RESEARCH ARTICLE

Lack of Recognition, Diagnosis, and Treatment of Overweight/Obesity in Children Hospitalized for Asthma

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ABSTRACT

OBJECTIVES: Information is lacking regarding recognition and treatment of overweight and obesity in children hospitalized for asthma. The study objectives were to determine the current practice of recognition, diagnosis, and treatment of overweight and obesity for children hospitalized for asthma and to describe demographic, asthma, and weight characteristics for these patients.

METHODS: A retrospective record review was conducted for children admitted to the hospital with asthma in 2012. Charts were reviewed for evidence of recognition, diagnosis, and treatment of overweight and obesity. Subjects were classified into age-adjusted Centers for Disease Control and Prevention weight categories based on BMI percentile and chronic asthma severity categories according to National Asthma Education and Prevention Program guidelines.

RESULTS: A total of 510 subjects aged 3 to 17 years were studied. Obesity was present in 19.6% and overweight in 13.3% of subjects. BMI percentile was recorded in only 3.3% of all charts, in only 11% of subjects with obesity, and in 0% of subjects with overweight. BMI percentile was documented more often in subjects with severe obesity ($P = .013$) and with moderate to severe persistent asthma ($P = .035$). Only 9 of 168 subjects who were overweight or obese (5.6%) were given a discharge diagnosis indicating overweight or obesity, and 14 (8.3%) received treatment. Chronic asthma severity differed by BMI weight category ($P < .001$), with a significant relationship between obesity status and chronic asthma severity in older subjects ($P = .033$). There were no differences in severity of acute episodes based on weight group.

CONCLUSIONS: Overweight and obesity were underrecognized, underdiagnosed, and undertreated in children hospitalized for asthma.

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Asthma and overweight are 2 of the most common chronic health problems in children. According to data from the National Center for Health Statistics, the prevalence of asthma in children in the United States was 9.3% in 2012.[1] In 2012 there were 123 100 asthma hospitalizations for children in the United States, making asthma the third most common reason for admission in children.[2] Also notable is a report from the Centers for Disease Control and Prevention (CDC), based on the data from the National Health and Nutrition Examination Survey, that 17.2% of children in the United States were obese and 14.5% were overweight in that same time period.[3]

There is an association between asthma and overweight or obesity; however, the mechanisms for the relationship are poorly understood. Production of preinflammatory cells and hormones due to adiposity and deconditioning due to inactivity have been proposed as mechanisms; however, studies are inconclusive.[4–6] Despite lack of clarity in the cause of the relationship, studies have shown that children with overweight or obesity are more likely to be diagnosed with asthma,[7,8] have more severe asthma symptoms,[9,10] and have higher likelihood of hospitalization.[10,11] Children admitted for asthma who are overweight have been shown to need more therapy and have longer hospital stays.[7–9,12–14] However, there is inconsistency in the literature, and some studies have not found that higher BMI percentile predicts admission or effects health care outcomes in children with asthma.[15–17] There remains a lack of data on the prevalence of overweight and obesity among children with asthma in the inpatient setting and, more importantly, a lack of information about the clinical practices related to this population.

The guidelines for asthma care by the National Asthma Education and Prevention Program (NAEPP) Guidelines[18] and the Global Initiative for Asthma (GINA) Strategy for Asthma Management and Prevention[19] recommend weight loss to improve the management of asthma for patients who have overweight or obesity, but there is not specific direction for monitoring and managing childhood overweight and obesity in the inpatient setting in those guidelines. The Joint Commission Children's Asthma Care metrics also do not address management of overweight and obesity for children hospitalized with asthma.[20]

There are also guidelines for the management and treatment of childhood overweight and obesity. The American Medical Association, in collaboration with the Health Resources and Service Administration and the CDC, convened the Expert Committee that developed an algorithm to assess obesity risk and outlined steps for prevention and treatment.[21] Identifying, plotting, and monitoring BMI percentile are essential steps in the algorithm[22] and are recommended for all hospitalized children by the National Association of Children's Hospitals and Related Institutions,[23] but studies have shown that providers in both primary care and inpatient settings are failing to measure and monitor BMI percentile.[24–26] A recent study by King et al[27] described lack of identification and treatment of overweight and obesity in hospitalized children; however, only a small number of patients with asthma were included, and results specific to the patients with asthma were not described.

