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To cite this article: Jennifer A. Lucas, Miguel Marino, Katie Fankhauser, Steffani R. Bailey, David Ezekiel-Herrera, Jorge Kaufmann, Stuart Cowburn, Shakira F. Suglia, Andrew Bazemore, Jon Puro & John Heintzman (2019): Oral corticosteroid use, obesity, and ethnicity in children with asthma, Journal of Asthma, DOI: [10.1080/02770903.2019.1656228](https://doi.org/10.1080/02770903.2019.1656228)

To link to this article: <https://doi.org/10.1080/02770903.2019.1656228>



Published online: 22 Aug 2019.



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Oral corticosteroid use, obesity, and ethnicity in children with asthma

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ABSTRACT

Objective: Comorbid asthma and obesity leads to poorer asthma outcomes, partially due to decreased response to controller medication. Increased oral steroid prescription, a marker of uncontrolled asthma, may follow. Little is known about this phenomenon among Latino children. Our objective was to determine whether obesity is associated with increased oral steroid prescription for children with asthma, and to assess potential disparities in these associations between Latino and non-Hispanic white children.

Methods: We examined electronic health record data from the ADVANCE national network of community health centers. The sample included 16,763 children aged 5–17 years with an asthma diagnosis and ≥ 1 ambulatory visit in ADVANCE clinics across 22 states between 2012 and 2017. Poisson regression analysis was used to examine the rate of oral steroid prescription overall and by ethnicity controlling for potential confounders.

Results: Among Latino children, those who were always overweight/obese at study visits had a 15% higher rate of receiving an oral steroid prescription than those who were never overweight/obese [rate ratio (RR) = 1.15, 95% CI 1.05–1.26]. A similar effect size was observed for non-Hispanic white children, though the relationship was not statistically significant (RR = 1.10, 95% CI: 0.92–1.33). The interactions between body mass index and ethnicity were not significant (sometimes overweight/obese $p = 0.95$, always overweight/obese $p = 0.58$), suggesting a lack of disparities in the association between obesity and oral steroid prescription by ethnicity.

Conclusions: Children with obesity received more oral steroid prescriptions than those at a healthy weight, which may be indicative of worse asthma control. We did not observe significant ethnic disparities.

ARTICLE HISTORY

Received 12 April 2019
Revised 29 July 2019
Accepted 11 August 2019

KEYWORDS

Asthma; childhood obesity; disparities; ethnicity; electronic health records

Introduction

Childhood obesity is one of many risk factors for the development of asthma. Comorbid asthma and obesity in children can lead to more severe and difficult to control asthma symptoms with decreased response to commonly prescribed asthma medications (1–4). Asthma severity and poor asthma control may be influenced by both inflammatory mechanisms as well as mechanical features related to obesity. In the United States, Latino children have poorer asthma outcomes and have a higher prevalence of childhood obesity than non-Hispanic white children (3,5,6), but it is not known whether obesity in Latino children has a differential impact

on asthma control as compared with non-Hispanic white children.

Inhaled “controller” glucocorticoids (referred to as inhaled glucocorticoids) are the preferred medications for long-term asthma control, and work by reducing inflammation in the airway. Oral glucocorticoids (referred to as oral glucocorticoids) are used for the treatment of exacerbations in cases of severe, persistent asthma, and may be indicative of poor asthma control. Inhaled glucocorticoids have been found to be less effective in children and adults with obesity (1,7,8), and children with obesity are more likely to require treatment with oral glucocorticoids (9,10). Additionally, research shows that Latinos are less

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likely to be prescribed and adhere to inhaled glucocorticoids than non-Hispanic white patients (11,12), however, again, it is uncertain whether or not obese Latino children are more likely to require or utilize oral glucocorticoids than obese non-Hispanic white children.

