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ARTICLE

Evaluation of the patterns of potentially toxic exposures in Mississippi following Hurricane Katrina

ROBERT COX[1], TERESA AMUNDSON[2], and BRUCE BRACKIN[3]

[1]*Medical Toxicology Service, Department of Emergency Medicine, The University of Mississippi Medical Center, Jackson, Mississippi, USA*
[2]*Mississippi Poison Control Center, The University of Mississippi Medical Center, Jackson, Mississippi, USA*
[3]*Mississippi Agromedicine Program, The University of Mississippi Medical Center, Jackson, Mississippi, USA*

Objective. To describe the changes in the frequency of selected toxic exposures reported to the state poison control center following Hurricane Katrina. *Methods.* The numbers of selected exposures reported to the Mississippi Poison Control Center at 0–2 weeks, 3–4 weeks, and 5–12 weeks following Hurricane Katrina were compared to those for the same time periods in the previous 3 years. Absolute numbers of exposures and odds ratios with confidence intervals were used for comparison. *Results.* In the first 2 weeks following Hurricane Katrina, there were 44 reported gasoline exposures compared to 7 expected, 8 lamp oil exposures compared to 1 expected, and seven carbon monoxide exposures compared to 1 expected. Only gasoline exposures remained elevated in the second 2 weeks period following the hurricane. Lamp oil exposures were elevated during the 5–12 week recovery period. There was no increase in the frequency of exposures to household cleaning agents, food poisoning, pediatric exposures, drug-related suicide events, bites and stings, or venomous snakebites. *Conclusions.* The most common toxic exposures following Hurricane Katrina were related to the lack of typical energy sources, electricity, and gasoline.

Keywords Hurricane; Disaster preparedness; Gasoline; Hydrocarbons; Carbon monoxide; Poison control centers

Introduction

In late August of 2005, Hurricane Katrina quickly became the most catastrophic hurricane ever to hit the shores of the United States. The Category 4 storm made landfall August 29 on the Mississippi Gulf Coast with winds up to 132 mph and a storm surge estimated at 27 feet in Hancock County, MS. It continued on a northeasterly path through Mississippi destroying homes, roadways and the electrical system over a large portion of the state. The path of Hurricane Katrina through Mississippi is shown in Figure 1. As of March 20, 2006, Mississippi's confirmed death toll was 238, while the overall death toll came to at least 1,604.

The impact of Hurricane Katrina lasted well after the storm. Over 900,000 homes and businesses in Mississippi lost power after the hurricane. This accounted for 64% of the state's electrical customers (1). One week later, over 40% still lacked power. A gasoline shortage plagued the state for approximately 2 weeks after the hurricane. Nearly 78,000 homes were damaged and 4,000 completely destroyed. An estimated 45,000 families in Mississippi were displaced (2). An assessment by the Centers for Disease Control and Prevention in Hancock County 2 weeks after the hurricane showed that 41% of the remaining households still lacked electricity, 21% lacked running water, 37% lacked a functioning toilet, 53% had no telephone, and 26% had no access to transportation (3). Many of the state's hospitals were either temporarily closed or had limited services for the first week following the hurricane. Some hospitals located in coastal counties had limited services for several months. Hurricane Katrina had a profound effect on the lives of the residents of Mississippi and Louisiana. Even for those fortunate enough to have an intact home, the lack of electricity, gasoline, food, water, and medical services impacted daily routines and activities. These disruptions lasted for weeks to months.