Recommendations by the Expert Committee[21] and the recent Children's Hospital Association Consensus Statement for Comorbidities of Childhood Obesity[28] are aimed at management of overweight and obesity in the primary care setting and are not specific to children admitted with asthma. Providers are recommended to implement overweight and obesity prevention strategies for all children. Thorough history, patient and family education for healthy eating and increased activity, and referral to a weight management program are recommended weight management strategies that would be appropriate for providers in any health care setting, including the inpatient setting. The importance of assessing for weight status and initiating treatment of overweight and obesity during admission is supported by recent studies that demonstrate an improvement in asthma symptoms and less use of health care resources with diet-induced weight loss for children with asthma who have overweight or obesity.[29–31]

The primary purpose of this study was to determine whether overweight or obesity was recognized, diagnosed, and treated in children hospitalized with asthma. A secondary purpose of the study was to describe the demographic, BMI, and asthma characteristics of the children in this study who were hospitalized with asthma.

METHODS

Institutional review board approval was granted before start of the study. This study used a retrospective cross-sectional design. The setting was a 250-bed urban tertiary children's hospital in the Midwest. The children's hospital is part of an academic medical center. All male and female children aged 3 to 17 years admitted with a primary diagnosis of asthma from January 1, 2012 to December 31, 2012 were included. Children <3 years of age were excluded to avoid confusion about the diagnosis of asthma and to ensure reliability of the use of BMI percentile as an indicator of weight status. Only the first admission for each subject during the study period was included in the sample to avoid bias. The electronic medical records were queried for International Classification of Diseases, Ninth Revision codes for asthma, 493.01, 492.02, 493.81, 493.82, 493.90, 493.91, and 493.92. Subjects with diagnoses that would alter the course of asthma treatment or make the diagnosis of asthma uncertain were excluded, including the diagnoses of vocal cord dysfunction, bacterial pneumonia, cystic fibrosis, bronchopulmonary dysplasia, sickle cell disease, cardiac disease, and rheumatologic disease. Patients with diagnoses of other chronic diseases affecting growth and subjects without height or weight measurements or implausible growth data were also excluded. Chart review was used to gather quantitative data for the baseline evaluation. The electronic medical record was queried to gather the date of birth, age, gender, race, insurance source, chronic asthma severity, overall length of stay (LOS), LOS in intensive care, primary discharge

diagnoses, order for dietitian consult or dietitian consult note, height, and weight. Subjects were grouped by age according to the age groups as defined by the NAEPP Asthma Guidelines18: 3 to 4 years, 5 to 11 years, and ≥12 years.

The primary investigator calculated BMI and BMI percentile, based on height, weight, age, and gender of the subject, by using the online CDC BMI calculator.[32] Subjects were grouped by CDC guidelines for weight categories[21] as follows: BMI <5th percentile was considered underweight, BMI 5th to 84th percentile was considered healthy weight, BMI 85th to <95th percentile was considered overweight, and BMI ≥95th percentile was considered obese. A subanalysis was conducted on subjects with BMI ≥95th percentile, excluding those with missing values of proper BMI recognition or asthma severity. In the subanalysis of those with obesity, severe obesity was defined as BMI ≥99th percentile.

Overall LOS and admission to the PICU served as indicators of the severity of the acute episode. The average LOS for asthma at the study hospital was 1.79 days for 2012. LOS was recoded at the median of 1.00 to form a binary variable: 0 to 1 day and ≥2 days. The indicators for chronic asthma severity were the categories as defined by the NAEPP Asthma Guidelines[18]: intermittent, mild persistent, moderated persistent, and severe persistent. All house staff physicians and nurse practitioners receive training to determine chronic asthma severity based on the NAEPP Asthma Guidelines. Chronic asthma severity was determined by the provider based on history obtained during the admission and documented electronically in the discharge instructions. Severity of the acute episode and chronic severity were compared between the weight categories of underweight, healthy weight, overweight, and obese.