The burden of asthma is high in low-income communities with large racial/ethnic minority populations, and some research has focused on reducing disparities that lead to poor asthma outcomes (13,14). Community health centers (CHCs) are clinics that serve disproportionate numbers of low-income patients and people in racial/ethnic minority groups. As obesity is also more common in disadvantaged communities, large numbers of obese children (Latino and non-Hispanic white) receive asthma care in this setting (15,16). In this article, we aim to determine whether obesity or overweight at CHC visits is associated with increased oral steroid use in children with asthma, and to identify potential disparities in this medication use between Latino and non-Hispanic white children. This study is novel in its use of electronic health record (EHR) data from primary care settings that provide healthcare to vulnerable children, an especially understudied population. We hypothesize that children who were consistently documented as overweight or obese at clinic visits will have an increased number of oral steroid prescriptions compared with children who were documented as never overweight/obese. Although little is known about oral glucocorticoids and obesity with regard to ethnicity, we hypothesized that the association between obesity and oral steroid prescriptions will differ between Latino and non-Hispanic white children, because there have been demonstrated ethnic disparities in the use of other medication classes.

Methods

Data and study population

We used data from the Accelerating Data Value Across a National Community Health Center Network (ADVANCE) Clinical Data Research Network (CDRN). The ADVANCE CDRN contains EHR data from the OCHIN network and Health Choice Network (HCN) of CHCs in nearly half of all US states (17) and has been successfully used to study vulnerable populations and health disparities (18–20). This network provides a large volume of care to vulnerable children. The population in this study included children ages 5–17 years with a documented asthma diagnosis (ICD-9 or ICD-10 codes for asthma

at a visit or on a problem list; see Table A1) who had at least one ambulatory visit in study clinics between 2012 and 2017. Children with cystic fibrosis were excluded due to use of oral glucocorticoids in treatment of cystic fibrosis (21).

The outcome variable was the number of courses of oral glucocorticoids prescribed during the study period. The rationale for using a count of oral glucocorticoids is based on information from the National Heart, Lung, and Blood Institute's Guidelines for the Diagnosis and Management of Asthma, which states that exacerbations requiring oral glucocorticoids fall under the risk component of assessing asthma severity and assessing asthma control. With regard to asthma control, the Guidelines report that for children 5–11 years old, and those 12 years old and above, exacerbations requiring 0–1 bursts of oral glucocorticoids per year indicate asthma that is well controlled, and two or more per year indicate asthma that is not well controlled (22). Oral steroid prescriptions were identified by NDC codes, reviewed and cleaned by analysts, and reviewed again for final categorization by a practicing clinician (Table A2). Oral glucocorticoids included dexamethasone, methylprednisolone, prednisolone, and prednisone.

The primary independent variables included a categorical variable denoting weight status over the study period, and ethnicity. As part of the clinical performance measures required of federal health center grantees, CHCs are required to record body mass index (BMI) for all pediatric patients at each visit (23,24). Many children will receive all of their medical care at these CHCs, and we believe that the continuity of this care may provide us with more accurate findings than less frequently measured non-BMI measures of obesity. Experts agree that BMI is an acceptable measure for obesity in children (25–28). Being overweight at a clinic visit was defined in children as having a BMI ≥ 85 th percentile to < 95 th percentile for their respective age and sex in accordance with Centers for Disease Control and Prevention (CDC) standards (29). Obesity at clinic visit was defined as a measurement of BMI ≥ 95 th percentile. Not being overweight/obese at a clinic visit was defined as the child's BMI being < 85 th percentile (29). BMI percentiles and groups were calculated using the R package *childsds*, version 0.6.7, using CDC parameters (30). Cut points for biologically implausible values (values with a low z-score of < -4 or a high z-score of > 8), were calculated according to CDC standards updated in 2016 (31), and values determined to be biologically implausible were not used in the analysis. To account

for varying number of visits and time in the study period between children, we evaluated the pattern of visits the children had throughout the study period to construct three mutually exclusive weight groups: (1) children who were “never overweight/obese” at any clinic visit; (2) children who were not overweight or obese at some visits and overweight or obese at others were denoted as “sometimes overweight/obese”; (3) children who were overweight or obese at all visits were denoted as “always overweight/obese” (Table A1). Lastly, the ethnicity variable was a dichotomous variable denoting if a child was Latino or non-Hispanic white. While we generally use Latino/a because it is often preferred in populations similar to our study population, the actual ethnicity information collected by clinics is “Hispanic” and “non-Hispanic white.” Other ethnicities were excluded due to low sample size and because potential disparities between white and Latino populations were the focus of this study.