Exposures to potentially toxic substances are one of the dangers that can occur in the recovery period following a hurricane. Previous studies have demonstrated an increased number of carbon monoxide exposures following hurricanes (4–8) and an increased number of exposures to gasoline (7). A larger than expected number of bites and stings were observed in Emergency Department visits following Hurricane Hugo in North Carolina (9). An increased percentage of hydrocarbon and bleach ingestions was observed in a Pediatric Emergency Department following Hurricane Andrew in Florida (10). The purpose of this study was to attempt to determine if there was any change in the patterns of exposures to potentially toxic

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Address correspondence to Robert Cox, Medical Toxicology Service, Department of Emergency Medicine, The University of Mississippi Medical Center, 2500 North State St., Jackson, Mississippi 39216-4505, USA. E-mail: rcox@emergmed.umsmed.edu

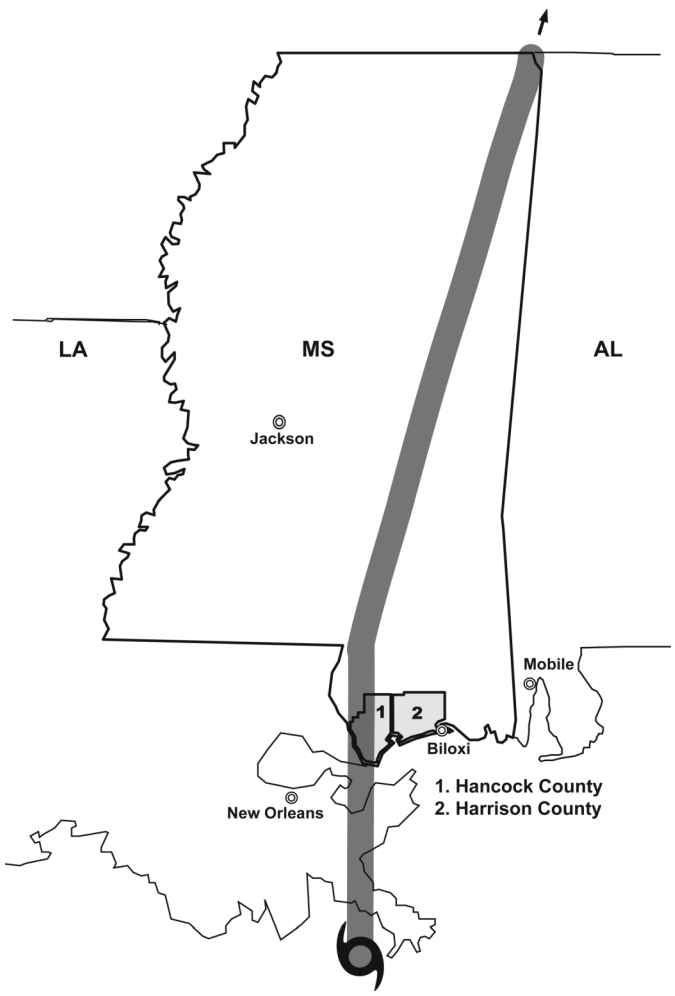

Fig. 1. The path of Hurricane Katrina through Mississippi.

substances in Mississippi following Hurricane Katrina. This type of information will be useful in helping to plan for medical response to future hurricanes and the type of educational programs required to help prevent toxic exposures following future hurricanes or other natural disasters.

Materials and methods

Setting

The Mississippi Poison Control Center (MPCC) is the only poison control center for the state of Mississippi and it serves the entire state. It fielded nearly 28,500 poisoning-related calls in 2005. The population of Mississippi in 2005 was approximately 2.9 million.

Study design

This study was a retrospective analysis using data from the Mississippi Poison Control Center's call database. The number of selected types of exposures and information calls at 0–2 weeks, 3–4 weeks, and 5–12 weeks following Hurricane Katrina was compared to the corresponding number of exposures during the same time periods for the previous 3 years. We chose to study exposures that have been reported to occur with an increased frequency following hurricanes or that were deemed a concern by poison center staff in this situation. Carbon monoxide exposures have been reported following hurricanes in several studies (4–8). Other exposures that have been reported to increase following hurricanes include hydrocarbons (7,10), bleach (10), insect bites and stings (11), and psychiatric problems (12–14). Lamp oil and gasoline were separated from general hydrocarbons due to a perceived increase in volume of calls by the MPCC staff following Hurricane Katrina. Food poisoning was chosen due to the lack of electricity, potable water, and functioning toilets (3). Pediatric drug exposures and all pediatric exposures were included in the analysis due to the experience of poison center staff working at disaster shelters. The University of Mississippi Human Assurances Committee exempted this study from the institution's human subjects research requirements.