The scanned notes in the electronic health records (EHRs) of all subjects were reviewed manually to determine whether the provider recognized the BMI percentile for the subject during the admission or at discharge. The indicator for recognition of BMI percentile was the recording of the BMI percentile by the provider in the admission note, any daily progress note, discharge instructions, or discharge letter. The EHRs of the patients with overweight and obesity were manually reviewed to determine whether the provider diagnosed overweight or obesity or provided or recommended treatment of overweight or obesity. Diagnosis of overweight or obesity was defined as provider documentation of a discharge diagnosis of overweight or obesity as determined by manual chart review. Any terminology for increased weight was accepted for diagnosis. Diagnostic coding of overweight or obesity was not accepted as a diagnosis because it indicated coding status, not provider diagnosis of obesity or overweight. Previous studies have shown inaccuracy and errors in International Classification of Diseases, Ninth Revision coding for obesity.[33,34] Treatment of obesity was defined as referral to a dietitian or consultation by a dietitian during the hospitalization or at discharge, evidence of instructions for healthy eating or exercise during the hospitalization or at discharge, or referral to a weight management program at discharge. Referral to a dietitian, a healthy eating recommendation, or referral to an outpatient weight management program was determined by a consultation order, a dietitian note, a provider note, or a discharge recommendation in the EHR.

The nurse research assistant, the primary investigator, and an unbiased researcher reviewed data collection in 20 random charts to ensure lack of bias and reliability of the manually gathered project data. Diagnosis of overweight or obesity, dietitian consultation, and recognition of BMI percentile had 100% agreement between the 3 reviewers. Fleiss's κ analysis indicated that there was substantial agreement between the 3 reviewers regarding diet or exercise counseling by the provider ($\kappa = 0.747$, $P = .036$).

Univariate summary statistics were compiled for demographic and clinical patient characteristics. Bivariate and multivariate categorical comparisons of BMI category, asthma severity, LOS category, and ICU admission were compared via Pearson's χ^2 test of association or Fisher's exact test, assessing post hoc significance between column proportions via z test. Multivariate comparison of BMI category and continuous LOS by asthma severity was assessed via 2-way analysis of variance and Fisher's LSD post hoc test.

RESULTS

Demographic Factors

Five hundred ten subjects met the criteria for inclusion in the sample; 59 admitted with a diagnosis of asthma were excluded from the analysis (Fig 1). Demographic characteristics of the subjects are listed in Table 1. Mean age of subjects was 8.4 years (SD = 3.8). Median age was 7.77 years. In all, 23.3% of patients were 3 to 4 years of age, 58.2% of patients were 5 to 11 years of age, and 18.4% of patients were 12 to 17 years of age. The majority of the subjects were male (62.9%), were African American (75.9%), and had government health insurance (66.5%).

Weight Category Distribution of the Sample According to BMI Percentile

Distribution of the sample by weight category is shown in Table 1. Demographic characteristics of the subjects across the weight category distribution are also shown in Table 1. There were no significant differences by gender, race or ethnicity, or insurance status across weight categories; however, patient age differed statistically by weight category ($P < .001$). Healthy weight subjects averaged 1.7 years younger than overweight subjects ($P = .008$) and 2.3 years younger than obese subjects ($P < .001$). Underweight subjects were 3.0 years younger than overweight subjects ($P < .001$) and 3.6 years younger than obese subjects ($P < .001$).

Recognition of BMI Percentile and Diagnosis of Overweight and Obesity

Review of the records revealed that documentation of BMI percentile by the provider was missing in 493 (96.7%) of the records of the total sample. Compared with subjects without documentation of BMI percentile, those with documentation had higher average BMI percentiles (79.9 vs 60.3, $P = .001$), more often had LOS of ≥2 days ($P = .046$), were ages 12 to 17 years ($P = .010$), and had severe persistent asthma ($P = .007$).

