

# Asthma Control and Associated Factors Among Children with Current Asthma – Findings from the 2019 Child Behavioral Risk Factor Surveillance System – Asthma Call-Back Survey

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**Purpose:** This study aimed to determine the prevalence and correlates of uncontrolled asthma among children with current asthma in four US states. We also determined the rates and correlates of asthma-related hospitalization, urgent care center (UCC), or emergency department (ED) visits.

**Participants and Methods:** We analyzed the 2019 Behavioral Risk Factor Surveillance Survey (BRFSS) Asthma Call-back Survey (ACBS) datasets. Asthma control status was classified as well-controlled or uncontrolled asthma based on day- and night-time asthma symptoms, activity limitation or use of rescue medications. Multivariable logistic regression models were used to identify the correlates of uncontrolled asthma and asthma-related hospitalization or UCC/ED visits.

**Results:** Among 249 children with current asthma, 55.1% had uncontrolled asthma while 40% reported asthma-related hospitalization or UCC/ED visits in the past year. Non-Hispanic ethnicity, ages of 0–9 and 15–17 years, household income <\$25,000, and not having a flu vaccination had higher odds of uncontrolled asthma. Conversely, asthma self-management education and households with two children compared to one were positively associated with uncontrolled asthma. For healthcare utilization, male and non-Hispanic children, along with those from households earning <\$25,000 exhibited higher odds of asthma-related hospitalization and UCC/ED visits.

**Conclusion:** Uncontrolled asthma and asthma-related visits to UCC/ED and hospitalization are common among children with current asthma. These outcomes are influenced by low household income and male sex, among other factors which call for multi-faceted interventions by healthcare providers and policymakers. Targeted strategies to effectively manage asthma and reduce the need for emergency healthcare services are recommended.

**Keywords:** asthma control, uncontrolled asthma, current asthma, pediatrics asthma

## Background

Asthma is a chronic condition that is characterized by inflamed airways that lead to wheezing, shortness of breath, chest tightness and coughing which are reversible and vary in intensity.<sup>1</sup> Pediatric asthma is a significant public health concern in the United States (US), affecting millions of children and imposing a substantial burden on healthcare systems, children, families, and society. About 6 million US children aged 0–17 years have asthma. The prevalence of asthma in US children younger than 18 years was 6.5% in 2021, with higher proportions in non-Hispanic Blacks (11.6%), children with the lowest household incomes (10.4%), children in the Northeast region (8.9%), those aged 5–17 years (8.1%), and boys (7.3%).<sup>2</sup> More than one-third of all children with asthma had one or more asthma attacks in 2021, and attacks were most common among children 0–4 years old.<sup>2,3</sup>

Poor access to healthcare, poor adherence to long-term asthma control medications, respiratory comorbidities, obesity, low parental education, exposure to smoking, and poverty are some of the risk factors for asthma attacks.<sup>3,4</sup> Emergency department and urgent care center (ED/UCC) visits for asthma attacks are also highest among children aged 0–4 years and non-Hispanic black children. Additionally, asthma accounted for 13.8 million missed school days among children aged 5–17 years in 2013. The average annual medical costs of asthma for children were nearly \$1000 per child in 2012.<sup>3</sup>

Many of these problems related to asthma morbidity can be significantly reduced through appropriate asthma management, which encompasses pharmacological and non-pharmacological therapies and strategies.<sup>1</sup> The recommended pharmacological therapies for asthma fall into three main categories, namely controller and reliever medications as well as add-on therapies for those patients with severe asthma. The controller medications currently recommended are low-dose ICS-formoterol combinations, which are intended to be used continuously, even when the child with asthma does not have symptoms. Reliever medications are taken as needed for symptom relief. The add-on medications in children with severe asthma are primarily biologics, such as the anti-immunoglobulin E *omalizumab* and other biologics for eosinophilic asthma.

