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ORIGINAL PAPER

# The Burden and Social Determinants of Asthma Among Children in the State of Georgia

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**Abstract**
Asthma is one of the most common chronic health conditions in children, and social determinants are thought to be important risk factors. We used Georgia data from the Behavioral Risk Factors Surveillance Survey (BRFSS), and data from the Georgia hospital and emergency department survey for children with a diagnosis of asthma. All data were from the years 2011 to 2016. SAS and SUDAAN were used to calculate weighted prevalence estimates and to perform univariate and multivariate analysis of the association between social determinants, demographic characteristics, other potential risk factors, and asthma-related outcomes. The prevalence of asthma is higher in African-American children and when the parental income is less than $75,000 per year. A multivariate analysis adjusting for ethnicity, parental income, and sex found that the strongest independent predictor of asthma was African-American race (aOR 2.9, 95% CI 1.5–5.8). African-American and multiracial children also experienced extremely high burdens due to asthma related hospitalizations and emergency department visits, with rates two to five times higher than children in other groups. The secular trend for ED visits and hospitalizations is declining. African-American race is an independent predictor of asthma in children in Georgia, and African-American and multiracial children experience a greater burden of asthma than children of other races. Programmatic efforts at the state and national level to improve access, adherence, and knowledge about asthma are important if we are to continue to improve outcomes for these children.

**Keywords** Asthma · Prevalence · Social determinants · Adults · Socioeconomic

## Introduction

Asthma is a chronic respiratory condition characterized by bronchospasm and inflammation leading to wheeze, dyspnea, shortness of breath, and exercise intolerance, among other symptoms. It is an important cause of pediatric morbidity and mortality and is the third leading reason for hospitalization among children 15 years and younger in the United States [1]. The prevalence of asthma among children in the United States was 9.5% in 2009, an increase from 8.7% in 2001 [2].

In 2015, using national data the prevalence of asthma is higher in non-Hispanic black than in non-Hispanic white children (13.4% vs 7.3%). It is also higher in boys than in girls, a disparity especially pronounced in non-Hispanic blacks (16.0% vs 10.8%) [3]. Hospitalization rates are more than four times higher for non-Hispanic black children than non-Hispanic white children (275.7 vs 60.9 per 100,000), as are death rates (9.2 vs 1.3 per million) [3]. Thus, asthma is not only more common in non-Hispanic blacks than whites, but serious complications and mortality are disproportionately more common.

One potential explanation for the large disparity in health outcomes by race and ethnicity is the effect of social determinants of health. These include tobacco use in the home,

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neighborhood violence or disorder, environmental pollution, pests in the home, stress, discrimination in access to and quality of health care, the downstream effects of structural racism, socioeconomic status, parental mental health problems, country of origin, and family structure [4–7]. These determinants can affect both clinical outcomes and the likelihood of complications.

In this study, we report the burden of asthma on children in the state of Georgia. Specifically, we evaluate recent trends in prevalence and complications, and the impact of social determinants of health on the prevalence of asthma, such as household income, race, rurality, and educational attainment.

## Methods

This was a secondary analysis of de-identified, publicly available data for the state of Georgia from the Behavioral Risk Factors Surveillance Survey (BRFSS), and data from the Georgia hospital and emergency department survey for children under the age of 18 years with a diagnosis of asthma. All data were from the years 2011 to 2017.

We used data for persons 18 years and younger responding to the BRFSS, an annual stratified random-digit dial telephone interview conducted by the CDC [8]. Participants are non-institutionalized Georgia residents who are asked about such topics as health behaviors, chronic conditions, substance use, and medical coverage. Caregivers of children with asthma are asked additional questions. Using the BRFSS, weighted prevalence estimates of asthma among Georgia children were calculated using SAS 9.4 and SUDAAN 11.0.1. We also calculated the association of asthma with certain healthcare-related variables such as demographics, tobacco use in the home, parental income, and parental education level. Univariate and multivariate logistic regression were performed in SUDAAN to calculate the adjusted odds ratios (aOR) for selected variables regarding the risk of having asthma.

Finally, de-identified hospital inpatient discharge and emergency department (ED) visit data are collected by the Georgia Department of Public Health from non-federal acute care hospitals in Georgia. These data sets were used to determine the burden of children hospitalized or seen in the ED with a primary diagnosis of asthma (ICD-9 493.0–493.9; ICD-10 J45). Because this was an analysis of publicly available de-identified data, institutional review board approval was exempt.