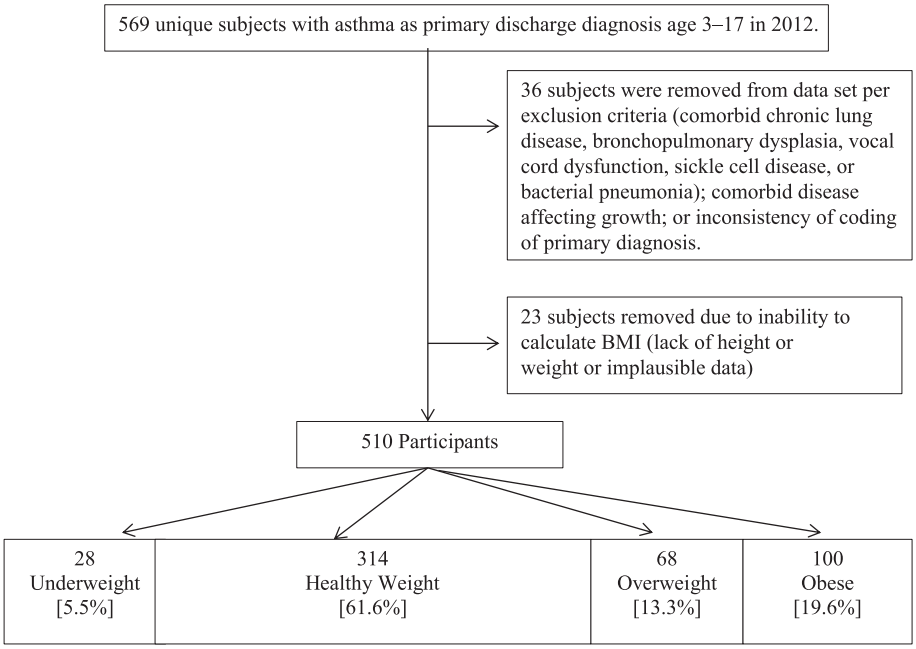

FIGURE 1 Flow of participants.

For the 168 subjects with overweight or obesity, BMI percentile was documented in only 11 (6.5%) of the charts. BMI percentile was not documented for any of the 68 subjects with overweight (0%). For the 100 subjects with obesity, BMI percentile was documented in 11 (11%) of the charts. Among subjects with obesity, those with recognition of BMI percentile had higher average BMI percentile (99.1 vs 97.7, $P = .016$) and more often had severe obesity (BMI percentile ≥99) than subjects with BMI 95th to 98th percentile (22.3% vs 4.7%, $P = .013$).

Only 9 of the 168 (5.4%) subjects with overweight or obesity were given a discharge diagnosis by the provider reflecting overweight or obesity in addition to the primary diagnosis of asthma. Only subjects with obesity were given a diagnosis of overweight/obesity. None of the subjects with overweight were diagnosed with overweight/obesity.

Treatment of Obesity and Overweight

Of 168 overweight or obese subjects, only 14 (8.3%) received treatment of obesity and overweight. All 14 of the subjects who received weight treatment were in the obese weight group (14%). Subjects received treatment consisting of ≥1 of the following: diet instruction or counseling ($n = 13$), instruction for increased activity ($n = 3$), inpatient dietitian consultation ($n = 8$), and referral for an outpatient weight management program ($n = 3$).

Asthma Characteristics

Chronic Asthma Severity

Data on chronic asthma severity are listed in Table 1. Chronic severity was found to be associated with BMI weight category ($P \leq .001$) (Table 1). As a result of the significant overall association between chronic severity and BMI weight category, pairwise post hoc testing was completed between each BMI weight category. Intermittent severity was different from both moderate persistent ($P < .001$) and severe persistent asthma ($P < .001$). Mild persistent severity was different from both moderate persistent ($P < .001$) and severe persistent asthma ($P < .001$).

Because of the significant difference in age between the weight categories, analyses were conducted stratifying by age. As shown in Fig 2, when the relationship of chronic asthma severity and weight category is adjusted for age category, there was a significant association between severe persistent chronic asthma and obesity for children in the oldest age group ($P = .033$). Children with obesity in the 12- to 17-year age group demonstrated 2 times more severe persistent asthma than those with obesity in the 5- to 11-year age group and 5 times more than those with obesity in the 3- to 4-year age group.

Severity of the Acute Episode

A χ^2 analysis of binary LOS and BMI percentile group suggests a lower proportion of underweight and healthy weight patients with LOS of ≥2 days as compared with subjects with overweight and obesity, but the difference fell short of statistical significance ($P = .055$). When adjusted for chronic asthma severity, LOS does not differ by BMI category, nor does BMI category have an interactive effect with asthma severity. However, LOS differs by chronic asthma severity when BMI category is accounted for ($P = .007$). When age was adjusted, LOS and BMI category did not show a statistically significant association.

Of the 510 subjects in the sample, 110 were admitted to the PICU (21.6%). Table 1 shows the comparison of admission to the

TABLE 1 Demographics and Asthma Characteristics of Children Hospitalized With Asthma by Weight Group ($N = 510$)