Subjects

Due to the large number of residents displaced by the hurricane and staying in shelters throughout the state, the decision was made not to limit the study to those counties directly affected by the hurricane. During the height of the response, there were 13,673 evacuees in registered shelters in Mississippi (2). Of the estimated 45,000 families displaced by the hurricane, it is unknown how many were staying with families in the state and how many left the state. There were also many Louisiana residents staying in shelters in Mississippi following Hurricanes Katrina and Rita. There was no way to reliably exclude calls from out of state residents who were residing in Mississippi following the hurricanes. Thus, the study group was all those individuals residing in Mississippi before and after Hurricane Katrina that reported potentially toxic exposures to the MPCC.

Data collection and processing

Data from each call to the MPCC is entered into a database, CasePro® (Rocky Mountain Poison and Drug Center, Denver, CO), that is written on Microsoft Sequel® Database (Microsoft Corporation, Redmond, WA). The numbers of individual exposures and types of calls per month were extracted using queries written on Microsoft Access® (Microsoft Corporation, Redmond, WA) from tables within the database that did not contain patient or caller identifiers. All calls placed to the MPCC between August 29, 2005 and November 30, 2005 were selected for evaluation in the post-hurricane period. The calls received during the same time periods from 2001–2004 were used for comparison.

Primary data analysis

The number of selected exposures was calculated for each time period following Hurricane Katrina and for the same time periods for the previous three years. Odds ratios with confidence limits were used to provide an indication of a change in the frequency of individual exposures in the periods following the hurricane. These were calculated using InStat (GraphPad Software, Inc., San Diego, CA). Confidence levels were calculated at the 95 percent level. Statistical significance was considered when the confidence intervals did not include unity.

Results

During the 12-week study period following Hurricane Katrina, the MPCC fielded 6,669 calls relating to humans, including 4,552 exposure calls and 2,117 information calls. This constituted a 13 percent increase over the average call volume (5,892 calls) over the same time period for the previous 3 years. There was an 8% increase in exposure calls, 4,552 in 2005 compared to an average of 4,202 in 2002–2004, and a 25% increase in information calls, 2,117 in 2005 compared to an average of 1,691 for 2002–2004. Precise categorization of the types of information calls following the hurricane was not possible within the Center's database. However, drug identification calls (pill IDs) were tracked and increased 43% from an average of 1,067 calls for the 12-week period in 2002–2004 (63% of information calls) to 1,525 in 2005 (72 percent of information calls). The two counties that suffered the most damage, Hancock and Harrison, are shown in Fig. 1. Calls from Hancock County, decreased from an average of 36 calls per month to 8 calls in September and 15 calls per month for the next 3 months. In Harrison County calls to the MPCC decreased from an average of 293 calls per month to 225 calls per month for the 3 months following the hurricane.

Results for types of exposures are shown in Table 1. There was an increase in lamp oil exposures in the first 2 weeks following the hurricane, with 8 cases being reported compared to an average of less than one case during that time period for the previous 3 years. There were no cases of lamp oil exposure reported in weeks 3–4 following the hurricane, but there were 6 cases reported in weeks 5–12 after the hurricane. There was a large increase in the number of gasoline exposures up to 4 weeks after the hurricane, but not for the 5–12 week period. Carbon monoxide cases reported to the MPCC were increased during the first 2 weeks following the hurricane. This was mainly due to a family of 5 that was using an indoor generator 2 days after the hurricane. There was no increase in carbon monoxide exposures for the 3–4 week period, but there was a non-significant increase during the 5–12 week post-hurricane period.

