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Disparities in emergency department visits in American children with asthma: 2006–2010

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ABSTRACT

Objective: This article was to examine the trends in emergency department (ED) visits for asthma among American children in 2006–2010 across sociodemographic factors, parental smoking status, and children's body weight status. **Methods:** We analyzed 5,535 children aged 2–17 years with current asthma in the Asthma Call-Back Survey in 2006–2010. Multivariate log binomial regression was used to examine the disparities of ED visits by demographics, socioeconomic status, parental smoking status, children's body weight status, and the level of asthma control. We controlled for average state-level air pollutants. Prevalence ratios (PRs) and 95% confidence intervals (CIs) were reported. **Results:** Minority children with current asthma had higher risks of ED visits compared with white children in 2009 and 2010, e.g., the PR (95% CI) for black children in 2009 was 3.64 (1.79, 7.41). Children who had current asthma and more highly educated parents experienced a higher risk of ED visits in 2007 (PRs [95% CI] = 2.15 [1.02, 4.53] and 2.97 [1.29, 6.83] for children with some college or college-graduated parents), but not significant in other years. Children with uncontrolled asthma were significantly more likely to visit the ED in 2008 (PRs [95% CI] = 2.79 [1.44, 5.41] and 6.96 [3.55, 13.64] for not-well-controlled and very poorly controlled children with asthma). **Conclusions:** Minority children with current asthma or children with uncontrolled asthma were more likely to visit EDs for asthma treatment. However, the disparities in ED visits across sociodemographics, health status, or asthma control vary in scale and significance across time. More research is needed to explain these differences.

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Introduction

Asthma exacerbations accounted for 1.8 million emergency department (ED) visits in 2011 and 439,000 hospital admissions in 2010 [1]; they were the number one condition resulting in hospital admission after ED visits among children aged 0–17 years in 2011 [2]. Asthma is a common chronic lung disease affecting persons of all ages and is characterized by episodic and reversible attacks or exacerbations of wheezing, breathlessness, chest tightness, and coughing [3, 4]. Although asthma cannot be cured, symptoms can be controlled with appropriate medical treatment, self-management education, and avoiding exposure to environmental irritants and allergens [5]. Poor asthma control is associated with increased ED visits, hospital inpatient admissions, and significant medical costs [6]. In 2007, the annual estimated total economic cost to society from asthma was \$56 billion, including \$50.1 billion for medical expenses, \$3.8 billion for loss of productivity resulting from missed school and work days, and \$2.1 billion for premature death [7].

Extensive evidence documents the significant differences in asthma prevalence by age, sex, race/ethnicity, and socioeconomic status (SES), with minority and low-income groups in the United States being disproportionately affected [8–14]. Minority children who live in low socioeconomic urban environments experienced higher asthma prevalence, morbidity, and mortality rates than white children [15]. Younger maternal age, residence in the center of cities, lower family income, lower birth weight, and being obese were associated with increased asthma prevalence among black children compared with white children [16]. In the period of 2008–2010, asthma prevalence was greater among children (9.6%) than adults (7.7%) and was especially high among boys (11.3%) and non-Hispanic black children (17.0%) [17]. Two recent publications have documented the trends in racial/ethnic disparities in asthma prevalence in adults and children [13, 18]. One study in 2008 used data from 1993 to 2005 to examine the trends in racial disparities in ED visits among patients with asthma in all age groups [19]. However, since 2008, no studies have ever been conducted on the trends

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in ED visit disparity or examined these disparities across SES, health behaviors/statuses, and asthma control among children with asthma.

To fill in this significant knowledge gap, we used national data to examine the disparities in ED visits among children with asthma by gender, race/ethnicity, household income, parental education, health statuses, and level of asthma control. We tested the hypothesis whether these disparities in ED visits among children with asthma vary across time. The knowledge obtained can help us understand the disparities of poor asthma control in certain sociodemographic groups, who may then consume more medical resources in the ED. Without precise information on the scale of the disparities in ED visits among children with asthma and the trends in these disparities, no responsive interventions can be designed and implemented to promote health equity.

In this paper, we used the Asthma Call-Back Survey (ACBS) data, part of the annual nationally representative Behavioral Risk Factor Surveillance System (BRFSS), to examine the trends in ED visit disparities among children with current asthma.