Covariates included age in years at first visit (restricted to dates between a child’s 5th and 18th birthday), sex (male or female), insurance status (never insured, some private insurance, some public insurance, some private and public insurance at visits over the study period), average number of ambulatory visits per year (<1, 1–2, 3–4, 5–9, and ≥10 visits), asthma severity (persistent or not persistent asthma specified on the problem list), prescription of inhaled “controller” glucocorticoids [average number per year (Table A2)], and albuterol or other rescue inhaler prescription at any point in the study (yes or no). Lastly, the state in which the clinic is located was included as a fixed effect to allow clustering of clinics within states and to account for state variability which explains differences in Medicaid policy, a state-level variable that is highly impactful in low-income demographics.

Statistical analysis

Patient characteristics between Latinos and non-Hispanic whites were compared using descriptive statistics. We performed generalized estimating equations (GEE) Poisson regression models which included all independent variables and covariates (for the overall analysis) and the interaction between ethnicity and BMI categorical group (for the analysis evaluating racial/ethnic disparities). Time in the study (in months) was included as the offset. We fitted GEE Poisson models with a compound symmetry correlation structure and empirical sandwich variance

estimator to obtain rates and rate ratios (RRs), accounting for clustering of patients within CHCs.

To address potential bias and heterogeneity of effects, sensitivity analyses were conducted with the data stratified by average number of visits per year (≤2, 3–6, and ≥7), with the assumption that those who utilized more healthcare would also receive more oral steroid prescriptions. Another sensitivity analysis stratified by asthma severity (persistent vs. not persistent), as children with a persistent asthma diagnosis might receive different care than those without a persistent asthma diagnosis. Given the low prevalence of missing data in our sample across all variables (1.2%), we handled missing data through list-wise deletion. All statistical analyses were performed using R software. The package Geepack, version 1.2-1 was used for the Poisson regression (32) and statistical significance was set at p values < 0.05. This study was approved by the Oregon Health and Science University Institutional Review Board.

Results

The study population was comprised of 16,763 children. Patient characteristics are shown in Table 1, overall and by ethnicity. The majority of patients were Hispanic (63.8%), male (56.0%), and first visited a CHC at age 7–10 years. Most patients had some public insurance (81.4%) and 1–2 ambulatory visits per year (42.2%). Overall, 39.1% of patients were overweight/obese at every visit, 38.0% were never overweight/obese, and 22.9% were sometimes overweight. The observed oral steroid prescription rate was <1 prescription per year on average for 91.0% of children. Furthermore, 81.9% had a prescription for albuterol and 89.7% had received <1 prescription for inhaled glucocorticoids per year.

The GEE Poisson regression results of the overall association between weight groups with all covariates are shown in Table 2. All covariates except for ethnicity were significantly associated with the rate of oral steroid prescription. Controlling for other factors, children who were sometimes overweight or obese at clinic visits had an 11% greater rate of oral steroid prescription than children who were never overweight/obese at visits (RR = 1.11, 95% CI: 1.03–1.20). Children who were always overweight/obese at clinic visits had a 14% greater rate of oral steroid prescription than those who never had visits at which they were overweight/obese (RR = 1.14, 95% CI: 1.06–1.22). Non-Hispanic white children had a lower rate of oral steroid prescription than Latino children,

Table 1. Population characteristics overall and by ethnicity ($N = 16\,763$).

