# Adverse Respiratory Symptoms and Environmental Exposures Among Children and Adolescents Following Hurricane Katrina

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## ABSTRACT

**Objectives.** Children and adolescents are especially vulnerable to environmental exposures and their respiratory effects. Following Hurricane Katrina in 2005, residents experienced multiple adverse environmental exposures. We characterized the association between upper respiratory symptoms (URS) and lower respiratory symptoms (LRS) and environmental exposures among children and adolescents affected by Hurricane Katrina.

**Methods.** We conducted a cross-sectional study following the return of the population to New Orleans after Hurricane Katrina (October 2005 and February 2006) among a convenience sample of children and adolescents attending New Orleans health facilities. We used uni-, bi-, and multivariable analyses to describe participants, exposures, and associations with URS/LRS.

**Results.** Of 1,243 participants, 47% were Caucasian, 50% were male, and 72% were younger than 11 years of age. Multiple environmental exposures were identified during and after the storm and at current residences: roof/glass/storm damage (50%), outside mold (22%), dust (18%), and flood damage (15%). Self-reported URS and LRS (76% and 36%, respectively) were higher after the hurricane than before the hurricane (22% and 9%, respectively, $p<0.0001$). Roof/glass/storm damage at home was associated with URS (adjusted odds ratio [AOR] = 1.59, 95% confidence interval [CI] = 1.15, 2.21) and LRS (AOR=1.35, 95% CI 1.01, 1.80), while mold growth at home was associated with LRS (AOR=1.47, 95% CI 1.02, 2.12).

**Conclusions.** Children and adolescents affected by Hurricane Katrina experienced environmental exposures associated with increased prevalence of reported URS and LRS. Additional research is needed to investigate the long-term health impacts of Hurricane Katrina.

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Hurricane Katrina, the deadliest hurricane to strike the United States since 1928, made landfall in the U.S. Gulf Coast Region on August 29, 2005.[1,2] Heavy rains, strong winds, and storm surges caused widespread damage in Louisiana, Mississippi, Florida, and Alabama.[3] New Orleans, Louisiana, a city largely below sea level, was particularly vulnerable to the hurricane's destructive force.[2] Large sections of New Orleans, as well as the surrounding parishes, remained flooded for weeks. As a result, excessive moisture coupled with the area's humid climate created optimal conditions for mold growth within buildings and on accumulated waste and debris from damaged homes.[4] Exposure to mold and damp indoor spaces can cause both upper respiratory symptoms (URS) and lower respiratory symptoms (LRS), and can trigger asthma attacks and allergic reactions,[5,6] with increased rates of respiratory symptoms among residents affected by widespread community flooding events.[7–9]

Following the storm, the Centers for Disease Control and Prevention (CDC) and the Louisiana Department of Health and Hospitals (LDHH) conducted an investigation of post-Katrina homes and found visible mold growth in 46% of inspected residences at levels equal to or above threshold levels associated with URS and LRS in previous studies investigating typical mold-associated symptoms, such as cough; airway hyper-reactivity; influenza-like symptoms; ear, nose, and throat irritation; and decreased lung function. Predominant fungi indoors and outdoors in this post-Katrina study were *Aspergillus subspecies* (*spp.*) and *Penicillium spp.* Measurements of indoor airborne endotoxin levels in households after Hurricane Katrina suggested a 20-fold elevation over levels measured in previous studies (outdoor levels were elevated up to 10-fold). Exposure to (1–>3)-β-D-glucan, a cell-wall component not specific to fungi, which has also been linked to respiratory health effects in previous studies, was also elevated in household measurements following Hurricane Katrina.[4]

These findings suggest that residents moving back to the area after Hurricane Katrina were at increased risk of both URS and LRS. Area hospitals reported increased numbers of patients with URS and LRS, with local doctors using the term "Katrina cough" to describe the respiratory symptoms (e.g., cough, congestion, runny nose, sore throat, and sinus headaches) that they believed to be attributed to the hurricane, including mold, dust, and irritating fumes circulating in the area's atmosphere following Hurricane Katrina.[10,11]

The LDHH conducted a case-control study to determine if the observed increases in URS and LRS were associated with exposures resulting from the hurricane.[12] The LDHH case-control study found no significant increase in URS and LRS within the New Orleans area when compared with rates in other parts of the state and country, and concluded that the proportions of respiratory conditions observed in New Orleans after the hurricane were similar to national data for the same time period.[12] Limitations of the LDHH case-control study included focusing only on emergency room visits for URS and LRS and not including patients visiting physician's offices or outpatient departments. At times when several hospitals and medical offices remained closed, excessive waiting hours in emergency rooms may have prevented patients with mild-to-moderate respiratory symptoms from seeking care in acute settings. In addition, the LDHH study focused on adult participants and did not include patients seen for well-visits, in diverse practice settings, or for non-respiratory chief complaints with concurrent respiratory symptoms.