There was no observed increase in the number of exposures to household cleaning agents, pediatric drug exposures, or total pediatric exposures. There also was no increase in the numbers of bites and stings, venomous snakebites or food poisoning following the hurricane. There was no observed increase in drug-related suicide events reported to the MPCC during any of the time periods following the hurricane.

Discussion

In the immediate aftermath (1–2 days) of hurricanes, traumatic injuries are usually the major medical concern. During the recovery period this transitions into other types of medical problems such as infectious diseases and those relating to the lack of food, potable water, energy sources, sewage disposal, and lack of medical care and medications. Alternative fuel sources used for electricity and light provide the potential for human contact and toxic consequences. Crowded shelters provide the opportunity for children to gain access to adult's medications. Many adults keep their medications in unlabeled containers and depend on their local pharmacies to know their medications. Emergency planners need to know the types of potentially toxic exposures that are most likely following a hurricane or similar natural disaster.

Similar to previous studies, we observed an increased number of carbon monoxide exposures following the hurricane (4–8). Seven cases of carbon monoxide exposure were reported to the MPCC in the first 2 weeks following the hurricane. Multiple radio and television public service announcements concerning the proper ways to use portable generators were made during the year preceding Hurricane Katrina. Additional announcements were made in the weeks following the hurricane, but it is uncertain how many of those affected heard them due to the lack of electricity. There was only a single case of carbon monoxide exposure reported during the next 2 weeks, but there were seven more cases during weeks 5–12 following the hurricane. A survey of hyperbaric oxygen (HBO) facilities in Alabama, Mississippi and Louisiana reported treating six cases of carbon monoxide poisoning from Mississippi in the 4 weeks following Hurricane Katrina (5). Records of the carbon monoxide cases reported to the MPCC did not indicate that any of the cases were treated at HBO centers. Thus, the six cases mentioned from the review of HBO facilities are probably in addition to those cases reported here. Given the inherent differences in the reporting systems of HBO centers and poison control centers and the subtlety of symptoms associated with carbon monoxide toxicity, both systems probably underestimate the total number or exposures. The use of portable gasoline-driven electric generators has become widespread. Although these come with warnings to only use outdoors, they are still used inside or in garages, usually in an attempt to keep them from being stolen. A previous study in Florida showed that 17.5% of homeowners used portable generators and improper placement of these accounted for over 96 percent of the carbon monoxide poisonings following hurricanes (6). Despite numerous press releases and public announcements in the year preceding Hurricane Katrina and in the immediate

Table 1. Reported numbers of selected exposures in Mississippi following Hurricane Katrina