$N = 16,763$	Overall N (%)	Latino ($n = 10,696$, 63.8) N (%)	Non-Hispanic white ($n = 6067$, 36.2) N (%)
Age in years			
5–6	3698 (22.1)	2486 (23.2)	1212 (20.0)
7–10	6545 (39.0)	4365 (40.8)	2180 (35.9)
11–13	4196 (25.0)	2505 (23.4)	1691 (27.9)
14–18	2324 (13.9)	1340 (12.5)	984 (16.2)
Sex			
Female	7382 (44.0)	4636 (43.3)	2746 (45.3)
Male	9381 (56.0)	6060 (56.7)	3321 (54.7)
Insurance type ^a			
Never insured	812 (4.8)	569 (5.3)	243 (4.0)
Some public insurance	13,640 (81.4)	8977 (83.9)	4663 (76.9)
Some private insurance	1234 (7.4)	514 (4.8)	720 (11.9)
Some public and private insurance	1077 (6.4)	636 (6.0)	441 (7.3)
Visits per year ^b			
Less than 1	2968 (17.7)	1607 (15.0)	1361 (22.4)
1–2	7073 (42.2)	4554 (42.6)	2519 (41.5)
3–4	3588 (21.4)	2432 (22.7)	1156 (19.1)
5–9	2342 (14.0)	1592 (14.9)	750 (12.4)
10 or more	792 (4.7)	511 (4.8)	281 (4.6)
Obesity status			
Never overweight/obese	6370 (38.0)	3,728 (34.9)	2,642 (43.5)
Sometimes overweight/obese	3839 (22.9)	2596 (24.3)	1243 (20.5)
Always overweight/obese	6554 (39.1)	4372 (40.9)	2182 (36.0)
Albuterol prescription			
Yes	13,728 (81.9)	8970 (83.9)	4758 (78.4)
No	3035 (18.1)	1726 (16.1)	1309 (21.6)
Inhaled glucocorticoids per year			
Less than 1	15,038 (89.7)	9475 (88.6)	5563 (91.7)
1	1084 (6.5)	766 (7.2)	318 (5.2)
2	333 (2.0)	237 (2.2)	96 (1.6)
3 or more	308 (1.8)	218 (2.0)	90 (1.5)
Asthma severity ^c			
Persistent	2615 (15.6)	1756 (16.4)	859 (14.2)
Not persistent	14,148 (84.4)	8940 (83.6)	5208 (85.8)

^aInsurance type based on primary payor type for all eligible encounters.^bVisits per year included ambulatory visits at ADVANCE Community Health Centers.^cPersistent asthma is defined as having persistent asthma denoted on the problem list. See Table A1 for more detail.

although this difference was not significant ($RR = 0.96$, 95% CI: 0.89–1.04). Children with public insurance had significantly lower rates of oral steroid prescription than children who had no insurance at any visit in the study period ($RR = 0.61$, 95% CI: 0.53–0.71). Similarly, children who were privately insured and those who utilized both public and private insurance had lower rates of oral steroid prescriptions compared to uninsured children (20 and 37% lower, respectively). As the number of primary care visits per year increased, the rates of oral steroid prescriptions also increased. Additionally, children who used other asthma medications and had a persistent asthma diagnosis had higher rates of oral steroid prescription (Table 2).

Figure 1 shows results from the GEE Poisson regression model with interaction terms evaluating ethnic disparities in the relationship between weight and oral steroid prescribing rates. Among Latino children, those who were sometimes overweight/obese were prescribed oral glucocorticoids at a rate 11% higher than the prescription rate among children who were never overweight/obese ($RR = 1.11$, 95% CI:

1.01–1.21). For non-Hispanic white children, this relationship between weight groups was not significant ($RR = 1.11$, 95% CI: 0.81–1.36). The interaction between sometimes overweight/obesity and ethnicity was not significant (p values = 0.95).

Latino children who were always overweight/obese received a prescription for oral glucocorticoids at a rate 15% higher than Latino children who were never overweight/obese during the study ($RR = 1.15$, 95% CI: 1.05–1.26). A similar effect size was observed for non-Hispanic white children, though the relationship was not statistically significant ($RR = 1.10$, 95% CI: 0.92–1.33). The interaction between always overweight/obesity and ethnicity was also not significant (p values = 0.58).

Sensitivity analyses demonstrated that the RRs of oral steroid prescriptions were qualitatively similar across patient visit categories (Table A3). When stratified by asthma severity (persistent and non-persistent asthma), among those without persistent asthma ($n = 14\,148$), Latino children who were recorded as overweight/obese at some visits had a 15% higher rate

Table 2. Oral steroid prescription overall ($N = 16\,763$).