Descriptive data are presented for asthma prevalence, the characteristics of children with asthma, and hospitalization and emergency department visit rates by population subgroup. Logistic regression was performed with the likelihood of prevalent asthma as the dependent variable, using backward selection to develop the model.

## Results

Table 1 summarizes data regarding the self-reported point prevalence of asthma in children under 18 years of age in Georgia. The point prevalence of self-reported asthma is lower in 2017 (9.1%) than in 2012 (10.8%). There was an increase in 2015, but this may be due in part to coding issues related to the introduction of ICD-10 that year. In general, the prevalence of asthma was higher in children 10 years and older, in children of African-American race, and those of non-Hispanic ethnicity. The prevalence is also higher when the parental income is less than $75,000 per year, although there was no clear pattern by parental educational attainment or parental smoking. Housing status or quality of housing is not collected in the surveys and thus could not be taken into consideration.

Table 2 describes the characteristics of children with asthma in Georgia from 2012 to 2017. Most children with asthma are male, and 45% are 10 years or older. In all but two years (2014 and 2015), over half of children with asthma in Georgia are African-American, and over 60% live in households with an income less than $50,000. In the most recent year, nearly 18% lived in a household where at least one parent smoked.

Table 3 summarizes hospitalization rates for asthma among children in Georgia between 2012 and 2017. Higher rates were consistently seen for males, younger children, and children of African-American race or multiracial children. Overall rates declined from 123/100,000 in 2012 to 104/100,000 children in 2017. Table 3 also summarizes emergency department visits for asthma by overall and by population subgroup during the same period. Similarly, rates were highest in males, younger children (under 10 years of age), and children of African-American race or multiracial children. And, as with hospitalizations, these rates showed a general decreasing trend from 2012 to 2017. In October of 2015, medical coding for inpatient hospital discharges and emergency room visits changed from ICD-9 CM to ICD-10CM. Due to the magnitude of the changes and coding differences, 2015 inpatient hospital discharge and emergency room visits data is not available.

In the multivariate analysis, the best model based on inspection of the log likelihood ratios include race, ethnicity, parental income, and sex. The referents were male, white race, non-Hispanic ethnicity, and parental income greater than $75,000. Male sex (aOR 1.63, 95% CI 0.87–3.1), Hispanic ethnicity (aOR 1.26, 95% CI 0.32–4.86) and parental income were not significantly associated with the dependent variable of prevalent diagnosis of asthma, although there

**Table 1** Asthma prevalence in children 0 to 17 years of age in Georgia from 2012 to 2016

| Variable | 2012 (%) | 2013 | 2014 (%) | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| Overall asthma prevalence | 10.8 | 10.7% | 10.2 | 11.1% | 8.8% | 9.1% |
| Ever told had asthma | 16.5 | 16.2% | 13.9 | 15.3% | 14.5% | 13.5% |
| Sex | | | | | | |
| Male | 12.5 | 12.6% | 14.1 | 11.7% | 10.9% | 10.4% |
| Female | 9.0 | 8.8% | 5.6 | 10.6% | 7.1% | 7.8% |
| Age | | | | | | |
| 0–4 years | 7.5 | 6.9% | 6.6 | NR | NR | NR |
| 5–9 years | 8.2 | 14.5% | 10.4 | NR | NR | NR |
| 10–14 years | 14.7 | 11.1% | 12.8 | NR | NR | NR |
| 15–17 years | 13.4 | 9.6% | 10.5 | NR | NR | NR |
| Race (non-Hispanic) | | | | | | |
| White | 9.1 | 7.6% | 8.5 | 10.3% | 6.3% | 5.4% |
| African-American | 14.7 | 16.7% | 13.1 | 14.1% | 13.6% | 14.5% |
| Other | 4.3 | 4.8% | 9.0 | 3.7% | 10.6% | 3.4% |
| Ethnicity | | | | | | |
| Hispanic | 5.6 | 5.6% | 4.7 | 6.8% | 6.8% | 4.1% |
| Non-Hispanic | 11.7 | 11.5% | 11.2 | 11.7% | 9.2% | 10.0% |
| Parent income | | | | | | |
| $0–$24k | 11.4 | 11.7% | 13.0 | 10.9% | 12.3% | 12.8% |
| $25k–$49k | 8.8 | 9.9% | 9.2 | 14.9% | 6.8% | 9.6% |
| $50k–$74k | 10.1 | 11.0% | 8.8 | 10.2% | 8.7% | 4.0% |
| > $75k | 7.5 | 4.9% | 7.1 | 7.3% | 6.1% | 5.9% |
| Parent education | | | | | | |
| Did not graduate HS | 7.8 | 13.0% | 8.8 | 11.3% | 8.7% | 7.9% |
| Graduated HS | 10.0 | 8.5% | 10.0 | 13.9% | 7.5% | 8.4% |
| Some College | 10.6% | 9.6% | 10.7 | 12.0% | 7.4% | 6.2% |
| Graduated College | 8.8 | 7.3% | 9.1 | 7.4% | 9.4% | 8.3% |
| Parent currently smokes | | | | | | |
| Yes | 6.3 | NR | 11.8 | 13.0% | 7.9% | 6.1% |
| No | 10.3 | NR | 9.3 | 10.7% | 8.3% | 8.0% |