Methods

Data

Current asthma and ED visit data

The BRFSS is an annual telephone survey of noninstitutionalized American adults aged 18 years or older [20] and was used in the recent publication on trends in asthma prevalence in the United States [13]. The BRFSS has been conducted cooperatively by the states and the Centers for Disease Control and Prevention (CDC) since 1984, providing national and state-level representative data on health behaviors, chronic health conditions, and the use of health care services. A multistage, disproportionate stratified sample design was employed by the BRFSS consistently across the years. After telephone numbers were randomly selected, computer-assisted telephone interviews were conducted by trained professionals in each state. Currently, the BRFSS interviews approximately 400,000 subjects annually and is the largest health survey in the world [20].

To estimate the lifetime and current asthma burden among American children, the BRFSS has added a Childhood Asthma Module to the survey since 2005 that selects a child randomly in the household. The child's adult caregiver answers questions regarding the selected child about whether the child has ever been diagnosed with asthma and currently has asthma. If ever diagnosed with asthma, interviewers will call back in approximately 2 weeks to conduct the ACBS, including in-depth

questions about health status and health care usage of children with asthma.

The Childhood Asthma Module and the ACBS module were pilot tested in 2005 and have expanded to other states since 2006 [21]. Our study period was from 2006 to 2010. Although more recent ACBS data are available from 2011 to 2013, we ended the analyses in 2010 because of the following reasons: First, the BRFSS made two critical changes in sampling method, adding cell-phone-only respondents into the sampling frame in selected states in 2011 and into the frame for all states in 2012–2013. Second, the number of states participating in the ACBS decreased significantly from 35 in 2010 to 14, 10, 10, in 2011, 2012, and 2013, respectively, which reduced the sample size significantly. We conducted extensive scenario analyses and concluded that the data prior to 2010 are not comparable with those in 2011 or in 2012–2013, so a trend analysis using data from 2011 to 2013 is not feasible. This is also consistent with the CDC's guideline not to compare the data prior to 2011 with the more recent data in 2011–2013 [22]. Since very few states participated in the ACBS every year, we included 15 states in the analyses that participated in at least four of the five ACBS surveys and account for 42.7% of all ACBS children: Connecticut, Georgia, Hawaii, Indiana, Kansas, Maine, Maryland, Massachusetts, Michigan, Montana, Nebraska, New York, Texas, Utah, and Vermont. Our trend analyses indicated that the samples from these states were comparable across years (see the results and Table 1). In summary, the ACBS data provide valuable information for examining the disparities in ED visits for asthma treatment among children in 2006–2010.

Air quality data

The air quality can trigger or exacerbate asthma and lead to possible ED visits. The concentration of particulate matter (PM₁₀) and ozone (O₃) has been positively linked to asthma-related ED visits and hospital admissions [23, 24], decreased lung function [25–28], and fatalities from respiratory diseases [29]. We used the Air Trends Data issued by the US Environmental Protection Agency [30], which measures five common air pollutants or criteria pollutants: carbon monoxide (CO), ozone (O₃), nitrogen dioxide (NO₂), particulate matter, and sulfur dioxide (SO₂). Since the asthma ED visits in the ACBS were based on the last 12 months, we used the average state-level pollutant data for the last year.

Measurements

Outcome variables

An ED visit status was recorded in the survey based on the answer to the survey question “During the past

Table 1. Descriptive statistics of children in asthma call-back survey in 2006–2010[†].