Effective management of asthma, however, requires the provision of self-management education that is recommended by the US National Asthma Education and Prevention Program (NAEPP)<sup>5</sup> and Global Initiative for Asthma (GINA)<sup>1</sup> guidelines. In a chronic disease such as asthma, the role that the patients and their primary caregivers play to effectively implement healthcare recommendations is of paramount importance. In line with this, these guidelines recommend that all children with asthma and their caregivers be regularly exposed to education and skills that will help them to effectively manage asthma. Different benefits have been reported with regular self-management education such as in improved asthma control, the reduction of up to two-thirds in asthma-related hospitalizations, unscheduled clinic and ED visits, missed school or workdays and nocturnal awakenings.<sup>6</sup>

As per NAEPP<sup>5</sup> and GINA<sup>1</sup> recommendations, the essential components for the self-management education include skills training in using inhaler devices, encouraging adherence to anti-asthma medications, appointments and other advice, asthma information, training in guided self-management with monitoring of symptoms or peak flow, provision of a written asthma action plan and a regular review of asthma control, treatment, and skills by a healthcare provider. While providing self-management education, the partnership between the children/caregivers and their healthcare providers has been found to be very effective.<sup>7</sup>

Understanding the prevailing prevalence and risk factors for uncontrolled asthma and asthma-related hospitalization or ED/UCC among children is crucial to develop effective preventive measures, optimizing treatment strategies including the self-management education, and alleviating the burden of asthma. Therefore, this study aimed to provide an estimate on the prevalence of children with uncontrolled asthma. Furthermore, this study determined the correlates of uncontrolled asthma and asthma-related hospitalization or ED/UCC, as well as the relationship between asthma self-management education and achieved level of asthma control among children with current asthma in four US states that participated in CDC's 2019 Child Behavioral Risk Factor Surveillance System (BRFSS) and Asthma Call-back Survey (ACBS).

## Methods

### Study Design

A cross-sectional survey design was used in 2019 to determine the correlates for asthma control and asthma-related hospitalization or ED/UCC among children with current asthma. We analyzed the publicly available 2019 Child BRFSS/ACBS dataset from four US states, focusing on children <18 years.

The BRFSS is an ongoing telephone survey that collects data from a random, representative sample of non-institutionalized adults in the US in all 50 states, the District of Columbia and three territories. The survey encompasses health risk behaviors, chronic health conditions and the use of preventative services. The ACBS is a follow-up to the BRFSS conducted approximately two weeks later to collect detailed information related to asthma, including asthma control, medication use, self-management education and healthcare utilization. Respondents who are eligible for the ACBS are those who report ever being diagnosed with asthma. In cases where both the selected child and the BRFSS adult in the household are eligible, only one of them is eligible to participate in the survey. If the child is selected, the information is collected from a parent or a caregiver.

The unequal probability of sample selection and the differential non-response by those with different demographic, economic and health characteristics were adjusted using sample weighting. More information on participating states, weight calculation and response rates can be found elsewhere.<sup>8</sup>

This study only included children (age 0 to 17) with current asthma. Asthma status was assessed using the following two questions: “Has a doctor, nurse, or other health professional ever told you your child had asthma?” and “Does the child still have asthma?” Those who answered “yes” to both questions were considered to have current asthma. Those who answered “yes” to only one of the questions and “no” to both questions were considered not to have current asthma and were excluded from the study.

## Outcome Measures

Uncontrolled asthma and asthma-related hospitalization or ED/UCC were the primary outcome measures for this study.

Asthma control was assessed using a previously used algorithm.<sup>9</sup> Specifically, questions dealing with the frequency of asthma symptoms and nighttime awakenings, activity limitations and use of short-acting beta-2 agonists (SABA) were used to classify asthma control as “well-controlled” or “uncontrolled”. A child was classified as having “uncontrolled asthma” if he or she had any of the following: asthma symptoms more than twice a week in the past 30 days, more than one nighttime symptom due to asthma in the past 30 days, any activity limitation in the past 30 days due to asthma or use of SABA more than two days a week in the past three months.