All prevalence estimates are weighted

*NR* not reported

was a trend toward greater risk in those with income less than $25,000 per year (aOR 1.99, 95% CI 0.87–6.5). African-American race was a strong independent predictor of prevalent asthma (aOR 2.90, 95% CI 1.45–5.8).

## Discussion

We found higher prevalence of asthma in children of African-American race and non-Hispanic ethnicity. The prevalence is also higher when the parental income is less than $75,000 per year, although there was no clear pattern by parental educational attainment or parental smoking, which may suggest another known social determinant, such as housing, is an underlying cause of the differences in prevalence. A multivariate analysis adjusting for race, ethnicity, parental income, and sex, the odds of asthma were nearly three times higher in African-American children than in other children.

Despite making up only about one-third of the population under age 18 years, over half of children in Georgia with asthma are African-American. This overall difference in prevalence may be explained, in part, by the differences in income by race in Georgia. Of the approximately 566,000 children living in poverty in Georgia in 2016, approximately 48.5% or 272,000 of those children are African-American [9]. And, children overall are more likely to live in poverty than adults in Georgia—one in three children vs one in five nonelderly adults [10].

We also found much higher rates of emergency department visits and hospitalizations for asthma among African-American children than children of other races. For example, in the most recent year, hospitalization rates for African-American and multiracial children were more than

**Table 2** Characteristics of children with asthma in Georgia from 2012 to 2016

| Variable | 2012 (%) | 2013 | 2014 (%) | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| Sex | | | | | | |
| Male | 59.3 | 58.3% | 72.9 | 52.4% | 60.1% | 58.1% |
| Female | 40.7 | 41.7% | 27.1 | 47.6% | 39.9% | 41.9% |
| Age | | | | | | |
| 0–4 years | 16.9 | 16.8% | 16.5 | NR | NR | NR |
| 5–9 years | 21.5 | 38.2% | 28.7 | NR | NR | NR |
| 10–14 years | 29.8 | 29.2% | 35.1 | NR | NR | NR |
| 15–17 years | 31.8 | 15.8% | 19.7 | NR | NR | NR |
| Race (non-Hispanic) | | | | | | |
| White | 45.5 | 37.6% | 44.7 | 50.0% | 37.1% | 33.3% |
| Black | 50.7 | 57.4% | 48.3 | 47.9% | 54.6% | 63.4% |
| Other | 3.8 | 5.0% | 7.0 | 2.1% | 8.3% | 3.3% |
| Ethnicity | | | | | | |
| Hispanic | 7.3 | 7.6% | 6.9 | 8.7% | 12.0% | 8.6% |
| Non-Hispanic | 92.7 | 92.4% | 93.1 | 91.3% | 88.0% | 91.4% |
| Parent income | | | | | | |
| $0–$24k | 39.9 | 39.1% | 43.0 | 32.1% | 44.4% | 44.3% |
| $25k–$49k | 21.3 | 30.7% | 21.7 | 31.3% | 17.5% | 24.4% |
| $50k–$74k | 14.5 | 16.6% | 10.7 | 13.4% | 12.8% | 6.2% |
| > $75k | 24.4 | 13.7% | 24.6 | 23.1% | 25.3% | 25.1% |
| Parent education | | | | | | |
| Did not graduate HS | 12.7 | 25.7% | 15.6 | 19.7% | 17.8% | 18.1% |
| Graduated HS | 29.5 | 24.2% | 27.9 | 32.2% | 25.9% | 31.2% |
| Some College | 32.2 | 32.5% | 32.0 | 29.7% | 27.2% | 23.1% |
| Graduated College | 25.6% | 17.6% | 24.4 | 18.4% | 29.1% | 27.6% |
| Parent currently smokes | | | | | | |
| Yes | 14.3 | NR | 22.4 | 19.0% | 17.6% | 13.9% |
| No | 85.7 | NR | 77.6 | 81.0% | 82.4% | 86.1% |