	Weeks after hurricane		
Exposure/call type	0–2	3–4	5–12
All human exposures			
2005	679	865	3,008
2002–2004 ave (range) [total]	748 (671–816) [2243]	666 (597–747) [1999]	2788 (2668–2933) [8363]
Lamp oil			
2005	8	0	6
2002–2004 ave (range) [total]	0.7 (0–1) [2]	1.3 (0–2) [4]	1 (0–3) [3]
OR (95% CI)	13.4 (2.8–63.1)	0.3 (0–4.8)	5.6 (1.4–22.3)
Gasoline			
2005	44	25	28
2002–2004 ave (range) [total]	7 (5–10) [21]	9 (7–13) [28]	29 (25–36) [87]
OR (95% CI)	7.3 (4.3–12.4)	2.1 (1.2–3.6)	0.9 (0.6–1.4)
Carbon monoxide			
2005	7	1	7
2002–2004 ave (range) [total]	1 (0–3) [3]	1.3 (0–3) [4]	2.7 (0–5) [8]
OR (95% CI)	7.8 (2.0–30.2)	0.6 (0–5.2)	2.4 (0.9–6.7)
Bites and stings*			
2005	23	21	75
2002–2004 ave (range) [total]	27 (26–31) [83]	25 (21–31) [75]	60 (53–65) [181]
OR (95% CI)	0.9 (0.6–1.5)	0.6 (0.4–1.0)	1.2 (0.9–1.5)
Venomous snakebites			
2005	5	8	18
2002–2004 ave (range) [total]	7.7 (6–10) [23]	10 (7–13) [30]	14 (12–17) [42]
OR (95% CI)	0.7 (0.3–1.9)	0.6 (0.3–1.3)	1.2 (0.7–2.1)
Food Poisoning			
2005	6	7	19
2002–2004 ave (range) [total]	4 (3–7) [12]	5.3 (2–9) [16]	20 (16–26) [61]
OR (95% CI)	1.7 (0.6–4.4)	1 (0.4–2.5)	0.9 (0.5–1.5)
Household cleaning agents			
2005	44	67	259
2002–2004 ave (range) [total]	51 (47–60) [154]	60 (48–69) [180]	224 (214–237) [671]
OR (95% CI)	0.9 (0.7–1.3)	0.8 (0.6–1.1)	1.1 (0.9–1.3)
Drug-related suicide calls			
2005	47	59	200
2002–2004 ave (range) [total]	65 (57–75) [194]	51 (48–56) [153]	232 (200–254) [695]
OR (95% CI)	0.8 (0.6–1.1)	0.9 (0.6–1.2)	0.8 (0.7–0.9)
Pediatric exposures†			
2005	311	429	1,528
2002–2004 ave (range) [total]	377 (311–378) [1132]	348 (315–429) [1045]	1444 (1432–1453) [4332]
OR (95% CI)	0.8 (0.7–1.0)	0.9 (0.8–1.0)	1.0 (0.9–1.0)
Pediatric drug exposures†			
2005	119	207	699
2002–2004 ave (range) [total]	164 (153–179) [493]	151 (134–168) [453]	650 (612–671) [1951]
OR (95% CI)	0.8 (0.6–0.9)	1.1 (0.9–1.3)	1.0 (0.9–1.1)

*Excluding venomous snakebites.
†Children < 6 years old.

post-hurricane period, this continued to be a problem in Mississippi.

Gasoline shortages plagued Mississippi for approximately two weeks following Hurricane Katrina. In some coastal areas shortages existed for a longer period of time. For the first 4 weeks following Hurricane Katrina, we observed a significant increase in gasoline exposures. Siphoning was mentioned in the call records in 48 of the 69 cases (70%) of gasoline exposure that were reported during the first 4 weeks following the hurricane. Gasoline

exposures due to siphoning were also observed by the Florida Poison Information Center Network following Hurricanes Wilma and Fran in 2005 (7). An increase of pediatric hydrocarbon aspiration cases that was not statistically significant following Hurricane Andrew in 1992 has also been reported (10).

In the absence of electricity, oil lamps are commonly used for light in Mississippi. Unfortunately, the lamps or the oil are commonly put in places where children can gain access to them. Although the numbers of lamp oil exposures were not as large as those for gasoline exposures, there was a significant increase in lamp oil exposures in first 2 weeks following Hurricane Katrina and again in the 5–12 week recovery period.

During floods, snakes are reported to seek higher ground. This can increase the likelihood of human contact immediately following the flood and during cleanup activities. Hurricane Katrina produced significant flooding in coastal areas of Mississippi and scattered flooding in other areas of the state. Venomous snakebites are common in Mississippi, with 123 venomous snakebites reported to the MPCC in 2004 and 111 in 2005. There was no increase in the number of venomous snakebites reported to the MPCC in any of the time periods studied following Hurricane Katrina.

Bites and stings were reported as reasons for seeking emergency medical care following Hurricane Hugo (11). No significant increase in bites and stings was detected in Florida following the 2005 hurricane season by using poison control data (7) and no increase in reported cases was detected in Mississippi in this study. The differences are most likely a result of how data was collected in each study. The data following Hurricane Hugo was collected from seven emergency departments. The data collected here and in Florida in 2005 were from poison control centers that depend on independent reporting. Many people may not consider a bite or sting reason to contact a poison control center but instead directly seek emergency medical care. Medical personnel in emergency departments may not report bites and stings to poison control centers.