Asthma-related hospitalization or ED/UCC visit was measured using a composite measure consisting of the following questions: (1) “During the past 12 months, has {child’s name} had to visit an emergency room or urgent care center because of {his/her} asthma?” and (2) During the past 12 months, that is since [1 YEAR AGO TODAY], has {child’s name} had to stay overnight in a hospital because of {his/her} asthma?

## Independent Variables

We collected information on several potential risk factors for uncontrolled asthma and asthma-related hospitalization or ED/UCC visit. These included socio-demographics, cost barriers, insurance type, asthma self-management education, medication-related and environmental factors. Demographic characteristics included the child’s age, sex, race/ethnicity, the number of children in a household, annual household income, and guardians/parents’ highest education. Information about cost barriers to visiting a primary care provider or a specialist for asthma-related care or buying asthma medications in the past 12 months was also collected. Further, we assessed if the child has had any kind of health insurance coverage, including prepaid plans (eg, HMOs) or government plans (eg, Medicare, Medicaid, or Children’s Health Insurance Program [CHIP]), and if they had insurance coverage gaps in the past 12 months. Environmental factors included exposure to secondhand smoke, mold, cockroaches, mice, rats, and indoor pets in the past 30 days. Additionally, we obtained information on dehumidifiers and exhaust fan use, as these could affect asthma outcomes. Additional information collected on risk factors included asthma-controller medications use in the past three months and the child’s flu vaccine status.

## Asthma Self-Management Education

The 2019 ACBS questionnaire has seven dichotomous yes/no questions related to asthma self-management education programs. These are as follows: (1) “Has a doctor or other health professional ever taught you or {child’s name} how to recognize early signs or symptoms of an asthma episode?”; (2) “Has a doctor or other health professional ever taught you or {child’s name} what to do during an asthma episode or attack?”; (3) “Has a doctor or other health professional ever taught you or {child’s name} how to use a peak flow meter to adjust his/her daily medications?”; (4) “Has a doctor or other health professional EVER given you or {child’s name} an asthma action plan?”; (5) “Have you or {child’s name} ever taken a course or class on how to manage {his/her} asthma?”; (6) “Did a health professional show {him/her} how to use the inhaler?” and (7) “Has a health professional ever advised you to change things in {his/her} home, school, or work to improve his/her asthma?”. The asthma self-management education scores have eight levels, ranging from 0 to 7, which were created by summing-up the number of “yes” responses to all seven questions. Uninformative responses such as “I

don't know" were treated as missing values. Accordingly, higher scores would indicate that the child received more asthma self-management education/component.

## Statistical Analysis

Sampling weights were used to calculate population prevalence estimates. Weighted analyses were performed using the complex survey procedures in SPSS v 29 to account for the BRFSS/ACBS complex sampling design, nonresponse, and unequal sampling probabilities. Given our focus on pediatric asthma, only data from 249 children with current asthma are presented. We calculated the prevalence estimates of sociodemographic and other respondent characteristics by asthma status. Two separate multivariable logistic regression models were used to determine the association between child characteristics and asthma outcomes. Uncontrolled asthma (yes/no) and asthma-related hospitalization or ED/UCC in the past 12 months (yes/no) were the outcomes of interest. The same child characteristics were included as independent variables in models examining both outcomes. These were the child's sex (male/female), age (0–9, 10–14 or 15–17), Hispanic origin, flu vaccine status, parent's current smoking status (yes/no), parent's highest education (High school or below, some college, or college graduate), the number of children in the household (1 child, 2 children or  $\geq 3$  children), annual household income (<\$25,000, \$25,000–\$50,000 or  $> \$50,000$ ), asthma self-management education, asthma-controller medication use (yes/no), and environmental factors (such as dehumidifier use [yes/no], exhaust fan use [yes/no], and having indoor pets [yes/no]). The overwhelming majority of respondents had insurance coverage, and only few reported cost barriers; thus, these variables were excluded from regression models. Likewise, some environmental factors (eg, secondhand smoke, mold, cockroach, mice, and rats) were only reported by a few respondents, and they were excluded from regression models. Adjusted odds ratio (AOR) and associated 95% confidence intervals (CIs) were computed for each independent variable with all the other potential risk factors included in the models. Statistical significance was set at a p-value  $< 0.05$ .