Year	2006	SE	2007	SE	2008	SE	2009	SE	2010	SE	2006–2010	SE	P _{trend} ^{††}
N	1,033		1,131		1,201		1,238		932		5,535		
Age in months (Median)	132		140		141		143		141		141		
Gender (%)													
Male	59.9	3.3	59.1	2.7	55.7	2.9	56.9	3.1	53.8	3.4	57.3	1.4	0.27
Race (%)													
White	53.8	3.6	58.3	2.8	52.1	2.9	57.0	3.4	57.6	3.6	55.4	1.5	0.62
Black	15.8	3.1	14.2	2.1	16.9	2.3	20.6	3.1	20.1	3.8	17.2	1.3	0.11
Hispanic	22.7	3.7	14.5	2.0	17.4	2.5	17.3	3.0	13.5	2.2	17.5	1.4	0.15
Income (%)													
<\$35,000	43.1	3.9	35.4	2.7	33.7	3.0	34.3	3.2	34.4	3.8	36.2	1.5	0.08
\$35,000–\$75,000	29.0	3.0	31.6	2.5	29.9	2.5	25.0	2.6	26.6	3.0	28.5	1.2	0.22
>\$75,000	28.0	2.7	33.0	2.6	36.3	2.7	40.7	3.0	38.9	3.2	35.3	1.3	0.001
Education (%)													
≤HS grad	35.3	3.6	32.3	2.6	29.3	2.7	29.3	3.0	27.6	2.7	30.7	1.4	0.08
Some college	32.1	3.4	26.0	2.4	26.0	2.4	29.4	3.0	31.4	3.5	28.6	1.3	0.94
College graduate	32.6	2.9	41.7	2.6	44.7	2.8	41.3	3.0	41.1	3.2	40.7	1.4	0.09
Parental smoking (%)													
Yes	45.2	3.6	41.6	2.7	41.0	2.9	37.4	3.0	38.9	3.1	40.9	1.4	0.11
Child's body weight status (%)													
Normal	54.4	3.6	58.1	2.9	58.8	2.9	59.9	3.4	57.5	3.4	58.0	1.5	0.46
Overweight	15.7	2.4	15.4	2.2	16.1	2.0	15.9	2.5	14.0	2.1	15.5	1.0	0.74
Obese	29.9	3.7	26.5	2.6	25.1	2.5	24.3	3.0	28.5	3.1	26.5	1.4	0.59
Asthma control													
Well controlled	50.0	4.6	53.8	3.2	47.5	3.5	58.4	3.7	53.5	4.2	53.0	1.8	0.37
Not well controlled	34.3	4.4	28.9	2.7	35.8	3.5	29.1	3.3	31.7	3.7	31.9	1.7	0.71
Very poorly controlled	15.7	2.6	17.3	2.5	16.7	2.5	12.4	2.1	14.8	2.6	15.1	1.1	0.36

[†]Selected states: CT, GA, HI, IN, KS, ME, MD, MA, MI, MT, NE, NY, TX, UT, VT; ^{††}p-value: Significance of year-wise difference.

12 months, has {child's name} had to visit an emergency room or urgent care center because of {his/her} asthma?" This outcome measures one or more ED visits in the past 12 months but does not count ED visits or specify a single ED visit. Since the ED visit in the last 12 months was only related to children with current asthma, we only included children who were reported to still have asthma at the time of the interview. Since ED visits for children younger than two years could be more heterogeneous, we only included children aged 2 years or above.

Confounding variables

Age, gender, race/ethnicity, insurance status, parental education, parental smoking behavior, and income group were controlled. Race/ethnicity was categorized as "non-Hispanic whites," "non-Hispanic blacks," "Hispanics" and "Other." Parental education was classified as "≤ high school," "some college," and "≥ college graduate." Household income groups were created as "<\$35,000," "\$35,000–\$75,000," and "≥\$75,000." For convenience, we labeled these incomes as low-, middle-, and high-income levels. Parental smoking behavior ("current smoker or not") and the child's body weight status (normal, overweight, or obese) were also added as controls for health behaviors and indicators of general health. Overweight and obesity were defined as body mass index ≥ 85th and 95th percentile of the sex-specific BMI-for-age growth chart [3].

Level of asthma control

We used the three-level classification (well controlled, not well controlled, and very poorly controlled) developed by the CDC, which was based on daytime symptoms, night-time awakenings in the past 30 days, and use of short-acting β_2 -agonists (SABA) for symptom control [32, 33]. Based on daytime symptoms, the level of asthma control (well/not well/very poorly) controlled was defined as ≤2 day/week, >2 day/week, and throughout the day, respectively. Based on the SABA used, well/not well/very poorly controlled were defined as ≤2 day/week, >2 day/week, and several times/day, respectively. The cut-off points for the classification were more complicated if nighttime awakenings were used. More details can be found in Zahran et al. (2014, 2015) [32, 33].