	Rate ratio	95% CI
Obesity status		
Never overweight/obese	ref	
Sometimes overweight/obese	1.11	1.03-1.20
Always overweight/obese	1.14	1.06-1.22
Age in years		
5–6	ref	
7–10	0.81	0.76-0.87
11–13	0.60	0.54-0.65
14–18	0.56	0.49-0.68
Ethnicity		
Latino	ref	
Non-Hispanic White	0.96	0.89-1.04
Insurance status		
Never insured	ref	
Some public insurance	0.61	0.53-0.71
Some private insurance	0.80	0.66-0.96
Some public and private insurance	0.63	0.53-0.75
Visits per year		
Less than 1	ref	
1–2	2.07	1.86-2.30
3–4	3.71	3.31-4.16
5–9	4.97	4.38-5.65
10 or more	6.83	5.61-8.31
Sex		
Female	Ref	
Male	1.07	1.003-1.13
Albuterol use		
No	Ref	
Yes	2.31	2.08-2.56
Inhaled glucocorticoids per year	1.05	1.04-1.06
Asthma severity		
No	ref	
Yes	1.62	1.51-1.74

Note. GEE Poisson model adjusted for age in years at first visit, sex, insurance type, visits per year, ethnicity, albuterol use, inhaled glucocorticoids per year, asthma severity, and state. CI: confidence interval.

of oral steroid prescription. Latino children who were overweight/obese at all visits had a 21% higher rate of oral steroid prescription. These increases were not observed in non-Hispanic white children with non-persistent asthma or in any children who had persistent asthma. None of the interactions evaluating ethnicity disparities were significant in stratified models.

Discussion

We studied whether overweight/obesity across multiple clinic visits was associated with higher rates of oral steroid prescription in children with asthma, with special attention to identifying disparities in medication prescription between Latino and non-Hispanic white children. This study innovatively leveraged EHR data and CHC patient populations to inform delivery of asthma care among vulnerable populations, namely low-income and minority children.

We found that children identified as being overweight or obese received more prescriptions for oral steroid medications for asthma control than children who were not overweight or obese. Taken as an indication of condition severity and management, the

elevated reliance on oral steroid medications among overweight children suggests that these patients may have worse outcomes and may have suboptimal management of asthma symptoms. Untreated asthma can lead to other adverse, acute and chronic, health outcomes. Furthermore, uncontrolled asthma can limit physical activity, which in turn may drive weight gain, and finally, worsen resting asthma symptoms in a negatively enforcing cycle. This finding is consistent with previous research, as asthma is often less effectively controlled in children with overweight and obesity than in healthy weight children, often due to decreased response to inhaled glucocorticoids (33–35). It is unclear why inhaled glucocorticoids do not work as well in obese patients as in patients who are at a healthy weight, although it is believed that systemic inflammation resulting from obesity may alter the function of the medication. Additionally, hormones produced by adipose tissue, such as leptin, may play a role in the differences in asthma control in those who are obese compared to those who are lean (4,7,34). Also, pressure on the chest and airways from excess weight can also contribute to decreased lung function and difficulty breathing (1,34).

However, this study augments the state of the literature on obesity and asthma in children by demonstrating a concrete, objectively measured outcome that differs by weight.

Although an increase in oral steroid medication was seen among Latino children in our population who were sometimes or always overweight/obese at clinic visits while controlling for confounding variables, contrary to our hypothesis, we did not find a significant difference in the number of oral steroid prescriptions between Latino and non-Hispanic white children with asthma during the study period. The CHCs in the ADVANCE CDRN are required to provide care regardless of a patient's ability to pay (23), which may be a factor in eliminating health disparities overall. When access to care is improved, outcomes can also improve. One study found fewer racial/ethnic disparities in utilization of health care among children who received preventive care from CHCs compared to trends in health care use nationally (36). Moreover, reduced disparities in obtaining health care services have been shown in CHCs (37–39).