Variable	Total Sample		Underweight		Healthy Weight		Overweight		Obese		*P*
	510	100.0	28	5.5	314	61.6	68	13.3	100	19.6	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	
Demographics											
Age											<.001*
3–4 y	119	23.3	9	32.1	88	28.0	13	19.1	9	9.0	
5–11 y	297	58.2	19	67.9	178	56.7	39	57.4	61	61.0	
12–17 y	94	18.4	0	0.0	48	15.3	16	23.5	30	30.0	
Gender											.500
Female	189	37.1	7	3.7	122	64.6	25	13.2	35	18.5	
Male	321	62.9	21	6.5	192	59.8	43	13.4	65	20.2	
Race or ethnicity											.962[a]
Caucasian	98	19.2	7	7.1	61	62.2	13	13.3	17	17.3	
African American	387	75.9	20	5.2	238	61.5	52	13.4	77	19.9	
Asian	3	0.6	0	0.0	2	66.7	0	0.0	1	33.3	
Other	17	3.3	1	5.9	11	64.7	2	11.8	3	17.6	
Unknown	5	1.0	0	0.0	2	40.0	1	20.0	2	40.0	
Insurance status[b]											.441[a]
Government	339	66.5	20	5.9	207	61.1	43	12.7	69	20.4	
Commercial	150	29.4	7	4.7	96	64.0	19	12.7	28	18.7	
Self-pay	19	3.7	1	5.3	10	52.6	6	31.6	2	10.5	
Missing	2	0.4	0	0.0	1	50.0	0	0.0	1	50.0	
Asthma characteristics											
LOS											.055
0–1 d	265	52.0	14	5.3	177	66.8	33	12.5	41	15.5	
≥2 d	245	48.0	14	5.7	137	55.9	35	14.3	59	24.1	
PICU admission											.179
Yes	110	21.6	7	6.4	59	53.6	15	13.6	29	26.4	
No	400	78.4	21	5.3	255	63.7	53	13.3	71	17.8	
Chronic asthma severity[b]											.001*
Intermittent	88	17.3	7	8.0	60	68.2	10	11.4	11	12.5	
Mild persistent	114	22.4	10	8.8	82	71.9	6	5.3	16	14.0	
Moderate persistent	211	41.4	9	4.3	124	58.8	32	15.2	46	21.8	
Severe persistent	88	17.3	1	1.1	46	52.3	19	21.6	22	25.0	
Missing	9	1.8	1	11.1	2	22.2	1	11.1	5	55.6	

Variable	Total Sample		Underweight		Healthy Weight		Overweight		Obese		*P*
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Age, y	8.4	3.8	6.5	2.5	7.8	3.6	9.5	3.9	10.1	3.7	<.001*

*$P < .05$.
[a] Fisher's exact test.
[b] Missing category excluded from analysis with weight group.

PICU by weight group. Because of the significant difference in age between the weight categories ($P < .001$), the comparison of PICU status by weight category was also stratified by age group. When age was adjusted, the comparisons of admission to the PICU and weight category also did not indicate any statistically significant association. When we adjusted for chronic asthma severity, admission to the PICU did not differ by BMI category.

DISCUSSION

This retrospective chart audit of children admitted to the hospital for treatment of asthma finds a striking absence of recognition, diagnosis, and treatment of obesity and overweight, important