Statistical analysis

Our analysis took into account the complex survey design of the BRFSS/ACBS. We calculated the descriptive statistics in each year and then for pooled data. Due to various sample sizes and sampling weights across years, we reweighted the pooled data following the CDC's guideline [34]. We then estimated the prevalence of ED visits in each subgroup in each year as well as in the entire study period. We conducted multivariate log binomial regression to examine the associations between ED visits and explanatory variables across years while controlling state-level air pollution. Prevalence ratios (PR) and

95% confidence interval (95% CI) were reported. We also applied the logistic regression using the binary ED visit status as the outcome variable and the year as the explanatory variable to test whether the risk of ED visit significantly varied across time. *p*-values for the trends were provided (*p* < 0.05 considered significant). All analyses were conducted with Stata 11.

Results

Our analytical sample included 5,535 children aged 2–17 years with current asthma in the ACBS for 2006–2010 (Table 1). The median age of these children with current asthma was 141 months. 57.3% of them were boys, and 55.4% of them were white. Slightly more than one-third of them were in either low-income or high-income groups. There were more children with college-educated parents than with less educated parents ($\leq$ high school). Approximately 40.9% of these children's parents smoked. The overweight and obesity rates in children with asthma were 15.5% and 26.5%, respectively. Except for the percentage of high-income groups, all the other descriptive characteristics were not statistically different across years ($P_{\text{trend}} > 0.05$), which indicates that our samples were comparable across years in the study period.

ED visit rates vary across groups (Table 2). Boys had higher ED visit rates than girls, except in 2008 and 2010. Whites had the lowest ED visit rates among all race/ethnic

groups consistently across time. Low-income children had the highest ED visit rates across income groups in all years except 2009, and the ED visit rates for high-income children were significantly lower than those of low-income children in 2006, 2007, and 2010. The disparity of ED visit rates across parental education was much smaller than that across income groups. The ED visit rates of children with parents having some college education were very similar to the rates of children with high school-educated parents, except in 2006. Statistical significance across education was only achieved in 2010 in the college-educated parent group (*p* < 0.05). Well-controlled children had the lowest prevalence rates of ED visits consistently across the years. However, only in 2008 were the disparities across the levels of asthma control statistically significant. In the pooled analyses, minority, low-income, and not-well-controlled children were significantly higher in ED visits than the reference groups. No significant trend changes in prevalence of ED visits were detected in each subgroup (all $P_{\text{trends}} > 0.05$).

After controlling multiple confounding factors, disparities in ED visits still existed (Table 3). The significant PRs were mostly found across race/ethnic group, parental education, body weight status, and level of asthma control. The PRs of black and Hispanic children were all greater than 1. The prevalence of visiting the ED among black children in 2006 was 2.72 times (95% CI: 1.08, 6.88), and in 2009, it was 3.64 times (95% CI: 1.79, 7.41) more than

Table 2. Percentage of ER visits (standard errors) among asthmatic children in ACBS 2006–2010[†].