## Ethical Considerations

The BRFSS-ACBS survey was done in accordance with the principles of the Declaration of Helsinki and was approved by the IRBs of the CDC and the participating states. Furthermore, each participant gave informed consent, and the confidentiality of their identity was maintained.<sup>10</sup> The present study used publicly available and de-identified data from the BRFSS-ACBS survey.

## Results

### Respondent Characteristics

A total of 385 children (<18 years) were ever diagnosed with asthma. Of these, 249 (64.7%) reported that they currently had asthma and were included in the final analysis. Since sampling weights were incorporated into these analyses, this study population represents 548,729 US children with current asthma. Majority of the children with current asthma were male (53.8%), non-Hispanic (81.8%), aged 0–9 years (40.9%), and urban residents (96.6%). Nearly half of the children (48.1%) were living in homes with an annual household income of  $\geq \$50,000$ . Most of the children had health insurance coverage (95.2%), and only 14.7% were unable to see a primary care doctor, a specialist or buy medication for asthma in the past 12 months due to cost barriers. Most children (58.2%) had their flu vaccines, but only 30% took asthma-controller medications in the past 90 days. Most guardians/parents of the children were non-smokers (81.2%) and attended or graduated from college (75.5%). Regarding environmental risk factors, only 5.9% of the children were exposed to secondhand smoke. About 16.6% lived in homes where cockroaches, mice or rats were seen, and 13.7% lived where mold was seen or smelled in the past 30 days. Further, most respondents reported having indoor pets (62.1%) and exhaust fans (68.1%), but only 39.1% reported having dehumidifiers (Table 1).

### Asthma Self-Management Education

Most children with current asthma had education on early signs and symptoms of asthma (80.9%) and attack response (80.8%), as well as an asthma action plan (53.7%). The majority had no education on a peak flow meter (66.5%) nor