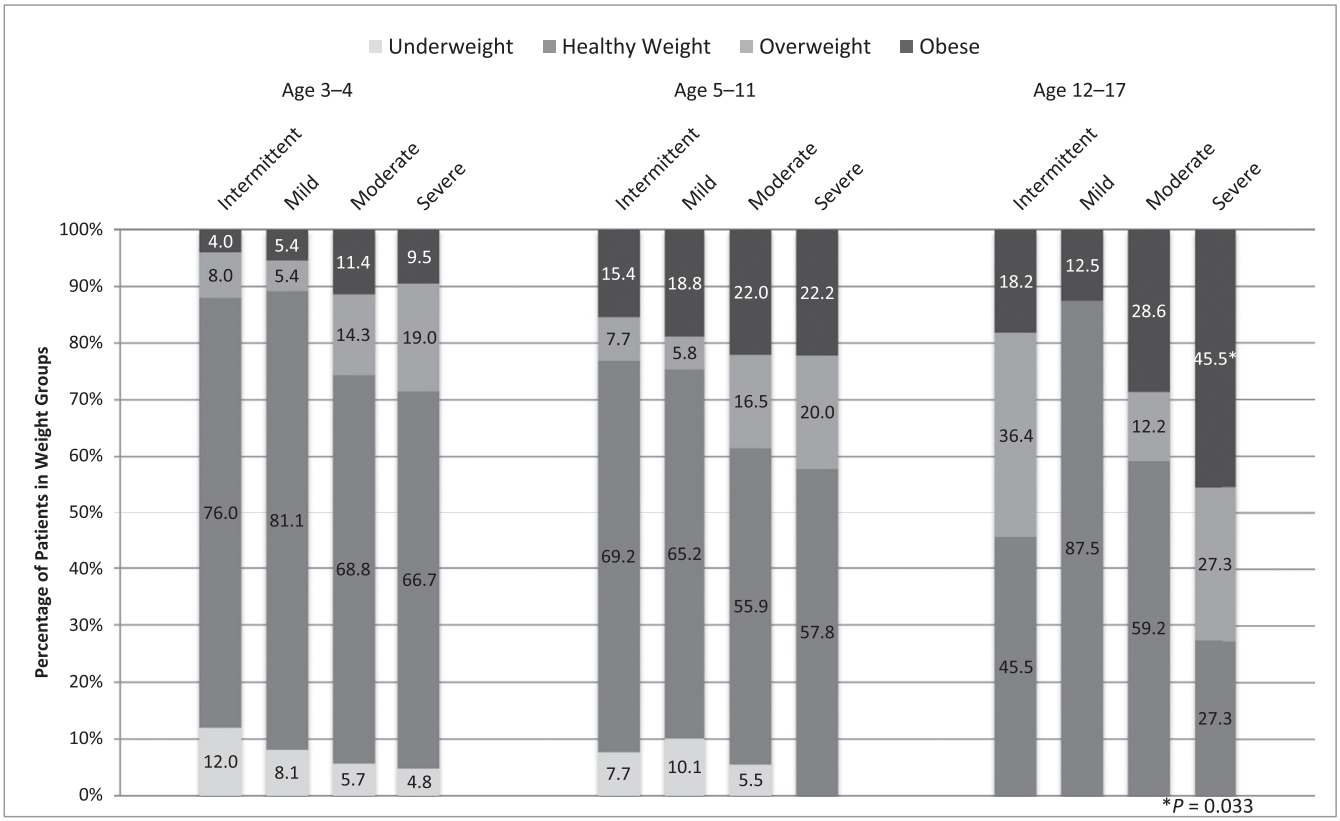

FIGURE 2 Asthma severity by BMI percentile group stratified by age category.

comorbidities of asthma. In the total sample, only 3.3% of all children had evidence of provider documentation of BMI percentile. For the children with overweight or obesity, only 6.5% had a BMI percentile documented in the record, only 5.4% were diagnosed with overweight or obesity at discharge, and only 8% had a treatment recommendation related to weight management.

The importance of monitoring BMI percentile is supported in the literature[21,23]; however, investigators have reported a lack of monitoring BMI percentile of all children in all settings, including the inpatient setting.[24,26,28] Young et al[23] recommend consistent identification and treatment of overweight and obesity as the standard of care for all children admitted to children's hospitals. This is the first study to specifically examine recognition, diagnosis, and treatment of overweight and obesity in children hospitalized for asthma. BMI percentile was recognized in some subjects with obesity (11%). Of the subjects with obesity, those with severe obesity were significantly more likely to have BMI percentile recognized ($P = .016$). It is possible that providers are able to recognize severe obesity by physical examination or that extreme obesity was prioritized as a significant health issue by the provider. More remarkable is the lack of recognition of overweight in this study. None of the patients with overweight were recognized (0%). Missing identification of those with overweight may be a missed opportunity to prevent development of obesity and reduce the severity of asthma symptoms and comorbidities associated with weight.

In the overall sample BMI percentile was significantly more likely to be recognized in older subjects ($P = .010$). Although it is important that BMI percentile was recognized in the older subjects, there is evidence that recognizing overweight and obesity in younger children may affect health outcomes. A longitudinal study of healthy children by Cunningham et al[35] demonstrated that younger children with overweight were more likely to have obesity as teens. A recent study by Aragona et al[36] demonstrated that overweight and obese preschool children admitted with asthma were >2 times as likely to have repeat emergency visits as lean preschool children. Strunk et al[37] showed that subjects in the Childhood Asthma Management Program who became obese in young adulthood had lower lung function compared with those who remained normal weight. Although our study design is not longitudinal, the results suggest that an association of asthma severity and weight becomes more pronounced among older children, and they support the importance of recognizing and treating overweight in younger children. Additional longitudinal studies of children with asthma and overweight are needed to analyze the impact of asthma on the development of obesity with age.