As a result of these methodological limitations, associations between repercussions of the storm and URS and LRS may have been underestimated in the LDHH study. While children are a vulnerable population with specific health needs, especially after a natural disaster,[13] only 26 children and adolescents aged ≤24 years were included in the LDHH case-control study.[12] Children are at an increased risk of developing respiratory conditions after exposure to mold, dust, allergens, and other irritants, including sewage.[10,14–26] The purpose of this period cross-sectional study was to characterize associations between environmental and residential exposures and respiratory symptoms among a convenience sample of children and adolescents who sought care in the New Orleans metropolitan area immediately following Hurricane Katrina.

## METHODS

We used data collected from an anonymous, period, cross-sectional health survey (the Health Survey for Children and Adolescents After Katrina [HSCAAK]) for this analysis; methods have been described elsewhere.[13] Briefly, the HSCAAK was administered to a convenience sample of children and adolescents, aged ≤24 years, seeking care at participating sites in New Orleans between October 2005 and February 2006. Patients (or guardians) at all clinics offering pediatric and adolescent services were offered the study as they registered for the visit.

We examined self-reported residential exposures during and after the storm in association with self-reported clinical symptoms of URS and LRS based on standardized measures.[13] To assess differences in associations between children with and without preexisting chronic conditions, participants were categorized as

having a preexisting chronic condition if they answered "yes" to having diabetes, asthma, other chronic lung disease, allergies, human immunodeficiency virus/acquired immunodeficiency syndrome, other immune disease, heart defect/disease, cystic fibrosis, mental retardation, attention deficit hyperactivity disorder, autism, depression, other mental health or behavior problems, seizure disorder, sickle-cell disease, kidney failure/dialysis, or liver failure prior to August 2005. We used frequency distributions, univariate and bivariate analyses, as well as unadjusted and adjusted logistic regression analyses to describe the sample, assess the relationship between exposures and outcomes of interest, and evaluate potential confounders. We conducted frequency analyses to describe the prevalence of self-reported URS and LRS at the time of the clinic visit. McNemar's test was used to compare responses of reported URS and LRS before and after Hurricane Katrina.

To investigate the relationship between residential exposures and subsequent adverse health outcomes, we performed logistic regression to obtain unadjusted odds ratios (ORs) and adjusted ORs (AORs) among the whole study sample and among study participants with preexisting chronic conditions. Study participants indicated the total number of days exposed to outside environmental contaminants during the evacuation or since returning to New Orleans (irrespective of location to which they returned). We conducted simple and multiple logistic regression analyses to assess the association between number of days breathing outside environmental contaminants and reporting of URS and LRS. Variables associated with the outcomes of interest on the bivariable analysis with $p<0.20$ were included in a multivariable logistic regression model. In the full model, correlates with $p>0.10$ were eliminated using a manual, stepwise technique, starting with the variable with the largest $p$-value. If a variable was considered to be a confounder, or if its elimination caused a change in estimates of more than 5%, it was maintained in the model.

This study was designed to help direct future investigations related to the health effects of hurricanes among children; therefore, assessment of significance was not adjusted for Type I error. We performed analyses using SAS® version 9.1[27] and Stata® version 10.0.[28]

## RESULTS

Of 1,243 participants, the median age was 5.8 years (interquartile range [IQR] = 2.0, 11.9) and the majority of participants (72.2%) were aged <10 years (Table 1). Males comprised 50.3% of participants, and