**Table 1** Characteristics of Children with Current Asthma by Level of Asthma Control

| Variables  | Unweighted<br>(N) | All<br>Respondents<br>N=548,729<br>Weighted<br>(%) | Asthma Status                                |  | p-value |
|--|-------------------|--|--|--|---------|
|  |                   |  | Controlled<br>N = 246,612<br>Weighted<br>(%) | Uncontrolled<br>N = 302,117<br>Weighted<br>(%) |         |
| <b>All</b>   | 249               | 100  | 44.9   | 55.1   |         |
| Female   | 117               | 46.2   | 48.6   | 37.7   | 0.125   |
| Age (years)  |                   |  |  |  |         |
| 0–9  | 70                | 40.9   | 40.9   | 41.0   | 0.189   |
| 10–14  | 115               | 35.8   | 42.0   | 30.8   |         |
| 15–17  | 64                | 23.2   | 17.1   | 28.2   |         |
| Child race/ethnicity   |                   |  |  |  |         |
| Hispanic   | 26                | 18.2   | 19.6   | 17.1   | 0.578   |
| Non-Hispanic   | 223               | 81.8   | 80.4   | 82.9   |         |
| Annual household income  |                   |  |  |  |         |
| <25,000  | 43                | 26.8   | 12.9   | 20.9   | 0.003   |
| 25,000–50,000  | 42                | 25.1   | 28.0   | 22.7   |         |
| >50,000  | 149               | 48.1   | 59.0   | 38.8   |         |
| Parent/Guardian Education  |                   |  |  |  |         |
| High school or below   | 49                | 24.6   | 20.4   | 28.0   | 0.234   |
| Some college   | 84                | 38.8   | 36.4   | 40.7   |         |
| College graduate   | 116               | 36.7   | 43.2   | 31.4   |         |
| Number of children in the household  |                   |  |  |  |         |
| 1 Child  | 105               | 30.5   | 32.3   | 28.9   | 0.817   |
| 2 Children   | 86                | 41.2   | 39.3   | 42.8   |         |
| ≥3 children  | 58                | 28.3   | 28.3   | 28.3   |         |
| Urban status   |                   |  |  |  |         |
| Urban county   | 227               | 96.6   | 96.7   | 96.5   | 0.909   |
| Rural county   | 22                | 3.4  | 3.3  | 3.5  |         |
| Guardian/Parent's current smoking status   |                   |  |  |  |         |
| No   | 219               | 81.2   | 88.4   | 75.4   | 0.012   |
| Yes  | 29                | 18.8   | 11.6   | 24.6   |         |
| Experienced cost barrier to visit a PCP, a specialist or buy asthma medication in the past 12 months | 28                | 14.7   | 2.2  | 25.0   | <0.001  |
| Child had insurance coverage   | 240               | 95.2   | 98.7   | 92.3   | <0.001  |
| Insurance type   |                   |  |  |  |         |
| Parents employer   | 168               | 51.8   | 58.1   | 46.2   | 0.040   |
| Medicaid/Medicare/CHIP   | 55                | 41.6   | 39.6   | 43.4   |         |
| Other  | 13                | 6.6  | 2.3  | 10.4   |         |
| Child had a flu vaccine  | 149               | 58.2   | 66.4   | 51.5   | 0.023   |
| Used asthma-controller medication in the past 3 months   | 68                | 30   | 29.6   | 30.3   | 0.935   |
| <b>Asthma self-management education</b>  |                   |  |  |  |         |
| Taught how to use a peak flow meter  | 92                | 33.5   | 25.0   | 40.4   | 0.039   |
| Taught what to do during asthma attack   | 214               | 80.8   | 82.3   | 79.6   | 0.636   |
| Taught how to recognize early sign or symptom  | 208               | 80.9   | 79.1   | 82.2   | 0.517   |
| Taken a course on asthma management  | 24                | 6.0  | 4.1  | 7.6  | 0.133   |
| Given asthma action plan   | 138               | 53.7   | 48.2   | 58.1   | 0.135   |
| Given professional instruction on inhaler use  | 226               | 93.8   | 94.1   | 93.6   | 0.826   |
| Inhaler use watched by a health professional   | 193               | 88.1   | 76.6   | 95.0   | 0.003   |

(Continued)

**Table 1** (Continued).

| Variables                      | Unweighted (N) | All Respondents N=548,729 Weighted (%) | Asthma Status                       |                                       | p-value |
|--------------------------------|----------------|--|-------------------------------------|---------------------------------------|---------|
|                                |                |  | Controlled N = 246,612 Weighted (%) | Uncontrolled N = 302,117 Weighted (%) |         |
| <b>Environmental triggers</b>  |                |  |                                     |                                       |         |
| Dehumidifier used              | 85             | 39.1                                   | 44.6                                | 34.7                                  | 0.143   |
| Exhaust Fan Used               | 162            | 68.1                                   | 62.0                                | 73.1                                  | 0.081   |
| Mold seen or smelled           | 19             | 13.7                                   | 12.3                                | 14.7                                  | 0.474   |
| Indoor Pets                    | 168            | 62.1                                   | 59.7                                | 64.0                                  | 0.578   |
| Cockroaches, mice or rats seen | 21             | 16.6                                   | 6.3                                 | 25.0                                  | 0.008   |
| Exposed to secondhand smoke    | 10             | 5.9                                    | 0.9                                 | 9.9                                   | <0.001  |

formal class on asthma management (94%). Most of them received instruction from a professional on inhaler use (93.8%), and their inhaler use was watched by a health professional (88.1%) (Table 1). The mean self-management education score for all children was 4.14 (SE = 0.08).