The majority of children in this study had public insurance. However, we found that children who never had health insurance had significantly more oral steroid prescriptions than children who had public and/or private insurance. Cost may factor into medication choices; while patients without health insurance

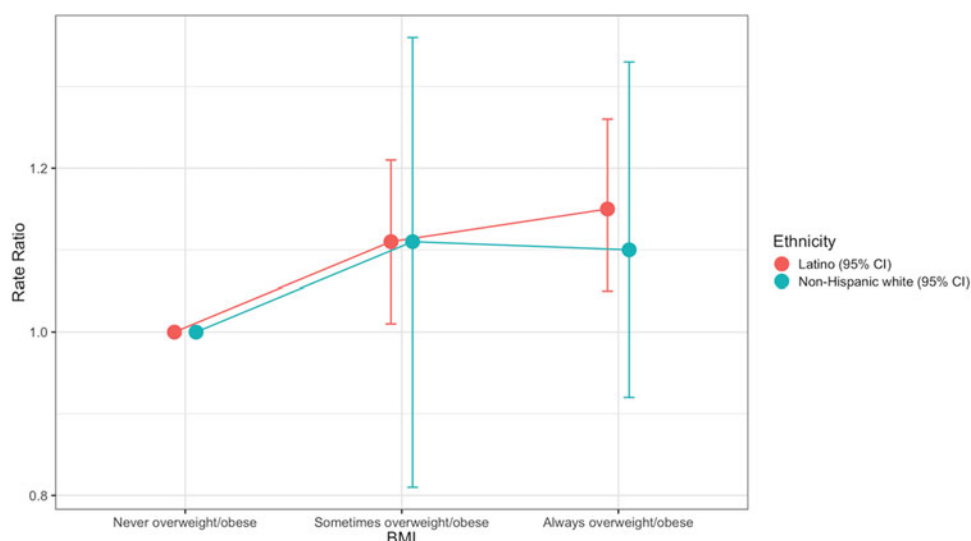


Figure 1. Rate ratios of the association between weight and oral steroid use by ethnicity. Model adjusted for age at first visit, sex, insurance type, visits per year, ethnicity, albuterol use, inhaled glucocorticoids per year, asthma severity, and state. Reference group is never overweight/obese. Interaction between sometimes overweight/obese and ethnicity $p = 0.95$. Interaction between always overweight/obese and ethnicity $p = 0.58$. CI: confidence interval.

can go to CHCs for care, inhaled steroid medication for asthma control is expensive, especially out of pocket. Pharmacy expenditures have been found to be more than three times higher for children with asthma than those without asthma (40). Although 43 state Medicaid programs had coverage for controller medications as of 2017, only nine state Medicaid programs covered all controller medications, meaning even among patients with public insurance regular coverage of asthma medication is not assured (41). Asthma controller medication adherence among Federally Qualified Health Center patients has been found to be low even when medication is offered at reduced cost (42). With reduced access to medications that would properly manage their asthma between visits, uninsured children may present with more severe asthma symptoms, prompting providers to prescribe more intense treatment at the point of contact.

The increased rate of oral steroid prescriptions among overweight Latino children with non-persistent asthma, not observed in other groups, suggests patient weight becomes more of a factor for determining treatment options when patients have only occasional asthma symptoms. Persistent asthma may uniquely signify asthma severity and (lack of) management to providers, despite a patient's weight, thus prompting more intense treatment; or it may serve to encourage better control by patients. It is also notable that this relationship was only observed for Latino children. Nonetheless, the differences in oral steroid prescriptions among patients with different asthma symptom frequency deserves more investigation.