**Table 1. Demographic and clinical characteristics of participants in a pediatric and adolescent health survey in New Orleans, Louisiana, October 2005–February 2006 (*n*=1,243)[a]**

| *Demographic/clinical characteristic* | N *(percent)* |
|---|---|
| Age (in years) | |
| <1 | 30 (11.2) |
| 1–≤4 | 397 (34.1) |
| 5–≤10 | 313 (26.9) |
| 11–≤15 | 213 (18.3) |
| 16–≤20 | 100 (8.6) |
| ≥21 | 10 (0.9) |
| Gender | |
| Male | 590 (50.3) |
| Female | 584 (49.7) |
| Race | |
| Caucasian | 525 (46.9) |
| African American | 493 (44.1) |
| Other/unknown | 100 (9.0) |
| Ethnicity | |
| Non-Hispanic | 858 (90.3) |
| Education of head of household | |
| <High school | 135 (10.9) |
| ≥High school diploma | 843 (67.8) |
| ≥College degree | 190 (15.3) |
| Unknown | 75 (6.0) |
| Primary language spoken at home | |
| English | 981 (96.3) |
| Health-care facility where seen | |
| Children's Hospital New Orleans—Specialty Clinics and emergency room | 794 (65.4) |
| Ochsner for Children Specialty Clinics | 162 (13.3) |
| Private practice in the New Orleans metropolitan area | 126 (10.4) |
| Covenant House Pediatric and Adolescent Community Clinic | 57 (4.7) |
| Convention Center and other urgent care facilities | 22 (1.8) |
| Purpose of visit to health-care provider | |
| A new health problem | 664 (59.3) |
| A problem that existed before Hurricane Katrina | 249 (22.2) |
| A physical/check-up/school enrollment or well-visit | 192 (17.1) |
| Combination of all | 15 (1.3) |
| Any preexisting chronic condition[b] | |
| Yes | 453 (40.6) |
| If yes, asthma | 194 (43.6) |
| Reported prevalence of clinical symptoms consistent with:[c] | |
| URS before Hurricane Katrina[d] | 242 (21.7) |
| URS after Hurricane Katrina[d] | 843 (75.6) |
| LRS before Hurricane Katrina[e] | 105 (9.4) |
| LRS after Hurricane Katrina[e] | 400 (36.0) |

*continued on p. 856*

**Table 1 (continued). Demographic and clinical characteristics of participants in a pediatric and adolescent health survey in New Orleans, Louisiana, October 2005–February 2006 (*n*=1,243)[a]**

| *Demographic/clinical characteristic* | N *(percent)* |
|---|---|
| Reported residential exposures at current residence | |
| Roof/glass/storm damage | 567 (50.0) |
| Mold | 232 (20.5) |
| Flood damage | 170 (15.0) |
| Reported outside exposures during or after Hurricane Katrina | |
| Mold | 212 (21.9) |
| Dust | 173 (17.9) |
| Chemicals | 64 (6.6) |
| Smoke/fumes | 52 (5.4) |
| Days of reported outdoor environmental exposures (mean [SD]) | |
| 0 | 696 (76.9) |
| 1 | 22 (2.4) |
| 2 | 24 (2.7) |
| 3–5 | 59 (6.5) |
| >5 | 104 (11.5) |
| Total | 4.52 (15.5) |

[a]Number missing from analysis ranges from 28 to 338 depending on question.

[b]Preexisting is defined as diagnosed or existing before August 2005.

[c]Number missing from analysis = 130; 1,113 respondents completed the symptoms panel.

[d]Those classified into URS reported clinical symptoms of runny nose, stuffy nose, sore throat, flu-like illness, ear infection, new-onset cough, new-onset headache, and/or red eye or eye drainage.

[e]Those classified into LRS reported clinical symptoms of shortness of breath, pneumonia/bronchitis, asthma attack, cough >2 weeks, and/or difficulty breathing.

URS = upper respiratory symptoms

LRS = lower respiratory symptoms

SD = standard deviation

46.9% of participants were Caucasian. Of participants, 78.7% of their parents or guardians had a high school education or less. Nearly two-thirds (65.4%) presented at pediatric emergency rooms; the primary reason for seeking health care was a new health problem (59.3%). A preexisting chronic condition (diagnosed or existing before August 2005) was reported by 40.6% of participants, with 17.2% reporting preexisting asthma and 11.5% reporting preexisting allergies (data not shown).

The majority of participants evacuated the New Orleans area (91.3%), and most (78.8%) did so before Hurricane Katrina made landfall on August 29, 2005; 34.9% reported returning to their original residence in the months immediately following the hurricane. Many experienced health-care disruptions due to the hurricane: 37.8% missed doctor appointments, 19.7% ran out of medications, and 8.0% missed an immunization. Of all children with preexisting conditions, asthma was the most common, representing 43.6% of all those with such conditions. Children with preexisting conditions were less likely than children without preexisting conditions to present at the clinic for new conditions (39.1% vs. 61.5%, $p<0.001$), more likely to be in school at the time the survey was conducted (74.8% vs. 58.7%, $p<0.001$), more likely to have repeated a grade (14.7% vs. 7.1%, $p<0.001$), and more current in vaccinations (87.0% vs. 76.2%, $p<0.001$). As reported previously,[13] children with chronic conditions experienced increased disruptions in care and negative consequences of the hurricane. Of the 81 children who evacuated and who ran out of medications, 19 (23.5%) specified that they ran out of asthma medications or were afraid of running out of asthma medications (data not shown).