## Asthma Control

Among all children with current asthma, the majority reported having well-controlled asthma symptoms (88.8%) and nighttime symptoms (87.1%). However, over one-third (38.9%) of them had one or more activity limitations in the past 30 days due to asthma, and 16.4% used asthma rescue medications over the same period. In total, 55.1% of the children were classified as having uncontrolled asthma (Table 2).

## Asthma Adverse Outcomes and Healthcare Utilization

Most participants (76.8%) reported having at least one routine asthma check-up in the past year. Nearly half of the children (48.6%) had asthma attacks, and 33.9% and 22.3% had UCC and ED visits for asthma over the same period, respectively. Only 1.6% were hospitalized. Overall, 40.2% had asthma-related hospitalization or ED/UCC visits over one year prior to the survey (Table 3).

**Table 2** Level of Asthma Control Based on Four Different Criteria (N = 548,729)

| Variables   | Weighted (%) |
|---|--------------|
| Any activity limitation in the past 30 days                         |              |
| No  | 61.6         |
| Yes   | 38.4         |
| Asthma daytime symptoms   |              |
| ≤2 days/week  | 88.8         |
| >2 days/week  | 11.2         |
| Nighttime awakenings  |              |
| ≤2/month  | 87.1         |
| >2/month  | 12.9         |
| Short-acting β <sub>2</sub> -agonists use                           |              |
| ≤2 days/week  | 83.6         |
| >2 days/week  | 16.4         |
| <b>Level of asthma control (based on any of the above criteria)</b> |              |
| Controlled  | 44.9         |
| Uncontrolled  | 55.1         |

## Correlates of Uncontrolled Asthma

In multivariable logistic regression analyses (Table 4), asthma control was associated with age, ethnicity, household income, number of children in the household, self-management asthma education, and flu vaccine status. Compared to children aged 10–14 years, those aged 0–9 years (AOR = 2.36; 95% CI 1.08–5.15) and 15–17 years (AOR = 2.98; 95% CI 1.08–8.23) had higher odds of uncontrolled asthma. Non-Hispanic children had higher odds of uncontrolled asthma than Hispanic children (AOR = 2.67; 95% CI 1.37–5.21). Likewise, the odds of having uncontrolled asthma were higher among children with household incomes of <\$25,000 compared to those with highest income category (AOR = 4.88; 95% CI 1.94–12.25). Those who did not have a flu vaccine also had higher odds of uncontrolled asthma compared to those who were vaccinated (AOR = 2.11; 95% CI 1.02–4.33). The odds of uncontrolled asthma were also higher among children who live in households of two children than those children who live in a household with one child (AOR = 2.53; 1.32–4.83). Conversely, higher asthma self-management education scores were associated with an increased risk of uncontrolled asthma (AOR = 1.42; 95% CI 1.21–1.66). None of the environmental factors were significantly associated with uncontrolled asthma.

**Table 3** Asthma Attacks and Healthcare Utilization in the Past 12 Months (N = 548,729)

| Variables                        | Weighted (%) |
|----------------------------------|--------------|
| Had one or more asthma attacks   | 48.6         |
| Routine check-ups                | 76.8         |
| Urgent care visits (UCV)         | 33.9         |
| Emergency department (ED) visits | 22.3         |
| Hospitalization                  | 1.6          |
| Hospitalization or ED/UCV        | 40.2         |