This study had a number of limitations. The data was solely from primary care clinics and a lack of hospital or emergency department data means that we have likely missed oral steroid prescriptions in this population as these medications are often given in emergency situations. Additionally, some inhaled steroid prescriptions may be refilled up to 12 times, so one prescription a year could actually represent one refill per month, and this number should be interpreted cautiously. We were able to determine that prescriptions were ordered but could not confirm if those prescriptions were filled without pharmacy data. Further exploration into controller medication adherence in this population also may be warranted. Some children may have received glucocorticoids for rare rheumatologic or inflammatory conditions, the diagnoses of which were not present in our dataset, although even if present, these would be unlikely to affect our analysis given their infrequency in the general population. Additionally, this analysis was cross-sectional and cannot estimate causal relationships. We showed that there was a relationship between weight and treatment for asthma severity in children, but it is unclear whether the weight itself exacerbates asthma symptoms (or vice versa) or whether it negatively impacts the ability to manage asthma, which then leads to worse asthma outcomes and further weight gain over time. Further investigations could include additional race/ethnicity groups (e.g. non-Hispanic black children, etc.); our study focused on Latino children because of the unique possible barriers to care in this population.

Conclusions/key findings

We used EHR data to examine a large population ($N = 16\,763$) of vulnerable CHC patients with asthma in order to study the rates of oral steroid prescription in relation to weight status. We observed increases among Latino children with overweight and obesity compared to Latino children without overweight and obesity, but did not find ethnic differences in oral steroid use between obese Latino and non-Hispanic white children. Our findings indicate that children with comorbid asthma and overweight or obesity have poorer asthma control than children who have always been healthy weight, and they may require more attentive treatment to provide quality asthma care.

Acknowledgements

The research reported in this manuscript was conducted with the ADVANCE (Accelerating Data Value Across a National Community Health Center Network) Clinical Research Network, a partner of PCORnet®, the National-Patient Centered Clinical Network, an initiative of the Patient Centered outcomes Research Institute (PCORI). The ADVANCE network is led by OCHIN in partnership with the Health Choice Network, Fenway Health, Oregon Health and Science University, and the Robert Graham Center/Health Landscape. ADVANCE is funded through PCORI award number 13–060-4716.

Declaration of interest

The authors have no conflicts of interest to disclose.

Funding

This work was supported by the NIH National Institute on Minority Health and Health Disparities under grant number R01MD011404; and the National Institute on Drug Abuse under grant number K23-DA037453.

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Appendix

Table A1. Variable definitions.

Metric	Method	Areas of EHR included in search
Asthma diagnosis	Asthma diagnosis was determined by having a diagnosis encounter or problem list encounter with dx_cat (diagnosis category) of either "Disease Classification" or "General Asthma Dx." Problem list encounters were subset to diagnoses provided in a healthcare context to eliminate the self-reported asthma encounters	Diagnosis list, Problem list
Body mass index (BMI) assessment	BMI and BMI percentile were calculated at the encounter level using the 'chiltsds' package in R based on age, sex, weight, and height. Overweight was calculated as BMI over the 85 th percentile at a given encounter and obese was calculated as over the 95 th percentile at a given encounter. Biologically implausible values were flagged as over 8 standard deviations over or 4 under the mean BMI. To measure at the patient level, encounter level data was reduced to never, sometimes, or always mutually exclusive categories for both overweight and obese	BMI table
Medication administration	Type of administration was first categorized based on prescription unit where: chewable tablet, disintegrating tablet, extended release capsule, extended release tablet, oral capsule, oral tablet, oral solution, oral strip, oral suspension, and granules corresponded to swallowed ingestion, injectable solution, injectable suspension, and prefilled syringe corresponded to injected, inhalant powder, metered dose inhaler, oral powder, and oral spray corresponded to inhaled and nasal corresponded nasal. If a route of administration was not determined in the first round, a text search was performed connecting the keywords: tablets, capsules, and granules to swallowed, suspension, injection, and syringe to injected, inhaler, nebulizer, and spray to inhaled and nasal to nasal	Medication list
Medication category	Medication names were reduced by removing words shorter than 5 characters and common after cleaning the most frequent abbreviations, and the remaining medication keyword combinations were reviewed by the PI physician and categorized into one of seven categories: albuterol/rescue inhaler, inhaled corticosteroid, oral steroid, other inhaler, other non-inhaler, peak air meter, and remove. The medications included in this study were oral glucocorticoids, inhaled glucocorticoids, and albuterol (Table A2)	Medication category
Persistent asthma diagnosis	Asthma severity diagnosis was determined by dx_cat (diagnosis category) of "Disease Classification." ICD codes were used to determine asthma severity: Mild intermittent asthma, uncomplicated (J45.20), with (acute) exacerbation (J45.21), with status asthmaticus (J45.22); Mild persistent asthma, uncomplicated (J45.30), with (acute) exacerbation (J45.31), with status asthmaticus (J45.32); Moderate persistent asthma, uncomplicated (J45.40), with (acute) exacerbation (J45.41), with status asthmaticus (J45.42); and Severe persistent asthma, uncomplicated (J45.50), with (acute) exacerbation (J45.51), with status asthmaticus (J45.52) Mild intermittent asthma was classified as "not persistent", and mild persistent, moderate persistent, and severe persistent asthma were classified as "persistent" asthma	Diagnosis list, Problem list