Year	2006	2007	2008	2009	2010	2006–2010	<i>P</i> _{trend}
Gender							
Boys (ref)	21.2 (4.3)	18.0 (2.7)	13.1 (2.4)	20.5 (2.9)	22.7 (3.7)	18.7 (1.5)	0.92
Girls	17.9 (6.1)	10.9 (2.2)	19.6 (4.3)	15.1 (3.5)	25.1 (7.0)	17.6 (2.2)	0.63
Race/ethnicity							
White (ref)	14.0 (3.1)	10.4 (1.5)	10.7 (1.7)	13.4 (2.3)	15.5 (2.6)	12.3 (1.0)	0.56
Black	30.5 (8.8)	19.4 (6.3)	23.6 (5.7) ^{*††}	23.5 (6.2)	46.1 (12.1) ^{**}	27.4 (3.7) ^{***}	0.43
Hispanic	26.4 (11.4)	24.7 (6.5) ^{**}	15.0 (6.4)	26.2 (8.1)	23.2 (7.9)	24.4 (4.6) ^{**}	0.78
Income							
Low income (ref)	26.5 (6.9)	25.4 (4.3)	21.1 (5.5)	23.4 (4.8)	38.2 (8.4)	26.6 (2.9)	0.85
Middle income	20.8 (6.1)	11.3 (3.0) ^{**}	16.5 (4.2)	24.0 (5.1)	27.5 (6.8)	18.7 (2.2) [*]	0.21
High income	11.9 (3.1) [*]	9.0 (2.1) ^{***}	10.9 (2.7)	12.7 (2.8)	8.4 (2.4) ^{***}	10.8 (1.3) ^{***}	0.97
Education							
$\leq$ HS grad (ref)	26.5 (7.5)	17.3 (3.8)	15.0 (3.3)	18.3 (4.4)	29.8 (5.8)	21.1 (2.7)	0.80
Some college	16.4 (4.6)	16.7 (4.0)	17.7 (4.2)	18.9 (3.9)	30.3 (9.1)	19.1 (2.4)	0.22
College graduate	15.7 (4.8)	12.4 (2.3)	15.6 (4.2)	18.0 (3.4)	14.8 (4.2) [*]	15.4 (1.8)	0.83
Parental smoking							
Non-smokers (ref)	17.0 (3.8)	15.9 (2.5)	16.5 (3.1)	17.5 (2.7)	23.6 (5.6)	17.7 (1.6)	0.56
Smokers	23.6 (6.2)	13.9 (2.8)	15.1 (3.6)	19.6 (3.8)	24.1 (4.6)	19.1 (2.2)	0.96
Child's body weight status							
Normal weight (ref)	20.8 (5.1)	13.7 (2.4)	16.1 (3.9)	13.6 (2.6)	24.7 (6.7)	17.3 (1.9)	0.91
Overweight	16.2 (7.4)	14.1 (1.6)	15.7 (4.7)	24.2 (8.6)	12.1 (4.1)	14.9 (3.1)	0.33
Obese	13.8 (3.7)	19.9 (4.4)	13.9 (3.6)	24.8 (5.7)	26.2 (5.7)	18.8 (2.1)	0.06
Asthma control							
Well controlled (ref)	18.5 (5.5)	14.3 (3)	15.0 (4.8)	17.9 (3.7)	23.2 (8.1)	17.4 (2.2)	0.78
Not well controlled	32.3 (9.8)	19.0 (4.3)	21.0 (5.5) [*]	21.5 (3.9)	30.3 (6.5)	25.2 (3.5) [*]	0.63
Very poorly controlled	33.0 (7.1)	23.4 (6)	40.6 (7.8) ^{***}	32.4 (8.3)	40.3 (10.2)	32.9 (3.5) ^{***}	0.33

[†]Selected states: CT, GA, HI, IN, KS, ME, MD, MA, MI, MT, NE, NY, TX, UT, VT.

^{††}*p*-values were generated from bivariate logistic regression; **p* < 0.05; ***p* < 0.01; ****p* < 0.001.

Table 3. Prevalence Ratios and 95% Confidence Intervals of ER Visits among Asthmatic Children in 2006–2010[†].