**Table 4** Multivariable Logistic Regression Models Examining the Correlates of Uncontrolled Asthma and Asthma-Related Hospitalization or Emergency Department/Urgent Care Visits

| Variables                                    |  | Uncontrolled Asthma | Hospitalization or ED/UCV |
|--|--|---------------------|---------------------------|
|  |  | AOR (95% CI)        | AOR (95% CI)              |
| Child sex                                    | Female vs Male                           | 0.76(0.39, 1.46)    | 0.51(0.26, 0.99)*         |
| Child Age Group                              | Age 0–9 vs Age 10–14                     | 2.36(1.08, 5.15)*   | 0.76(0.31, 1.88)*         |
|  | Age 15–17 vs Age 10–14                   | 2.98(1.08, 8.23)*   | 1.59(0.59, 4.30)          |
| Child race/ethnicity                         | Non-Hispanic vs Hispanic                 | 2.67(1.37, 5.21)*   | 6.54(2.02, 21.21)*        |
| Guardian/Parent Education                    | Some college vs High school or below     | 1.58 (0.49, 5.09)   | 1.31(0.51, 3.35)          |
|  | College graduate vs High school or below | 1.44(0.40, 5.20)    | 1.04(0.29, 3.66)          |
| Annual household Income                      | < \$25,000 vs ≥\$50,000                  | 4.88(1.94, 12.25)*  | 8.28(2.55, 26.93)*        |
|  | \$25,000 - \$50,000 vs ≥\$50,000         | 1.05(0.44, 2.51)    | 2.46(0.70, 8.68)          |
| Number of children in the household          | 2 Children vs 1 Child                    | 2.53(1.32, 4.83)*   | 0.53(0.18, 1.59)          |
|  | ≥3 children vs 1 Child                   | 1.70(0.76, 3.82)    | 0.85(0.39, 1.88)          |
| Child had a flu vaccine                      | No vs Yes                                | 2.11(1.02, 4.33)*   | 0.64(0.32, 1.30)          |
| Asthma self-management education (sum score) |  | 1.42(1.21, 1.66)*   | 1.20(0.98, 1.46)          |
| Asthma-controller use in the past 3 months   | Yes vs No                                | 1.25(0.52, 2.96)    | 2.04(0.83, 4.96)          |
| Guardian/Parent's current smoking status     | Yes vs No                                | 1.66(0.74, 3.74)    | 1.02(0.45, 2.28)          |
| Dehumidifier use                             | Yes vs No                                | 0.50(0.24, 1.04)    | 0.64(0.31, 1.29)          |
| Exhaust Fan Use                              | Yes vs No                                | 1.84(0.77, 4.38)    | 3.98(1.96, 8.06)*         |
| Indoor Pets                                  | Yes vs No                                | 1.71(0.84, 3.49)    | 0.89(0.42, 1.86)          |

Note: \*p<0.05.

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.

## Correlates of Asthma-Related Hospitalization or Emergency Department/Urgent Care Center Visit

In multivariable regression analysis, female children were 49% less likely to have asthma-related hospitalization or ED/UCC visit in the past 12 months than males (AOR = 0.51; 95% CI 0.26–0.99). The odds of asthma-related hospitalization or ED/UCC visit were higher among non-Hispanic children compared to Hispanics (AOR = 6.54; 95% CI 2.02–21.21). Similarly, children with lowest household incomes had higher odds of asthma-related hospitalization or ED/UCC visit than children with highest household income (AOR = 8.28; 95% CI 2.55–26.93). Among environmental risk factors, having exhaust fans was associated with increased odds of asthma-related hospitalization or ED/UCC visit (AOR = 3.98; 95% CI 1.96–8.06).

## Discussion

The findings of this study revealed that 55.1% of the children with current asthma had uncontrolled asthma, and 40.2% had asthma-related hospitalization or ED/UCC visits over one year prior to the survey. Though not statistically significant in the regression analysis, the findings indicated that 25% of children with uncontrolled asthma faced cost barriers to visit a PCP, a specialist, or buy asthma medication, compared to 2.2% with controlled asthma. Children from households with incomes below \$25,000 had higher odds of uncontrolled asthma and related hospitalizations or UCC/ED visits. Conversely, higher scores in asthma self-management education were associated with increased odds of uncontrolled asthma risk, even though the majority of children did not receive a formal asthma management training.