In the overall sample, obesity was also more likely to be recognized in those with severe chronic asthma ($P = .007$). The NAEPP

Guidelines recommend addressing weight in patients with overweight or obesity and uncontrolled asthma.[18] Studies demonstrate improvement in asthma symptoms with weight loss and thus support the importance of recognizing and treating those with severe chronic asthma and overweight or obesity.[29–31] The results also demonstrate a relationship of chronic asthma severity and weight group that was significant in the older age category. Although a large prospective study by Peters[38] demonstrated no significant difference in chronic severity between weight groups, other studies have shown that children with asthma who are overweight or obese have more asthma morbidity.[39–42] Future studies may support stronger recommendations in the NAEPP and Global Initiative for Asthma guidelines related to weight recognition and management in all health care settings and in all age groups for children with asthma. The urban setting and prevalence of government-insured subjects in this study (66.7%) lends support to capitalizing on the opportunity to recognize and treat overweight and obesity in the inpatient setting. Children living in poverty have been shown to have higher utilization of urgent and acute care, lower utilization of primary and specialist care, and higher prevalence of both asthma and obesity.[42–44]

Even when obesity was recognized in this study, the provider did not always identify it as a discharge diagnosis. At the time of discharge only 5.4% of subjects with overweight or obesity received a diagnosis that indicated overweight or obesity. Other studies have noted underdiagnosis of overweight and obesity in hospitalized children.[27,33,45] Some studies indicate error or inaccuracy in overweight and obesity coding[14]; however, others, as in our study, demonstrate lack of provider diagnosis.[27,45] There could be many reasons for lack of diagnosis. Provider and patient sensitivity and bias have been shown to influence provider diagnosis and treatment of overweight and obesity.[21,46,47] In our study, to avoid possible provider or patient sensitivity to the word *obesity,* any term indicating overweight or obesity was accepted for diagnosis, and accuracy of the term according to BMI percentile was not studied. It is interesting that a study of hospitalized children by Bradford et al[48] showed that parents underestimate their child's weight status, but almost all parents in the study expected that providers would monitor BMI during admission and inform them of the results. The use of BMI percentile to spur additional assessment and diagnosis cannot be overlooked in the health care of all children in any setting.

In our study, only 8% of those with overweight and obesity had evidence of treatment, and subjects receiving treatment were in the obese group. Guidelines for treatment of overweight and obesity for children hospitalized with asthma are lacking; however, components of the Expert Committee[21] guidelines are appropriate for the inpatient setting. Nearly all patients in the study, regardless of weight status, were given instructions to "resume usual diet." Recommendations for healthful eating and increased activity, as recommended by the Expert Committee for children with BMI percentile ≥85, could become standard practice for children admitted with asthma. In addition, delivery of a written weight management plan could be part of the discharge instructions for those with BMI percentile ≥95. And those with severe obesity or failure to lose weight could be referred to outpatient management programs. Unfortunately, lack of resources in the community or limitations in insurance coverage may influence the provider's ability to refer patients for needed care.

Some elements of Expert Committee recommendations cannot be done in the inpatient setting because of the effects of the medications needed to treat the acute exacerbation. Results of inpatient screening of lipids and glucose are confounded by systemic corticosteroids, and blood pressure measurement is unreliable because of the effects of albuterol and corticosteroids. Laboratory screening, blood pressure measurement, and long-term monitoring of weight and asthma outcomes are best provided in the primary care setting; therefore, communication with the primary care team is crucial. Although the discharge instructions are faxed to all primary care providers, we did not assess for specific communication with the primary care provider regarding weight status or plan for management.

A recent study by Cygan et al[49] suggests that outcomes of pediatric overweight and obesity management in the primary care setting are improved with a systematic approach including use of an EHR that alerts providers to practice protocols, patient education, and provider training. There was limited capability of the EHR in the study hospital at the time of the study. BMI was available in the growth chart application, but BMI percentile had to be calculated with the CDC calculator. Recognition of weight status may have improved if BMI percentile were set to appear automatically in the EHR. Also, the electronic discharge instructions gave the provider a default option for resuming usual diet or an option for "other" that required manual entry of specific diet directions. Nearly all subjects in the study regardless of weight category were given directions to resume usual diet. This finding could be attributed to ease of entering the default option. As in the Cygan et al study,[49] optimizing the EHR has the potential to improve inpatient care. More studies are needed to determine effective use of the EHR to improve care of children with asthma and overweight or obesity.