All prevalence estimates are weighted

*NR* not reported

twice as high as those for white children (162 and 128 vs 71 per 100,000, respectively). Similarly, emergency department visits were nearly 4 to 5 times as likely among African-American and multiracial children than among white children (1782 and 1587 vs 465 per 100,000, respectively). These high rates create a disproportionate and severe burden on these children and their families. Some of the differences in rates may be explained in Georgia by the limited accessibility and availability of access to primary care for children on Medicaid, which is worse than for privately insured children [11].

Since 2011, the Department of Public Health in the state of Georgia has been targeting asthma in children with a series of programmatic efforts, particularly in collaboration with the Medicaid program and Medicaid managed care organizations, known as Care Management Organizations (CMOs), and with medical societies such as the Georgia Chapter of the American Academy of Pediatrics (GAAP). These include parental education; teacher education; resources for school nurses; emergency access to albuterol without a prescription in school settings; policies related to self-carry of asthma medications in schools; home trigger assessments; physician education; awareness campaigns for parents; self-management education training for care extenders such as community health workers; self-management education for high risk youth; mandatory reporting of pediatric asthma mortality; and, templates for asthma-action plans endorsed by Medicaid, the CMOs, and GAAP. These programs are especially focused on at risk children on Medicaid who have poorly controlled or uncontrolled asthma, and the organizations that serve those children.

Hospitalization rates for asthma have declined across all racial and age groups and for boys and girls, from an overall rate of 1164 hospitalizations per 100,000 children in 2012 to 968 per 100,000 in 2017. ED visits have seen a similar decline, again across all racial and age groups. However, due to the medical codes changing in 2015, hospitalization and emergency department visits rates before

**Table 3** Hospitalization rates and emergency department (ED) visits per 100,000 persons under age 18 years in the state of Georgia from 2012 to 2015, stratified by sex, age, and race

| | Hospitalization Rate (per 100,000 persons < 18) | | | | | |
|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| Entire population | 123 | 110 | 98 | NA | 105 | 104 |
| Total charges (million $) | $32.0 | $30.4 | $29.6 | NA | $32.1 | $37.4 |
| Sex | | | | | | |
| Male | 152 | 136 | 123 | NA | 130 | 127 |
| Female | 94 | 83 | 73 | NA | 78 | 80 |
| Age | | | | | | |
| 0–4 years | 200 | 175 | 159 | NA | 175 | 183 |
| 5–9 years | 166 | 150 | 132 | NA | 137 | 131 |
| 10–14 years | 64 | 59 | 52 | NA | 54 | 54 |
| 15–17 years | 27 | 23 | 23 | NA | 26 | 26 |
| Race | | | | | | |
| White | 83 | 72 | 71 | NA | 81 | 71 |
| Africa-American | 182 | 166 | 142 | NA | 149 | 162 |
| Asian | 45 | 38 | 28 | NA | 43 | 32 |
| American Indian | 50 | 51 | 32 | NA | 45 | 121 |
| Pacific Islander | 109 | 106 | 26 | NA | 51 | 49 |
| Multiracial | 271 | 244 | 184 | NA | 123 | 128 |
| White race, by Age | | | | | | |
| 0–4 years | 154 | 132 | 119 | NA | 146 | 135 |
| 5–9 years | 99 | 83 | 92 | NA | 103 | 80 |
| 10–14 years | 39 | 38 | 39 | NA | 39 | 35 |
| 15–17 years | 19 | 18 | 15 | NA | 16 | 23 |
| African-American race, by Age | | | | | | |
| 0–4 years | 270 | 239 | 223 | NA | 235 | 270 |
| 5–9 years | 269 | 256 | 199 | NA | 202 | 216 |
| 10–14 years | 106 | 92 | 77 | NA | 80 | 88 |
| 15–17 years | 39 | 28 | 33 | NA | 44 | 34 |
| | ED visit rate (per 100,000 persons < 18) | | | | | |
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| Entire population | 1164 | 1055 | 1009 | NA | 931 | 968 |
| Total charges (million $) | $44.2 | $42.5 | $44.4 | NA | $45.8 | $55.7 |
| Sex | | | | | | |
| Male | 1421 | 1289 | 1212 | NA | 1131 | 1152 |
| Female | 894 | 811 | 797 | NA | 723 | 776 |
| Age | | | | | | |
| 0–4 years | 1514 | 1351 | 1256 | NA | 1120 | 1151 |
| 5–9 years | 1466 | 1397 | 1327 | NA | 1238 | 1289 |
| 10–14 years | 885 | 774 | 730 | NA | 715 | 762 |
| 15–17 years | 555 | 477 | 550 | NA | 496 | 515 |
| Race | | | | | | |
| White | 547 | 519 | 522 | NA | 465 | 465 |
| African-American | 2144 | 1877 | 1755 | NA | 1661 | 1782 |
| Asian | 324 | 273 | 191 | NA | 224 | 257 |
| American Indian | 415 | 262 | 537 | NA | 523 | 464 |
| Pacific Islander | 407 | 448 | 129 | NA | 455 | 271 |
| Multiracial | 2429 | 2450 | 2288 | NA | 1774 | 1587 |
| White Race, by age | | | | | | |