The prevalence of uncontrolled asthma (55.1%) was much higher than those reported by earlier studies which reported values below 40%.<sup>11,12</sup> It was, however, found to be slightly lower compared to another study that reported prevalence of 60%.<sup>9</sup> Low-income level (<\$25,000) was found to be a significant correlate in the present study and in other studies.<sup>9,11</sup> This highlights the need to address potential intervention targets, including the cost barriers households encounter when accessing healthcare and medications.

According to our findings, the majority of children with uncontrolled asthma experienced cost barriers to visit a PCP, a specialist or buy asthma medication despite having insurance coverage – a trend observed in other studies.<sup>11,12</sup> Children from lower income levels, with higher odds for uncontrolled asthma, deserve particular focus.<sup>11</sup> Healthcare providers should evaluate cost barriers during consultations. In cases where cost is indeed a barrier for example to buying asthma medications, prescribers should consider more cost-effective alternatives.<sup>13</sup>

In this study, high asthma self-management education scores were significantly associated with uncontrolled asthma, a finding also reported in other studies.<sup>12,14</sup> This is counterintuitive, as one would expect such education to decrease ED/UCC visits and hospitalizations while enhancing perceived asthma control and other patient outcomes.<sup>5,15</sup> This can, however, be explained by the reported high level of routine care visits and ED/UCC in the present study, which would lead to increased chance to be selected for asthma education, leading to high asthma education score.<sup>5</sup>

Our findings further revealed that only a little over half of the children with asthma received a written asthma action plan despite the recommendations from NAEPP<sup>5</sup> and GINA<sup>1</sup> guidelines that it should be provided to all patients with asthma for better asthma outcomes. Different studies have further attested as to how the provision of a written asthma action plan has led to significant increase in patient adherence to inhaled and oral corticosteroids and asthma control,<sup>16</sup> exhibit of higher self-efficacy among parents, being helpful for daily living such as managing the child's condition, decreased missed parent workdays and child missed-school days, among other things.<sup>17</sup> The level of asthma action plan provision for the 2019 Child BRFSS/ACBS, however, fairs better than previously reported findings.<sup>14,18,19</sup>

Furthermore, the findings from the asthma self-management education components revealed that the great majority of the self-management education recipients were given professional instructions on inhaler use including being watched by a health professional, were taught how to recognize early signs and symptoms and what to do during an asthma attack similar to that reported by Zahran et al.<sup>12</sup> The comparative figure for having received asthma management education was, however, quite low despite the recommendations to use such opportunities to provide culture-sensitive and individualized education on different aspects including the necessity of adherence to recommended medications.<sup>5,20</sup>



This study should be interpreted in consideration of the following limitations. The BRFSS-ACBS survey data is based on the caregivers' self-report and so objective measures related to asthma control and response to therapy were not used. The cross-sectional nature of the study for its part impedes the establishment of a temporal relationship between the risk factors and uncontrolled asthma or healthcare utilization. The other limitation is the low sample size due to the relatively low number of participating states in the BRFSS-ACBS survey, and thus the results may not be nationally representative.

## Conclusion

The findings from this study revealed that a high proportion of children with asthma had uncontrolled asthma and asthma-related hospitalization or ED/UCC visits. Factors associated with these outcomes include low household income, the absence of flu vaccination, male sex, and specific age groups—particularly younger children (0–9 years) and mid-teenagers (15–17 years). Specifically, lower household income significantly increased the risk of both uncontrolled asthma and healthcare utilization. These findings underscore the need for specific interventions tailored to low-income families and different sex and age groups to effectively manage asthma and minimize the need for emergency healthcare services.

## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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