Living situations following hurricanes provide opportunities for children to come into contact with potentially toxic substances. Large numbers of people were cramped into recovery shelters for several weeks and in some cases, months. According to American Red Cross Guidelines, all individuals were responsible for keeping their own medications, allowing potential access for children. For these reasons, we felt it important to examine pediatric exposures. We observed no increase in all pediatric exposures or in pediatric drug exposures in the time periods studied following Hurricane Katrina. When families were returning to their homes for cleanup, there was an opportunity for children or adults to ingest or contact cleaning agents. A non-significant increased percentage of pediatric bleach ingestions was observed after Hurricane Andrew (10). Following Hurricane Katrina, no increase in exposures to household cleaning agents was observed in Mississippi.

Previous studies have shown an increase in psychiatric complaints and suicide attempts (12) and an increase in the use of mental health services (13) and sleep disturbances (14) following hurricanes. One study from a children's hospital did not show an increase in psychiatric problems in children following Hurricane Andrew (10). Poison control centers are a good source for tracking suicidal drug overdoses. In the present study, no increases in drug-related suicide events were observed in the weeks immediately after the hurricane or in the recovery period.

Following the hurricane there was a large number of displaced people living in shelters. Many of these people needed assistance with identifying their medications. There was an increase in the number of calls from pharmacists, health-care workers, shelter workers, and individuals requesting assistance with drug identification. The MPCC also fielded a number of calls concerning the drinkability of water in certain areas, food safety, and questions about availability of medical resources. In this regard, the local poison control center became a valuable resource in dissemination of health-care and safety information in the post-hurricane period.

Limitations

The major limitation of this study is possible under-reporting of potentially toxic exposures. In the several weeks following Hurricane Katrina phone systems were down in portions of the state. Bellsouth estimated 600,000 customers without electricity immediately after the hurricane (2). Two weeks after the hurricane, 53% of the remaining households in Hancock County, the county hardest hit, were without a working telephone (3). It is also possible that Disaster Management Assistance Teams and emergency medical workers were too busy to report some exposures to the state poison control center. All of these factors would have had the greatest effect in the 2 weeks following the hurricane.

It is also possible that the general public would not routinely report some of the factors that were studied to a poison control center, such as insect bites or food poisoning. Mild carbon monoxide toxicity presents with vague symptoms, such as headache, fatigue, and dizziness and these cases could have gone undiagnosed. It is also probable that hyperbaric oxygen treatment centers did not report cases of carbon monoxide poisoning or reported them to neighboring states, depending on where they were located.

This study documented the types of exposures seen in Mississippi following a devastating hurricane. Large portions of Mississippi are rural, including many of the areas that were hardest hit. Many of these areas were economically depressed prior to Hurricane Katrina. Although the demographics would be similar for coastal areas of Louisiana, caution should be used in extrapolating these results to other areas. For example, in areas of Florida that are more economically advantaged, the availability and use of electrical generators may be much more widespread.

Conclusions

Following Hurricane Katrina, the main change in toxic exposures that was reported in Mississippi was related to the lack of typical energy sources – gasoline and electricity. Lamp oil and carbon monoxide exposures were increased in the first 2 weeks following the hurricane and gasoline exposures were increased for 4 weeks afterwards. The MPCC played an integral role in the dissemination of public health information and assisting in the identification of medications for those who were displaced from their homes. There was no observed increase in the number of pediatric drug or poison exposures, venomous snakebites, other bites and stings, exposures to household cleaning agents or reported cases of food poisoning. There was no increase in the number of suicide-related drug exposures reported to the MPCC. Poison centers can serve a vital role in the dissemination of health-care information following natural disasters. Using information collected from routine poison center operations can aid in health-care planning for future natural disasters.

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