**Table 3** (continued)

| | ED visit rate (per 100,000 persons < 18) | | | | | |
|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| 0–4 years | 777 | 738 | 710 | NA | 638 | 638 |
| 5–9 years | 632 | 631 | 630 | NA | 569 | 560 |
| 10–14 years | 398 | 366 | 371 | NA | 336 | 337 |
| 15–17 years | 285 | 246 | 310 | NA | 255 | 273 |
| African-American Race, by age | | | | | | |
| 0–4 years | 2703 | 2289 | 2128 | NA | 1883 | 1983 |
| 5–9 years | 2840 | 2616 | 2396 | NA | 2301 | 2487 |
| 10–14 years | 1670 | 1414 | 1278 | NA | 1310 | 1453 |
| 15–17 years | 977 | 811 | 915 | NA | 856 | 903 |

*NA* not available

2015 may not be considered strictly comparable to rates after 2015. While a cause and effect relationship between the state level asthma programs and declining costs cannot be proven, it is certainly plausible that it is at least partly responsible for this reduction in the burden of asthma as measured by hospitalizations and ED visits.

The annual cost burden for hospitalizations and ED visits has remained relatively stable, with an increase in 2017. This may be in part due to increasing costs of asthma medications, including especially inhalers and expensive monoclonal antibodies. However, we do not have detailed expenditure data by drug and by number of prescriptions per child, so this is somewhat speculative.

A limitiation of our study is the reliance on administrative data for utilization, although the source and reporting standards have been consistent throughout the study. Another limitation is the change in 2015 to the ICD-10 coding system, which makes comparisons before and after this changeover somewhat challenging. Strengths include a diverse, statewide sample, information on race and ethnicity, use of the well validated BRFSS as a key data source, and the longitudinal nature of the data.

These findings and trends provide important insights for public health practitioners and health care providers with limited resources seeking to implement population-level interventions for the control of asthma. Given the burden, it is plausible that hospitalizations for asthma in Georgia could be reduced further, for example, by increasing access to and the availability of primary care and asthma self-management education among the very low income; interventions that provide home trigger assessments and self-management education to children with uncontrolled asthma; interventions that reduce the cost barriers to asthma maintenance medications; the use of medical informatics tools for early identification of asthma in older adults; community interventions that reduce tobacco use and exposure to second-hand smoke; and interventions that effectively support individuals with an increased BMI in managing their asthma.

Focusing limited resources in high risk geographical areas, such as south and northwest Georgia, and the hospitals, health systems, Federally Qualified Health Centers, and health departments may also be a relevant strategy for making progress in addressing the burden of asthma in Georgia and other states.

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## Compliance with Ethical Standards

**Conflict of interest** All authors declare that they have no conflict of interest.

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