


## Original Research

**Cite this article:** Davis SA, Carpenter DM, Loughlin CE, Garcia N, Sleath B. Impact of Hurricane Matthew on a cohort of adolescents with asthma in North Carolina. *Disaster Med Public Health Prep.* 17(e446), 1–4. doi: <https://doi.org/10.1017/dmp.2023.115>.

**Keywords:** hurricane; flooding; asthma; quality of life; adolescent health

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# Impact of Hurricane Matthew on a Cohort of Adolescents With Asthma in North Carolina

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## Abstract

**Objective:** The aim of this study was to look at a cohort of adolescents who were already enrolled in a randomized controlled trial to see (1) how demographics were associated with hurricane impact, and (2) how hurricane impact was associated with reported asthma quality of life.

**Methods:** One hundred fifty-one adolescents ages 11–17 and their parents enrolled in a randomized controlled trial at 2 sites in southeastern North Carolina completed questions about asthma quality of life, demographics, and the impact of Hurricane Matthew.

**Results:** The most common effects of Hurricane Matthew were that the family's home was damaged or flooded (32.5%), the school was damaged or flooded (31.8%), and the home had mold or mildew as a result of flooding or damage (25.8%). Problems with access to care were more common for families whose adolescent was non-White ( $P = 0.04$ ), on Medicaid ( $P = 0.05$ ), or if the family spoke Spanish at home ( $P < 0.001$ ). Being affected by the hurricane was negatively associated with asthma quality of life.

**Conclusions:** Hurricane Matthew had significant impact on the health of adolescents with asthma in the affected region, especially in the most vulnerable populations. Providers should ensure that families of adolescents with asthma have a hurricane plan to mitigate impact on their children's health.

Asthma is one of the most common chronic conditions among children and adolescents in the United States.<sup>1</sup> Mold, mildew, and other consequences of excessive indoor moisture are a common trigger for asthma,<sup>2</sup> especially in disadvantaged families living in poor housing conditions.<sup>3–8</sup> Housing that contains higher levels of allergens, including mold and mildew, contributes to health disparities between affluent and low-income populations, including disparities in asthma outcomes.<sup>5–8</sup> Therefore, natural disasters associated with excessive moisture and flooding, such as hurricanes, might have profound impacts on children and adolescents suffering from asthma.<sup>2</sup>

Several studies have examined the consequences of Hurricane Katrina on the health outcomes of children living in and around New Orleans following the flooding and destruction in 2005.<sup>2,9,10</sup> Seventy-eight percent of children with asthma in the affected areas reported using more asthma medication in the 3 mo following Katrina compared with before.<sup>10</sup> In 2016, an ongoing randomized trial of an intervention designed to improve adolescents' communication with their asthma care providers<sup>11</sup> was affected by Hurricane Matthew. Many rivers in North Carolina reached their highest levels on record as a result of this storm.<sup>12</sup> Across the affected states, Matthew produced between \$10 and \$15 billion in damage, as well as washed-out and flooded roads, impeding transportation.<sup>12</sup> Some school districts were closed for as much as 3 wk, and at least 1 school was closed permanently due to the damage.<sup>13,14</sup>

The purpose of this study was to look at a cohort of adolescents who were already enrolled in a randomized controlled trial to see (1) how demographics were associated with hurricane impact, and (2) how hurricane impact was associated with reported asthma quality of life.

## Methods

This study used secondary data from a randomized controlled trial of an asthma intervention conducted between June 2015 and November 2016.<sup>11</sup> Adolescents were eligible if they were: ages 11 to 17 y; spoke and read English or Spanish; had persistent asthma; were present for an acute or follow-up asthma visit or a well-child visit; had previously visited the clinic at least once for asthma; and the parent present with them at the office visit was a legal guardian who had knowledge of their asthma. Using information from the eligibility screener that parents

completed with the research assistant, persistent asthma was defined as experiencing asthma-related daytime symptoms more than twice a week, asthma-related nighttime symptoms more than twice a month, or receiving 1 or more long-term controller therapies for asthma.<sup>15</sup> As part of the 12-mo parent survey,<sup>11</sup> caregivers at 2 rural clinics were asked questions about how the hurricane had affected them. These questions were added to a larger survey midway through the larger study when the hurricane struck. As part of the larger study, the hurricane questions were only administered to families at the 2 clinics in southeastern North Carolina, which was more severely affected by the hurricane than other parts of the state. Forty-two families had already completed the 12-mo visit before the hurricane, and therefore, were not included in the analyses. The study was approved by the University of North Carolina Institutional Review Board, and informed consent or assent was obtained from all participants.