Table A2. Medications.

Oral glucocorticoids	Inhaled glucocorticoids	Albuterol/rescue inhalers
Dexamethasone	Beclomethasone	Albuterol
Methylprednisolone	Betamethasone	Levalbuterol
Prednisolone	Budesonide	Formoterol
Prednisone	Ciclesonide	Pirbuterol
	Dexamethasone	Metaproterenol
	Flunisolide	
	Fluticasone	
	Mometasone	
	Prednisolone	
	Triamcinolone	

Table A3. Sensitivity analyses—stratified by number of visits and asthma severity.

	Rate ratio	95% CI
Visits, ≤ 2		
Hispanic never overweight/obese	ref.	
Hispanic sometimes overweight/obese	1.19	0.99-1.43
Hispanic always overweight/obese	1.08	0.93-1.26
Non-Hispanic white never overweight/obese	ref.	
Non-Hispanic white sometimes overweight/obese	1.33	0.96-1.83
Non-Hispanic white always overweight/obese	1.19	0.91-1.54
Visits, 3–6		
Hispanic never overweight/obese	ref.	
Hispanic sometimes overweight/obese	1.09	0.97-1.24
Hispanic always overweight/obese	1.09	0.97-1.23
Non-Hispanic white never overweight/obese	ref.	
Non-Hispanic white sometimes overweight/obese	1.24	0.97-1.59
Non-Hispanic white always overweight/obese	1.10	0.87-1.39
Visits, seven or more		
Hispanic never overweight/obese	ref.	
Hispanic sometimes overweight/obese	1.24	0.93-1.67
Hispanic always overweight/obese	1.16	0.85-1.59
Non-Hispanic white never overweight/obese	ref.	
Non-Hispanic white sometimes overweight/obese	0.88	0.44-1.77
Non-Hispanic white always overweight/obese	1.52	0.83-2.78
Persistent asthma		
Hispanic never overweight/obese	ref.	
Hispanic sometimes overweight/obese	1.02	0.86-1.20
Hispanic always overweight/obese	1.00	0.84-1.19
Non-Hispanic white never overweight/obese	ref.	
Non-Hispanic white sometimes overweight/obese	1.15	0.80-1.66
Non-Hispanic white always overweight/obese	1.09	0.78-1.54
No persistent asthma		
Hispanic never overweight/obese	ref.	
Hispanic sometimes overweight/obese	1.15	1.03-1.28
Hispanic always overweight/obese	1.21	1.09-1.34
Non-Hispanic white never overweight/obese	ref.	
Non-Hispanic white sometimes overweight/obese	1.11	0.91-1.36
Non-Hispanic white always overweight/obese	1.08	0.90-1.30

Note. All GEE Poisson models for Visits adjusted for age in years at first visit, sex, insurance type, ethnicity, albuterol use, inhaled glucocorticoids per year, and asthma severity. GEE Poisson model for Persistent asthma adjusted for age in years at first visit, sex, insurance type, visits per year, ethnicity, albuterol use, and inhaled glucocorticoids per year. GEE Poisson model for No Persistent asthma adjusted for age in years at first visit, sex, insurance type, visits per year, ethnicity, albuterol use. CI: confidence interval.