hospital status asthmaticus.

DESIGN/METHODS: We conducted a cross-sectional study of patients 5 to 17 years old hospitalized with status asthmaticus to 1 free-standing children's hospital system over 12 months. Only hospitalized patients initially treated in the hospital's emergency department were included to ensure all therapies/charges were examined. Patients with complex chronic conditions, pneumonia, or lacking recorded body mass index (BMI) were excluded. The primary exposure was BMI percentile for age. The primary outcome was LOS (in hours). Secondary outcomes were 90-day readmission rate, billed charges, and resource utilization: number of albuterol treatments, chest radiographs, intravenous fluids, intravenous or intramuscular steroids, and intensive care

unit admission. Bivariate, adjusted Poisson and logistic regression model analyses were performed.

RESULTS: Five hundred eighteen patients met inclusion criteria. Most had a normal BMI (59.7%); 36.7% were overweight or obese. LOS, readmissions, and resource utilization outcomes were not associated with BMI category on bivariate analyses. After adjustment for demographic/clinical characteristics, LOS decreased by 2% for each decile increase in BMI percentile for age. BMI percentile for age was not associated with billed charges, readmissions, or other measures of resource utilization.

CONCLUSIONS: Although BMI decile for age is inversely associated with LOS for in-hospital pediatric status asthmaticus, the effect likely is not clinically meaningful. *Journal of Hospital Medicine* 2015;10:160–164. © 2014 Society of Hospital Medicine

Pediatric hospitalizations for obesity-related conditions have doubled in the last decade, mirroring the trend of higher levels of childhood obesity in the United States.^{1–3} Recent studies have demonstrated worsened pediatric in-hospital outcomes, including mortality and increased resource utilization, for children with obesity across a range of diagnoses.^{4–10} Although the mechanisms driving the association between obesity and in-hospital outcomes are not fully known, for asthma it is believed that adipocytes expressing inflammatory markers create a low level of systemic inflammation, thereby increasing the severity of allergic-type illnesses and decreasing the response to anti-inflammatory medications, such as steroids.^{11–18} The relationship of obesity and in-hospital asthma outcomes is of particular interest because status asthmaticus is the most common reason for admission in children aged 3 to 12 years, accounting for approximately 150,000 admissions (7.4% of all hospi-

talizations for children and adolescents) and \$835 million in hospital costs annually.¹⁹

Few prior studies have examined the association of obesity and asthma outcomes in the in-hospital setting. The studies examining this association have found patients with obesity to have a longer hospital length of stay (LOS) and increased hospital costs.^{8,9,20} Obesity has also been associated with increased respiratory treatments and supplemental oxygen requirements.²⁰ Associations between obesity and admission rates from the emergency department (ED) for pediatric asthma have been inconsistent.^{21,22} Most of these prior studies had several limitations in identifying patients with obesity, including using weight-for-age percentiles or International Classification of Diseases, Ninth Revision (ICD-9) codes, rather than body mass index (BMI) percentile for age, the currently recommended method.^{23–25} Methods other than BMI have the potential to either underestimate obesity (ie, ICD-9 codes)²⁶ or to confound weight with adiposity (ie, weight-for-age percentiles),²⁷ thereby skewing the primary exposure of interest.

In the present study, we sought to examine associations between obesity and in-hospital outcomes for pediatric status asthmaticus using the currently endorsed method for identifying obesity in children, BMI percentile for age.^{23–25} The outcomes of interest included a broad range of in-hospital measures, including resource utilization (medication and radiology use), readmission rates, billed charges, and LOS. We hypothesize that obesity, due to its proinflammatory

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state, would result in increased LOS, increased resource utilization, and an increased readmission rate for children admitted with status asthmaticus.