The prevalence of self-reported URS and LRS post-Katrina was 75.6% and 36.0%, respectively, a significant increase over self-reported URS and LRS pre-Katrina (21.7% and 9.4%, respectively, $p<0.0001$) (Table 1). Increases in prevalence after the hurricane were identified for runny nose (12.7% vs. 58.4%; $p<0.0001$), stuffy nose (10.8% vs. 49.0%; $p<0.0001$), sore throat (3.6% vs. 30.7%; $p<0.0001$), flu-like illness (0.8% vs. 13.1%; $p<0.0001$), ear infection (6.6% vs. 16.1%; $p<0.0001$), new-onset cough (2.4% vs. 21.7%; $p<0.0001$), new-onset headache (1.3% vs. 10.5%; $p<0.0001$), red eye or eye drainage (1.3% vs. 4.7%; $p<0.0001$), shortness of breath (3.0% vs. 12.5%; $p<0.0001$), pneumonia/bronchitis (2.6% vs. 5.5%; $p<0.001$), asthma attack (4.4% vs. 9.1%; $p<0.0001$), cough >2 weeks (2.1% vs. 21.0%; $p<0.0001$), and difficulty breathing (1.9% vs. 10.9%; $p<0.0001$) (data not shown). Of those who reported symptoms after the hurricane, the symptom was not present before the hurricane in the majority of participants, including 49.9% of those reporting runny nose, 42.4% reporting stuffy nose, and 19.9% reporting cough of >2 weeks' duration (data not shown).

Participants reported substantial residential environmental exposures: 50.0% reported roof/glass/storm damage, 20.5% reported inside mold, and 15.0% reported flood damage (Table 1). Outside exposures were also commonly reported, including outside mold (21.9%), dust (17.9%), chemicals (6.6%), and smoke/fumes (5.4%). Duration of exposures varied with exposure via touch to sewage (median = 2.5 days; IQR 1, 5) or floodwater (median = 2 days; IQR 1, 4), breathing something that seemed unhealthy (e.g., mold, chemicals, dust, smoke, or fumes: median = 5.5 days; IQR 3, 30), drinking non-potable water (median = 4.5 days;

IQR 2, 8), or eating spoiled food (median = 3 days; IQR 1, 5) (data not shown).

Residential exposure to roof/glass/storm damage was significantly associated with URS and LRS in both unadjusted and adjusted logistic regression analyses (Table 2); residential exposure to mold was significantly associated with only LRS both before and after adjustment for confounders. Outside environmental exposures during or after the hurricane were associated with both URS and LRS. URS was significantly associated with outside-home exposure to mold and dust (Table 3); LRS was significantly associated with reported outside exposure to mold, dust, and smoke/fumes. After adjustment for confounders, child age as a continuous variable was associated with URS and LRS, with decreasing odds for every year increase in age.

The total number of days of exposure to harmful environmental contaminants during the evacuation or since returning to New Orleans was associated with both URS (AOR=1.02; 95% CI 1.00, 1.04; $p<0.05$) and LRS (AOR=1.03; 95% CI 1.02, 1.04; $p<0.0001$). Among participants with preexisting chronic conditions, the total number of days of exposure to environmental contaminants was significantly associated only with LRS (AOR=1.03; 95% CI 1.01, 1.05; $p<0.001$) (data not shown).