This study adds to our knowledge of the disease process in children with overweight and obesity who are hospitalized with asthma. The prevalence of overweight and obesity in this sample (32.9%) is similar to the prevalence of overweight and obesity in the general population at the time of the study (31.8%).[50] This study, as in a recent study by Aragona et al,[36] did not find a significant relationship between overweight or obesity and inpatient asthma clinical outcomes. It should be considered that LOS and admission to the ICU may be insensitive measures of the severity of the episode. Carroll et al[12] found that obese children received longer courses of supplemental oxygen, continuous albuterol, and intravenous steroids in the ICU. Objective assessment data such as oxygen saturation, peak flow measurement, asthma score, and

pulmonary function studies were not gathered or reported in this study and may have contributed to the understanding of the severity of the episodes. Including other objective parameters in future studies might help better define the effect of weight on severity of the acute episode.

This study has several potential limitations. Demographic characteristics of the sample should be considered in generalizing the results of this study. Data were gathered from a convenience sample of subjects admitted to a single tertiary pediatric hospital in an academic setting in the year 2012. Also, although the data in this study were representative of the race and ethnicity of the population cared for at this urban Midwestern children's hospital, it differed from that of the general population in the United States at the time of the study. Specifically, it did not include many Hispanic subjects, and race or ethnicity did not vary between weight groups. Although the association has varied widely in studies, race or ethnicity has been shown to influence both the prevalence of asthma and asthma control.[40,43,51,52]

The retrospective nature of this study influenced data collection and analysis. Lack of height or weight measurement or implausible measurements made calculating BMI percentile impossible for 23 subjects. Accuracy of measurement cannot be determined. Although the authors made every attempt to demonstrate consistency in data extraction, the potential for errors in recording data to the EHR still exist. The unavailability of the BMI percentile in the EHR was a barrier to providers and complicated their ability to recognize subjects' weight status. In addition, it is possible that providers recognized weight status but did not document recognition or treatment. The retrospective method influenced the ability to gather detailed information about chronic asthma characteristics and risk of severity for the subjects. Chronic asthma severity was extracted from the records as designated in a discrete electronic field by the provider who completed the discharge instructions. Although all physicians and nurse practitioners are trained to assess chronic severity based on the NAEPP guidelines, there could be variability due to the level of provider competency or completeness in assessing chronic severity. Chronic asthma severity was identified by providers in 501 of the 510 subjects in the sample; however, other details about asthma-specific characteristics such as Asthma Control Test score, lung function, previous admissions, previous emergency visits, asthma quality of life scores, environmental exposure, and family histories were not consistently available in the EHRs. Markers of severity of the acute episode were also chosen based on data available in the records. Binary LOS, 0 to 1 and $\geq$2 days, was also used by Aragona et al,[36] but it is not known whether it is indicative as a measure of severity of the admission. Spirometry has been used in other studies as an indicator of severity of the episode, but it is not routinely performed during admission and therefore was not available in the record. Obstructive sleep apnea, gastroesophageal reflux, exposure to tobacco smoke, and other comorbid conditions that may have influenced LOS or chronic severity were not examined in this study because of a lack of reliability in charting and coding in this retrospective study.

Data were not collected in this study to examine cost of care or readmission rate but could be an area for additional study. Although cost of care and rate of readmission or return to the hospital are important issues in health care, a recent study by Bettenhausen et al[17] did not show a relationship between BMI and resource utilization or cost of care; however, Aragona et al[36] did show that obese patients were more likely to have return visits.

The sample size proved to be a limitation in the analyses. Power was limited by the uneven distribution of sample patients across categorized variables of interest. Future analyses can benefit from the observed ratio of patient categorization and a priori power analysis.

CONCLUSIONS

In this study of children admitted to the hospital with asthma, overweight and obesity were infrequently recognized or diagnosed and seldom prompted treatment recommendations by providers. BMI percentile was more likely to be recognized in older subjects, subjects with severe obesity, and subjects with severe persistent asthma. The results of this study will be the basis for planning processes and establishing practice guidelines to improve recognition, diagnosis, and management of overweight and obesity in children who are hospitalized with status asthmaticus. Additional study will be needed to elucidate the barriers to recognition, diagnosis, and treatment of overweight and obesity for children admitted with asthma; the effect of optimizing the EHR to improve recognition and management of overweight and obesity; and the impact of including weight management in the inpatient setting on health care outcomes for children with asthma and overweight or obesity.

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