METHODS

Data Sources

Data for this retrospective cross-sectional study were obtained from 2 sources. First, we queried the Pediatric Health Information System (PHIS) administrative database, which draws information from multiple children's hospitals to identify patients at our 2 institutions of interest who met study criteria. The PHIS database also was used to collect patient demographic data. PHIS is an administrative database operated by Children's Hospital Association (Overland Park, KS) containing clinical and billing data from 43 tertiary care, freestanding children's hospitals, including data on 41 ICD-9 diagnoses, billed charges, and LOS. Based on the primary diagnosis, PHIS assigns each discharge to an All Patient Refined-Diagnosis Related Group (APR-DRG v.24) (3M Health information Systems, St. Paul, MN). APR-DRGs allow similar diagnoses to be grouped together.^{28,29} PHIS also uses ICD-9 codes to identify patients with a complex chronic condition (CCC).^{30,31} CCCs are those conditions "that can be reasonably expected to last at least 12 months (unless death intervenes) and to involve either several different organ systems or one system severely enough to require specialty pediatric care and probably some period of hospitalization in a tertiary care center."^{30,31} PHIS data quality is ensured through a collaborative effort of the participating hospitals, the Children's Hospital Association, and Truven Healthcare.

Second, standardized chart reviews were then performed to collect clinical data not found in PHIS: BMI, LOS in hours, and medications administered, including total number of albuterol treatments administered during both the admission and the associated preceding ED visit.

Study Setting and Participants

All admissions examined in this study were at Children's Mercy Hospitals. Children's Mercy Hospitals includes 2 separate hospitals: 1 hospital is a 354-bed academic, tertiary care freestanding children's hospital located in Kansas City, Missouri; a second, smaller, 50-bed freestanding hospital is located in Overland Park, Kansas. Both hospitals have pediatric emergency departments. Inclusion criteria included patients aged 5 to 17 years discharged for status asthmaticus (APR-DRG 141) at Children's Mercy Hospital from October 1, 2011 to September 30, 2012, with a recorded BMI during the admission or within 30 days of the admission. Patients between the ages of 2 and 5 years old were not included because of the incidence of viral-induced wheezing in this age group and therefore possible miscoding of the asthma diagnosis. Exclusion criteria included a concurrent diagnosis of a CCC or

bacterial pneumonia because these conditions could alter LOS, resource utilization, and readmission rates independent of the subject's status asthmaticus. In addition, to account for differences in the amount of treatment given in the pre-inpatient setting, patients not initially treated through the hospital's ED were excluded. For patients with multiple admissions during the study period for the same diagnosis, only the index admission was examined. The institutional review board at Children's Mercy Hospital approved this study with waiver of informed consent.

Study Definitions

BMI percentile for age was used as both a continuous and categorical predictor variable. As a categorical variable it was divided into 4 categories: "underweight" (BMI <5%), "normal" weight (BMI 5%–84%), "overweight" (BMI 85%–94%), and "obese" (BMI ≥95%).²³ Race was categorized "non-Hispanic white", "non-Hispanic black", and "other." "Other" included Asian, Pacific Islander, American Indian, and other. Ethnicity was categorized as "Hispanic" and "non-Hispanic." Insurance categories included "private" (commercial or TRICARE), "public" (Medicaid and Title V), and "other" (uninsured, self-pay, and other). Adjusted billed charges were calculated for each hospitalization. Adjusted billed charges are the billed charges adjusted by the US Centers of Medicare and Medicaid Services' price/wage index for the study site's location.^{32,33}

To compare albuterol of different delivery methods, albuterol equivalents were calculated. Based upon prior research demonstrating equal efficacy between albuterol administered by nebulizer and metered-dose inhaler (MDI),³⁴ every 2.5 mg of albuterol administered by nebulizer was treated as equivalent to 2 sprays of albuterol (90 µg/spray) administered by MDI. Therefore, albuterol 2.5 mg nebulized and 2 sprays of albuterol (90 µg/spray) were each defined as "1 albuterol equivalent." To compare continuous administration of nebulized albuterol with intermittent administration of albuterol, the total milligrams of continuously nebulized albuterol were examined. Per protocol at the study site, 10 mg per hour of continuous albuterol are administered for patients 5 years and younger and, for children 6 years and older, 15 mg per hour of continuous albuterol are administered. Based upon milligrams of albuterol nebulized, 5-year-old subjects receiving an hour of continuous albuterol would equal 4 albuterol equivalents (or 4 treatments of nebulized albuterol 2.5 mg/treatment or 4 treatments of albuterol 90 µg/spray 2 sprays/treatment); for patients 6 years and older, an hour of continuous albuterol would equal 6 albuterol equivalents (or 6 treatments of nebulized albuterol 2.5 mg/treatment or 6 treatments of albuterol 90 µg/spray 2 sprays/treatment). The variable "total albuterol" was then created to include albuterol equivalents delivered