Demographics were measured at baseline, including child's age in years, child gender (male or female), child race/ethnicity (Hispanic, non-Hispanic White, African American, American Indian, or Alaska Native, or other), language spoken at home (English or Spanish), and whether the child had Medicaid (yes or no). Asthma severity was also measured at baseline as mild persistent or moderate/severe persistent. The hurricane survey questions included whether the family's home was flooded or damaged, whether the family's home had mold or mildew as a result of flooding or damage, whether the child's school was damaged or flooded, whether the family had problems with access to care, and whether the family experienced the following problems: running out of asthma medication, missing asthma medication doses, and obtaining asthma medicine from the pharmacy. The 12-mo visit occurred a mean of 6 mo after the hurricane (standard deviation [SD]: 3 mo; range: less than 1 to 13 mo). Asthma quality of life was measured using the Juniper scale and was treated as a continuous variable, using the 23-item standardized version of the Juniper pediatric asthma quality-of-life questionnaire, with the total score calculated as the mean of the 23 items scored on a scale of 1 to 7.<sup>16</sup>

All analyses were performed using Statistical Product and Service Solutions (SPSS) version 26 (IBM SPSS, Armonk, NY). First, descriptive statistics were calculated for all the hurricane survey questions. Then the bivariate relationships between demographics and the hurricane survey answers were assessed using Pearson's chi-squared or t-tests. The bivariate relationships between hurricane survey responses and asthma quality of life were also assessed using Pearson's chi-squared or t-tests. Finally, linear regression was used to predict 12-mo asthma quality of life as a function of baseline quality of life, hurricane impact, and interaction between the 2 variables. For this purpose, hurricane impact was calculated as the total number of "yes" answers to the 7 hurricane impact questions.

## Results

One hundred fifty-one caregivers—all except for the 42 from families who had already completed the larger study before the hurricane—completed the hurricane questions. The demographics of the adolescents included in the analysis are shown in Table 1. The majority were male (56.3%) and almost half were African American. More than three-quarters of the adolescents had Medicaid. More than 60% had moderate to severe persistent asthma at baseline.

**Table 1.** Demographics of adolescents in the study (*N* = 151)

|                                    | <i>n</i> (%)                     |
|------------------------------------|----------------------------------|
| Child gender                       |                                  |
| Female                             | 66 (43.7)                        |
| Male                               | 85 (56.3)                        |
| Child race/ethnicity               |                                  |
| Non-Hispanic White                 | 36 (23.8)                        |
| African American                   | 61 (40.4)                        |
| Native American/American Indian    | 30 (19.9)                        |
| Hispanic                           | 24 (15.9)                        |
| Asthma severity                    |                                  |
| Mild persistent                    | 58 (38.4)                        |
| Moderate or severe persistent      | 93 (61.6)                        |
| Language spoken at home            |                                  |
| English                            | 133 (88.1)                       |
| Spanish                            | 18 (11.9)                        |
| Child has Medicaid                 | 116 (76.8)                       |
|                                    | Mean ± standard deviation, range |
| Child age                          | 13.3 ± 1.9, 11-17 years old      |
| Years living with asthma           | 9.8 ± 4.3, 1-17 years            |
| Asthma quality of life at baseline | 5.5 ± 1.3, 1.8-7.0               |
| Asthma quality of life at 12 mo    | 6.0 ± 1.2, 2.1-7.0               |

**Table 2.** Caregiver-reported effects of Hurricane Matthew (*N* = 151)

| Effect  | <i>n</i> (%) |
|---|--------------|
| Home was flooded or damaged                               | 49 (32.5)    |
| Home had mold or mildew as a result of flooding or damage | 39 (25.8)    |
| School was damaged or flooded                             | 48 (31.8)    |
| Problems with access to care                              | 31 (20.5)    |
| Ran out of asthma medication                              | 11 (7.1)     |
| Missed asthma medication doses                            | 11 (7.1)     |
| Problem obtaining asthma medicine from the pharmacy       | 13 (8.4)     |

The caregiver-reported effects of the hurricane are shown in Table 2. The most common effects were that the home was damaged or flooded (32.5%), the school was damaged or flooded (31.8%), and the home had mold or mildew as a result of flooding or damage (25.8%). Fewer families, but still at least 7% for each item, reported problems with access to care, including problems obtaining asthma medicine from the pharmacy, missed asthma medication doses, and running out of asthma medication.

Parents were more likely to report problems with access to care if their child was non-White ( $\chi^2 = 4.310$ ;  $P = 0.04$ ), on Medicaid ( $\chi^2 = 3.993$ ;  $P = 0.05$ ), or if the family spoke Spanish at home ( $\chi^2 = 20.628$ ;  $P < 0.001$ ). Spanish-speaking families were also more likely to report that their child's school was damaged or flooded ( $\chi^2 = 5.324$ ;  $P = 0.02$ ) and that they experienced problems with obtaining asthma medicine from the pharmacy ( $\chi^2 = 4.813$ ;  $P = 0.03$ ). No other responses to the hurricane questions were significantly associated with child race/ethnicity, Medicaid status, or language spoken at home.