## DISCUSSION

This study provides a community-based sample of respiratory health experiences of children and adolescents returning to the New Orleans area during the year immediately following Hurricane Katrina. HSCAAK remains the only study of its kind that has assessed

**Table 2. Unadjusted and adjusted characteristics associated with URS and LRS in children and adolescents after Hurricane Katrina and residential exposures in New Orleans, Louisiana, October 2005–February 2006 (*n*=1,243)**

| | *URS*[a] | | *LRS*[b] | |
|---|---|---|---|---|
| *Characteristic* | *OR (95% CI)* | *AOR (95% CI)*[c] | *OR (95% CI)* | *OR (95% CI)*[c] |
| Gender | | | | |
| Male | 1.0 | 1.0 | 1.0 | 1.0 |
| Female | 1.06 (0.80, 1.41) | 1.14 (0.83, 1.56) | 0.85 (0.66, 1.09) | 0.86 (0.65, 1.13) |
| Race | | | | |
| African American | 1.0 | 1.0 | 1.0 | 1.0 |
| Caucasian | 1.25 (0.92, 1.68) | 1.22 (0.87, 1.70) | 0.96 (0.73, 1.25) | 1.00 (0.75, 1.35) |
| Age (yearly increase) | 0.94 (0.92, 0.97)[d] | 0.94 (0.91, 0.97)[d] | 0.96 (0.94, 0.99)[e] | 0.96 (0.94, 0.99)[e] |
| Mold | | | | |
| No | 1.0 | 1.0 | 1.0 | 1.0 |
| Yes | 1.85 (1.25, 2.75)[e] | 1.51 (0.95, 2.40) | 1.48 (1.09, 2.01)[f] | 1.47 (1.02, 2.12)[f] |
| Flood damage | | | | |
| No | 1.0 | 1.0 | 1.0 | 1.0 |
| Yes | 1.68 (1.08, 2.61)[f] | 1.51 (0.89, 2.56) | 1.23 (0.87, 1.74) | 1.09 (0.72, 1.64) |
| Roof/glass/storm damage | | | | |
| No | 1.0 | 1.0 | 1.0 | 1.0 |
| Yes | 1.68 (1.26, 2.24)[g] | 1.59 (1.15, 2.21)[e] | 1.33 (1.03, 1.72)[f] | 1.35 (1.01, 1.80)[f] |

[a]"URS" consist of clinical symptoms such as runny nose, stuffy nose, sore throat, flu-like illness, ear infection, new-onset cough, new-onset headache, and/or red eye or eye drainage.

[b]"LRS" consist of clinical symptoms such as shortness of breath, pneumonia/bronchitis, asthma attack, cough >2 weeks, and/or difficulty breathing.

[c]Estimates were adjusted for all other variables listed in column.

[d]$p<0.0001$

[e]$p<0.01$

[f]$p<0.05$

[g]$p<0.001$

URS = upper respiratory symptoms

LRS = lower respiratory symptoms

OR = odds ratio

CI = confidence interval

AOR = adjusted odds ratio

**Table 3. Unadjusted and adjusted characteristics associated with URS and LRS in children and adolescents after Hurricane Katrina and outdoor exposures in New Orleans, Louisiana, October 2005–February 2006 (*n*=1,243)**

| | URS[a] | | LRS[b] | |
|---|---|---|---|---|
| *Characteristic* | *OR (95% CI)* | *AOR (95% CI)[c]* | *OR (95% CI)* | *AOR (95% CI)[c]* |
| Gender | | | | |
| Male | 1.0 | 1.0 | 1.0 | 1.0 |
| Female | 1.06 (0.80, 1.41) | 1.11 (0.80, 1.56) | 0.85 (0.66, 1.09) | 0.88 (0.65, 1.18) |
| Race | | | | |
| African American | 1.0 | 1.0 | 1.0 | 1.0 |
| Caucasian | 1.25 (0.92, 1.68) | 1.25 (0.88, 1.77) | 0.96 (0.73, 1.25) | 0.85 (0.62, 1.17) |
| Age (yearly increase) | 0.94 (0.92, 0.97)[d] | 0.94 (0.91, 0.97)[d] | 0.96 (0.94, 0.99)[e] | 0.95 (0.93, 0.98)[f] |
| Mold | | | | |
| No | 1.0 | 1.0 | 1.0 | 1.0 |
| Yes | 2.93 (1.83, 4.71)[d] | 1.95 (1.05, 3.63)[g] | 2.69 (1.96, 3.70)[d] | 1.92 (1.21, 3.05)[e] |
| Dust | | | | |
| No | 1.0 | 1.0 | 1.0 | 1.0 |
| Yes | 4.21 (2.33, 7.58)[d] | 3.37 (1.54, 7.38)[e] | 2.89 (2.05, 4.07)[d] | 2.12 (1.27, 3.55)[e] |
| Smoke/fumes | | | | |
| No | 1.0 | 1.0 | 1.0 | 1.0 |
| Yes | 2.77 (1.09, 7.09)[g] | 1.51 (0.52, 4.39) | 3.22 (1.77, 5.83)[d] | 2.60 (1.24, 5.46)[g] |

[a]"URS" consist of clinical symptoms such as runny nose, stuffy nose, sore throat, flu-like illness, ear infection, new-onset cough, new-onset headache, and/or red eye or eye drainage.