TABLE 1. Patient Characteristics by Body Mass Index Category

Patient Characteristics	Total	Category of Body Mass Index Percentile for Age				P*
		Underweight	Normal	Overweight	Obese	
Total patients, n (%)	518	18 (3.5)	310 (59.8)	88 (17.0)	102 (19.7)	
Age, y, median (IQR)	8 (6–11)	7.5 (5.8–9)	8 (6–10)	8 (6–10)	9 (7–12)	<0.001
Gender, n (%)						
Male	309	12 (3.9)	184 (59.5)	46 (14.9)	67 (21.7)	0.27
Female	209	6 (2.9)	126 (60.3)	42 (20.1)	35 (16.7)	
Race, n (%)						
Non-Hispanic white	124	8 (6.5)	76 (61.3)	15 (12.1)	25 (20.2)	0.021
Non-Hispanic black	295	7 (2.4)	182 (61.7)	58 (19.7)	48 (16.3)	
Other	99	3 (3.0)	52 (52.5)	15 (15.2)	29 (29.3)	
Ethnicity, n (%)						
Hispanic	59	1 (1.7)	25 (42.4)	11 (18.6)	22 (37.3)	0.002
Non-Hispanic	459	17 (3.7)	285 (62.1)	77 (16.8)	80 (17.4)	
Insurance, n (%)						
Private	163	10 (6.1)	97 (59.5)	28 (17.2)	28 (17.2)	0.48
Public	313	7 (2.2)	190 (60.7)	51 (16.3)	65 (20.8)	
Other	42	1 (2.4)	23 (54.8)	9 (21.4)	9 (21.4)	

NOTE: Abbreviations: IQR, interquartile range. *Categorical variables were compared by χ^2 test, and continuous variables were compared by Kruskal-Wallis test.

by metered dose inhaler and as both single and continuous nebulized treatments.

Main Exposure

The main exposure of interest was BMI percentile for age.

Outcome Measures

The main outcome measure was inpatient LOS measured in hours. Secondary outcome measures included the total albuterol (in the inpatient setting as well as combined inpatient and ED settings) and the administration of intravenous IV fluids and intramuscular (IM) or IV systemic steroids. Other secondary measures included readmission for status asthmaticus during the study period, adjusted billed charges, and inpatient chest radiograph utilization.

Statistical Analyses

We summarized categorical variables with frequencies and percentages, and used χ^2 test across BMI categories. The non-normal distribution of continuous dependent variables (LOS, number of albuterol treatments, billed charges) were summarized with medians and interquartile ranges (IQRs). Kruskal-Wallis test was used to examine outcomes across BMI categories. For regression models, BMI percentile for age was divided into deciles and treated as a continuous predictor. Factors used in the regression models included age, gender, race, ethnicity, and insurance. Total albuterol received in the ED was also included in the model to adjust for differences in the amount of treatment received prior to admission. Incidence rate ratios were created using Poisson regression for continuous outcomes (LOS, billed charges, and number of albu-

terol equivalent treatments administered), and odds ratios were created using logistic regression for dichotomous outcomes. All statistical analyses were performed using IBM SPSS Statistics version 20 (IBM, Armonk, NY), and *P* values <0.05 were considered statistically significant.