Year	2006 PR (95% CI)	2007 PR (95% CI)	2008 PR (95% CI)	2009 PR (95% CI)	2010 PR (95% CI)	2006–10 PR (95% CI)
Gender						
Male	Ref	Ref	Ref	Ref	Ref	Ref
Female	0.55 (0.24, 1.24)	0.88 (0.52, 1.50)	0.79 (0.45, 1.40)	1.04 (0.51, 2.10)	0.80 (0.48, 1.33)	0.84 (0.60, 1.18)
Race/ethnicity						
White	Ref	Ref	Ref	Ref	Ref	Ref
Black	2.72 (1.08, 6.88)^{††}	1.18 (0.51, 2.75)	1.67 (0.87, 3.19)	3.64 (1.79, 7.41)^{††}	1.55 (0.75, 3.21)	2.04 (1.37, 3.03)^{††}
Hispanic	1.43 (0.56, 3.69)	2.32 (0.99, 5.39)^{††}	2.06 (1.03, 4.10)^{††}	4.94 (2.35, 10.38)^{††}	1.01 (0.41, 2.53)	2.20 (1.44, 3.36)^{††}
Income						
Low Income	Ref	Ref	Ref	Ref	Ref	Ref
Mid-Income	0.94 (0.35, 2.52)	0.42 (0.2, 0.9)	1.94 (0.96, 3.92)	1.44 (0.72, 2.85)	0.59 (0.28, 1.27)	0.89 (0.58, 1.34)
High Income	0.40 (0.09, 1.67)	0.31 (0.15, 0.65)	1.03 (0.40, 2.64)	1.02 (0.42, 2.48)	0.22 (0.07, 0.69)	0.47 (0.28, 0.8)
Education						
≤ HS grad	Ref	Ref	Ref	Ref	Ref	Ref
Some College	0.73 (0.28, 1.91)	2.15 (1.02, 4.53)^{††}	0.56 (0.24, 1.31)	0.82 (0.38, 1.79)	1.71 (0.83, 3.53)	1.08 (0.71, 1.64)
College Grad	1.28 (0.45, 3.62)	2.97 (1.29, 6.83)^{††}	0.79 (0.41, 1.52)	1.60 (0.72, 3.55)	1.76 (0.71, 4.34)	1.50 (0.93, 2.42)
Smoking						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.88 (0.43, 1.82)	0.90 (0.55, 1.47)	1.07 (0.61, 1.88)	0.89 (0.44, 1.79)	1.62 (0.96, 2.74)	0.90 (0.63, 1.28)
Child's Body Weight Status						
Normal	Ref	Ref	Ref	Ref	Ref	Ref
Overweight	0.39 (0.10, 1.44)	0.30 (0.08, 1.11)	2.12 (0.96, 4.68)	1.67 (0.62, 4.53)	0.21 (0.07, 0.61)	0.75 (0.42, 1.36)
Obese	0.33 (0.12, 0.95)^{††}	1.28 (0.72, 2.26)	1.00 (0.50, 2.04)	1.03 (0.58, 1.84)	0.68 (0.34, 1.34)	0.79 (0.55, 1.14)
Asthma Control						
Well Controlled	Ref	Ref	Ref	Ref	Ref	Ref
Not Well Controlled	1.53 (0.68, 3.42)	1.66 (0.90, 3.09)	2.79 (1.44, 5.41)^{††}	0.75 (0.38, 1.48)	0.82 (0.44, 1.53)	1.35 (0.95, 1.93)
Very Poorly Controlled	1.35 (0.59, 3.07)	1.75 (0.66, 4.62)	6.96 (3.55, 13.64)^{††}	1.75 (0.84, 3.64)	0.97 (0.31, 3.01)	1.73 (1.14, 2.62)^{††}

[†] State level air pollutants were controlled, including standardized values of CO, ozone, NO₂, particulate matters, and SO₂.

^{††} P < 0.05.

that among white children. The PR of visiting the ED among Hispanics peaked in 2009 (PR = 4.94; 95% CI: 2.35, 10.38). There were no significant protective effects of income. Children with more highly educated parents were significantly more likely to visit the ED in 2007 (PRs for some college and college graduate parent groups were 2.15 [95% CI: 1.02–4.53] and 2.97 [95% CI: 1.29–6.83], respectively). The PR of ED visits in obese children was significantly smaller than 1 in 2006 (PR = 0.33, 95% CI = 0.12, 0.95). Compared with well-controlled children with asthma, not-well-controlled and very-poorly-controlled children with asthma had PRs over 1 in 2006–2008, while the PRs in 2008 were highly significant (2.79 and 6.96 for not-well-controlled and very-poorly-controlled children, respectively). However, the PRs in 2009 and 2010 were not statistically different from 1 in not-well-controlled and very-poorly-controlled children. In the pooled analyses, minority children and children with very poor control had a significantly higher prevalence of ED visits than white children and those who were well controlled. Three air pollutants, carbon monoxide (CO), ozone (O₃), and nitrogen dioxide (NO₂), had a significant relationship with ED visits in 2010, but not in other years.

In summary, we observed a higher risk of ED visits in minority children or children with poor control of asthma. However, the prevalence of ED visits could be

higher within higher-education groups or normal-weight groups at certain times. The scale and the significance of the disparities in ED visits vary across time.

Discussion

This study not only confirmed the existing racial/ethnic disparities in ED visits found in the all-ages 2008 study [19], but provided a few new notable points: First, the disparities in ED visits across household income levels were not significant after controlling other confounding factors, but the disparities in ED visits across parental educations were significant. Second, we observed disparities in ED visits across asthma control groups, but they were only significant in selected years. Third, all these disparities in ED visits among asthmatic children, including the most persistent disparity across race/ethnicity, vary across time in both significance and scale.