[b]"LRS" consist of clinical symptoms such as shortness of breath, pneumonia/bronchitis, asthma attack, cough >2 weeks, and/or difficulty breathing.

[c]Estimates were adjusted for all other variables listed in column.

[d]$p<0.0001$

[e]$p<0.01$

[f]$p<0.001$

[g]$p<0.05$

URS = upper respiratory systems

LRS = lower respiratory systems

OR = odds ratio

CI = confidence interval

AOR = adjusted odds ratio

health outcomes among children and adolescents following the storm. The results suggest that children and adolescents faced multiple types of residential and environmental exposures during their evacuation and return to New Orleans, thereby potentially compromising their respiratory health and suggesting an overall significant increase in URS and LRS after the storm.

These findings echo those found in other studies,[4,10,11,23,25,26,29] providing additional self-reported information on a child- and adolescent-specific sample that is often missed in larger studies or focused outbreak investigations. Findings suggest that there is a relationship between environmental exposures and URS and LRS, which can be exacerbated by adverse exposures, and may be worse in children and adolescents with preexisting health conditions. Younger children are at particular risk of adverse exposures on respiratory health. We found that relatively few children ran out of medications or were afraid of running out of medications, suggesting that our findings are unlikely the result of medication need.

This study also represents a unique opportunity to describe the relationship between adverse exposures faced by children and adolescents returning to New Orleans after Hurricane Katrina and the impact of these exposures on post-hurricane respiratory symptoms. These findings suggest that there may be a relationship between adverse post-Katrina exposures and URS and LRS, which may be dose-dependent and differential based on the child's preexisting disease status and age. Recognizing that some children may be disproportionately affected during and after hurricanes is essential to take preventive measures for these subsets of the population in advance of future hurricanes

making landfall, or at least in advance of these subsets of the population returning to hurricane-affected areas. Small children may be more sensitive and intensely exposed to household environmental hazards when playing near the ground and potentially inhaling or ingesting toxic substances. To prevent unnecessary harm to the health of children and adolescents after a natural disaster, meticulous cleanup of property destroyed by floodwater, mold, dust, and storm damage is essential, as is outside community-level remediation of environmental toxins.

### Limitations

This study had several limitations. First, the study's cross-sectional design prevented attribution of temporality or causality. All exposures and outcomes data were collected at one time point and may have been influenced by the occurrence of the storm and personal experiences, as well as recall bias. Estimates of exposure were not validated by exposure measurements or medical chart abstraction and, thus, may have resulted in misclassification. For children with preexisting conditions, given that they were self-reported, challenges in determining whether there were comorbidities or other medical concerns limited our ability to stratify by asthma status.

In addition, environmental exposures may have been accurately recalled at different rates. For example, residential roof/glass/storm damage is more noticeable than residential mold growth or water damage. Large-scale prospective surveillance studies should quantify inside and outside home exposures in high-risk environments and assess the prevalence of LRS and URS in children with and without preexisting conditions over time.

Other limitations of the study included using a convenience sample of children and adolescents seeking medical care, which prevented us from being able to generalize our findings to the larger population of New Orleans. However, this study sampled at all of the facilities that were functioning after the storm and rolled out to each of the facilities as they reopened, thus making this study representative of all the open facilities, even if they were not randomly selected. In view of the extraordinary circumstances following Katrina, collection of denominator data that would have provided an estimate of response rate was not possible; however, qualitative data from providers suggest that there were very few refusals. The relatively long survey was completed in most cases, and extensive comments were written on the forms; these comments suggest that participants comprehended the survey and took it seriously.

## CONCLUSIONS

Children and adolescents are a vulnerable population with specific health needs and warrant special attention, especially after a natural disaster. The increased prevalence of respiratory symptoms among children and adolescents with preexisting health conditions highlights a population at particularly high risk of developing adverse respiratory events following environmental exposures. Future studies are critically needed to continue to examine the adverse health effects of natural disasters on children and adolescents as a vulnerable population.

All instruments and study procedures were approved prior to administration of the survey by the governing Institutional Review Boards of the Children's Hospital, Tulane Hospital, George Washington University, and Ochsner Hospital and Clinic.

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