RESULTS

Patient Characteristics

Of 788 patients admitted for status asthmaticus during the study period, 518 (65.7%) met inclusion criteria; 42 (5.3%) did not meet inclusion criteria due to lack of a documented BMI (Table 1). Most patients were normal weight (59.7%). Approximately one-third (36.7%) were either overweight or obese. The median age was 8 years, with patients with obesity being significantly older than underweight patients (9 vs 7.5 years, *P* < 0.001). The majority of patients were black/African American (56.9%) and non-Hispanic (88.6%). The percentage of patients who were obese was higher in patients of other race (29.3%) than whites (20.2%) or blacks (16.3%) (*P* < 0.05). Patients of Hispanic ethnicity had a higher rate of obesity compared to non-Hispanic patients (37.3% vs 17.4%, *P* < 0.01). There were no differences in BMI categories for insurance.

LOS and Resource Utilization

The median LOS for all patients was approximately 1 day (Table 2). The median number of albuterol treatments in the inpatient setting was 14 (IQR, 8–24). When albuterol treatments given in the ED were included, the median number of treatments increased to 38 (IQR, 28–48). Approximately one-half of patients required supplemental oxygen, one-third received IV fluids, and one-fifth received either IV or IM steroids (with all but 1.6% of the remaining patients receiving oral steroids). Less than 5% of the study population received magnesium sulfate, epinephrine, required intensive care unit (ICU) admission, or were readmitted for status asthmaticus within 30 days. Approximately 15% of patients received a chest radiograph. The median adjusted billed charge was approximately \$7,000. There were no differences in any of these outcomes by BMI category (*P* > 0.05).

Multivariable Results

After adjusting for age, gender, race, ethnicity, and insurance, the decile of BMI percentile for age showed a small negative association with LOS. Specifically, for each decile increase for BMI percentile for age, LOS decreased by approximately 2%. BMI percentile for age was not associated with other measures of resource utilization including total albuterol use, adjusted billed charges, readmission, ICU care, receipt of supplemental oxygen or a chest radiograph, IV fluids, or other medications (IV/IM steroids, epinephrine, or magnesium sulfate).

TABLE 2. Resource Utilization, Readmissions, Length of Stay, and Billed Charges for In-Hospital Status Asthmaticus by Body Mass Index Category

	Body Mass Index Category				
	Total	Underweight	Normal	Overweight	Obese
Total Patients, n (%)	518	18 (3.5)	310 (59.8)	88 (17.0)	102 (19.7)
LOS, h, median (IQR)	26 (18–41)	41 (19.5–60.5)	26 (18–41)	26 (19.25–40)	31 (19–42)
Inpatient albuterol equivalents, median (IQR)	14 (8–24)	19 (9.5–28)	14 (8–24)	14 (8.5–22)	16 (8–24)
Total albuterol equivalents, median (IQR)	38 (28–48)	34 (27–34)	36 (28–48)	37 (28–49.5)	40 (30–52)
Adjusted billed charges, \$, median (IQR)	6,999.5 (5292–9258)	7,457 (5604–8536)	6876 (5237–9390)	7056 (5409–9061)	7198 (5331–9306)
All readmits, n (%)	44 (8.5)	2 (11.1)	29 (9.4)	7 (8.0)	6 (5.9)
Readmits within 30 days, n (%)	11 (2.1)	1 (5.6)	7 (2.3)	1 (1.1)	2 (2.0)
ICU admissions, n (%)	24 (4.6)	0 (0)	13 (4.2)	7 (8.0)	4 (3.9)
Chest radiograph, n (%)	64 (12.4)	5 (27.8)	34 (11.0)	12 (13.6)	13 (12.7)
Oxygen, n (%)	255 (49.2)	11 (61.1)	157 (50.6)	42 (47.7)	45 (44.1)
IV/IM steroid, n (%)	93 (18.0)	2 (11.1)	53 (17.1)	18 (20.5)	20 (19.6)
Epinephrine, n (%)	2 (0.4)	0 (0)	2 (0.6)	0 (0)	0 (0)
Magnesium, n (%)	15 (2.9)	0 (0)	8 (2.6)	3 (3.4)	4 (3.9)
IV fluids, n (%)	152 (29.3)	4 (22.2)	85 (27.4)	31 (35.2)	32 (31.4)

NOTE: Abbreviations: ICU, intensive care unit; IM, intramuscular; IQR, interquartile range; IV, intravenous. *All differences between body mass index categories were nonsignificant ($P > 0.05$).