The significant disparities in ED visits are disturbing since most ED visits for asthma are preventable by proper chronic disease management, namely, if health care providers and patients follow the standard protocols such as the National Asthma Education and Prevention Program (NAEPP) guidelines [19, 35]. Two potential factors may explain the disparities in ED visits. First, children

with varying sociodemographic factors may have varying and disproportional exposure to environment hazards, such as living in households with poor air quality, e.g., dust, or with proximity to an air pollution source, e.g., highways [36, 37]. The other possible explanation is a disparity in access to health care across race/ethnicity [38, 39]. More importantly, even with the same access to regular health care, the disparities in access to preventive and specialist care for asthma patients may still exist across race/ethnicity [41]. For example, the lower number of inhaled corticosteroid prescriptions for minority children could indicate poorer long-term management of asthma.

Compared with research on racial/ethnic disparities in ED visits among children with asthma, less evidence was available regarding socioeconomic disparities, most of which were about adult asthma patients. For example, there were clear inverse gradients between income levels, prevalence, and ED visits among adults with asthma [13, 42]. Interestingly, these two studies used different national datasets but documented the same findings regarding the educational disparities in asthma prevalence: Populations with some college had a greater risk of asthma compared with lower educational groups. Our study complements this literature and adds two new findings: First, the socioeconomic-linked disparities of ED visits among children with current asthma can vary from year to year. In certain years, the disparities may not be statistically significant. No significant disparities in ED visits were found across household incomes, while children with less-educated parents may not have similar risks and sometimes may have a lower risk of ED visits. The underlying educational level across parents may trigger different health care usage behaviors among parents during pediatric asthma attacks [43].

The lower risk of ED visits among obese children is also worth discussion. Although obesity in general is associated with increased risk of asthma, the relationship is more pronounced in adults [44]. The relationship between the pathophysiology of obesity and that of asthma is more mixed. For example, one large study of children indicated that the highest BMI quintile experienced the lowest risk of significant airflow obstruction, possibly due to higher usage of bronchodilators in obese children [45]. Our results suggest that in some years, obese children with asthma may experience a lower risk of ED visits, although the scale and the significance of the relationship may vary from year to year. The level of asthma control, especially very poor control, was still a significant predictor of ED visits among children with asthma, even after controlling sociodemographics. However, the effect of asthma control over ED visits varied across time: e.g., the PRs of asthma control were

smaller in 2009 and 2010 than those in 2008. This result indicates that other time-varying factors that are beyond the level of asthma control, such as uncontrolled environmental irritants, may trigger asthma ED visits [46]. NAEPP 2007 guidelines recommend that patients with uncontrolled asthma should receive long-term control medication [47]. However, providers may not fully implement the guideline, which results in only two-thirds of children with uncontrolled asthma having long-term control medication [33]. Researchers recommend more cultural and population-specific asthma control to reduce the severity of asthma exacerbations [47].

The varying disparities in ED visits across time may reflect the complex nature of asthma, whose symptoms may depend on the expression of the individual's genes, household SES, exposure to the physical environment, or interactions with different health care systems [48]. Our study suggests that the disparities in ED visits among children were not necessarily static but dynamic as the result of a wide variety of factors [49]. Even for the most persistent disparity in ED visits, racial disparity, its scale and significance can vary from year to year. Therefore, more flexible strategies are needed to reduce these disparities instead of targeting only one factor in asthma management.

A few limitations of the study need to be acknowledged. First, the ACBS is a part of the BRFSS, which is based on self-reported health outcomes and health care usages. Therefore, recall or report bias could underestimate or overestimate the number of ED visits. Moreover, the BRFSS is administered by state agencies, which might introduce some differences in implementation. However, the CDC has conducted extensive training of the agencies and established solid quality control to minimize potential errors. This study did not include all states, which may limit its generalizability. More research is needed to understand the disparities in ED visits among children with current asthma.

Conclusions

In conclusion, significant racial/ethnic disparities existed in the number of ED visits among children with current asthma in 2006–2010. Minorities or children with poor asthma control could be at risk for more ED visits, although the scale of the negative effect may be influenced by other SES and environmental factors (social or natural environment), as well. More prevention or intervention should be implemented to promote equal access to quality asthma care among children across race/ethnicity and SESs.

Declaration of interest

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

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