Mean quality of life was 5.5 (SD 1.3) at baseline and 6.0 (SD 1.2) at 12 mo (Table 1). Variables that were significantly associated with lower asthma-related quality of life at 12 mo were: home flooded or damaged ( $t = 2.666$ ;  $P = 0.009$ ), home had mold or mildew as a

result of flooding/damage ( $t = 2.211$ ;  $P = 0.03$ ), problems with access to care ( $t = 2.201$ ;  $P = 0.03$ ), problems with running out of asthma medication ( $t = 2.905$ ;  $P = 0.004$ ), and problems with missing asthma medication doses ( $t = 2.498$ ;  $P = 0.01$ ).

In the multivariable regression predicting asthma quality of life at 12 mo, baseline quality of life ( $\beta = 0.448$ ;  $P < 0.001$ ), hurricane impact ( $\beta = -0.719$ ;  $P = 0.01$ ), and the interaction term between baseline quality of life and hurricane impact ( $\beta = 0.593$ ;  $P = 0.03$ ) were all significant. These results indicate that increased impact of the hurricane predicted lower 12-mo quality of life, with a greater effect when baseline quality of life was lower.

### Limitations

Limitations of the study include being limited to 1 region of North Carolina affected by 1 hurricane, limiting generalizability to other regions or other hurricanes. The study did not record which adolescents may have been from the same family. The randomized trial was ongoing at the time of the hurricane, which can be both a limitation because the study had to rely on self-report of hurricane impact from parents, and also, a strength because it was possible to ask families in the immediate aftermath of the hurricane. A strength was the diverse population enrolled in the study, with a majority of the adolescents receiving Medicaid. The present study was also performed in a rural area, unlike many studies that focused on urban New Orleans following Hurricane Katrina.

### Discussion

Hurricane Matthew appears to have affected North Carolina adolescents with asthma in many ways. Many families reported damaged or flooded homes with mold or mildew growth, which is a common asthma trigger. For some families, adolescents' health problems were exacerbated by difficulty accessing care, running out of asthma medication, or difficulty obtaining asthma medicine from the pharmacy. Some of the reported issues were more significant in adolescents who were non-White, Spanish-speaking, or on Medicaid.

The findings were similar to other studies that assessed the impact of hurricanes on the health of children and adolescents with asthma. The Head-off Environmental Asthma in Louisiana (HEAL) study in Louisiana also found that children living in homes with higher mold concentrations due to flooding experienced worse asthma symptoms.<sup>17</sup> The present study's findings also suggest an impact on asthma-related quality of life. At the time of peak impact, Hurricane Katrina had flooded a higher percentage of homes than the present study's study population reported from Matthew, but the HEAL study data were collected 2 y after the hurricane when many people previously affected had moved into cleaner homes or had their homes remediated.<sup>2</sup> The present study shows that measuring impact shortly after a hurricane also demonstrates a measurable impact on adolescents' asthma quality of life and access to care.

Populations known to suffer health disparities in the study region, including non-White adolescents, Spanish speakers, and adolescents receiving Medicaid, showed significantly greater quality-of-life impact, especially in terms of access to care. Following hurricanes, disaster relief providers should ensure that vulnerable populations receive the asthma medications they need to prevent asthma emergencies. When a hurricane approaches,

preventative community-level preparations should include outreach to families to ensure they can get a prescription filled before significant flooding and hurricane damage begin. Providers should also consider asking families of children with asthma if they have a hurricane plan, including a supply of medication in case they are unable to travel to the pharmacy for several weeks. Having a supply of medication on hand may help prevent spikes in asthma-related emergency department visits, such as the one that the New Jersey Department of Health observed after Hurricane Sandy.<sup>18</sup> In hurricane-prone areas, every family with a member who has asthma should also be educated about mold and mildew control in the home to minimize this common trigger.

### Conclusions

Families living with asthma in hurricane-prone regions, especially from disadvantaged populations, can be seriously affected in the aftermath of hurricanes. Medical and public health professionals in these areas must be ready to help families prepare for potential disruptions to their children's care before a hurricane landfall and mitigation strategies for allergen exposures after landfall.

**Acknowledgments.** The sponsor had no role in study design; the collection, analysis, and interpretation of data; the writing of the report; or the decision to submit the manuscript for publication.

**Author contribution.** Drs. Davis, Carpenter, Loughlin, and Sleath participated in the study design. All authors participated in the acquisition and analysis of data. Drs. Davis and Sleath participated in the drafting of the final manuscript. All authors participated in the critical review of the manuscript. All authors have given final approval to the manuscript.

**Funding.** This work was supported by the Patient-Centered Outcomes Research Institute (grant number CDR-1402-09777). Dr. Sleath is also supported by the National Center for Advancing Translational Sciences (NCATS), National Institutes of Health (Grant Award Number UL1TR002489).

**Competing interests.** The authors have no conflict of interest.

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