DISCUSSION

Our study suggests that the decile of BMI percentile for age is inversely associated with LOS but did not have a clinically meaningful effect. Secondary measures, such as total albuterol needs and adjusted billed charges, did not show an association with BMI percentile for age. There were also no associations between BMI percentile for age and other resource utilization outcomes.

Our findings differ from previous studies examining in-hospital status asthmaticus in children who are overweight or obese. In addition, the present study was able to adjust for therapies received prior to admission. Carroll et al. demonstrated an increased LOS of approximately 3 days for overweight or obese asthmatics admitted to the ICU with status asthmaticus as well as increased duration of supplemental oxygen, continuous albuterol, and intravenous steroids.²⁰ It is possible that differences in methodology (ie, weight-for-age percentile vs BMI percentile for age, inclusion of ED treatments), different thresholds for treatment of status asthmaticus outside the ICU, or differences in patient populations studied (ie, only ICU patients vs all in-hospital patients) explain the difference between their findings and the present study. The present study's use of BMI percentile for age follows current recommendations for classifying a patient as obese or overweight.^{23–25} However, the use of classifications other than BMI percentile for age would tend to bias toward the null hypothesis, whereas in Carroll's study children who were overweight or obese had increased resource utilization. Additionally, in the time frame between this publication and the current study, many hospitals worked to standardize asthma hospitalizations by creating weaning protocols for albuterol, thereby decreasing LOS

for all asthmatics, which may also affect the differences in LOS between groups of obese and nonobese patients.³⁵

Woolford et al. found approximately a one-half-day increase in LOS and \$2,000 higher mean charges for patients admitted with status asthmaticus and a secondary diagnosis of obesity.^{8,9} Study location and differing methods for defining obesity may account for the discrepancy between Woolford's findings and our study. We examined children admitted to the inpatient floor of a tertiary care children's hospital compared to Woolford et al.'s examination of pediatric patients admitted to all hospitals via the Kids' Inpatient Database (Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality). That study also relied on the coding of obesity as an ICD-9 diagnosis, rather than examining the BMI of all admitted patients. Previous research has demonstrated that relying on a coded diagnosis of obesity is not as sensitive as measurement.²⁶ By relying on ICD-9 diagnosis coding, only patients with very high BMIs may be diagnosed with obesity during the admission and therefore only associations between very high BMI and status asthmaticus will be examined.

There are several limitations to our findings. First, our study was limited to a single, tertiary care children's hospital and may not be generalizable to other hospitals. Our hospital standardizes the treatment of inpatient status asthmatics by formation of a respiratory care plan, involving interval scoring of respiratory symptoms and automatic spacing of albuterol treatments. This likely minimizes physician-to-physician variation. Second, we included only those patients who were initially treated within the ED associated with the admitting hospital to minimize the effects of timing for treatments prior to admittance.

This excluded those patients first cared for by their primary care physician or by an outlying ED. Therefore, our sample may be biased toward a study population less connected to a medical home and therefore possibly poorer asthma control. Third, to utilize the most accurate method to define obesity, we excluded approximately 5% of eligible patients because BMI was unavailable. This may have included children with more severe asthma symptoms, as a height measurement may have been deferred due to their higher acuity. Asthma severity or chronicity would be associated with our outcomes of interest. However, we were unable to collect reliable data on severity or chronicity. Finally, to measure the amount of total albuterol needed by a patient during the ED and inpatient admissions, albuterol treatments delivered by MDI, nebulizer, or continuously were converted into “total albuterol.” Although based upon total milligram dosing and studies comparing routes of albuterol administration,³⁴ the validity of this conversion is unknown.

CONCLUSION

Although BMI percentile for age is inversely associated with LOS for in-hospital pediatric status asthmaticus, the impact of BMI on this outcome likely is not clinically meaningful. Future investigations should examine other elements of BMI and in-hospital status asthmaticus, such as any associations between BMI and admission rates.

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