munity (*2,3*). As needs change, repeat assessments also can be instrumental in determining changing community needs.

A cluster sample design, such as the one used in Hancock County, can be applied when limited information is available regarding persons who did not evacuate and when identifying geographic features are destroyed or missing. This assessment used geographic information systems (GIS) to randomly select households to interview in each selected cluster and GPS units to navigate to those selected households. This represents one of the first times that GIS and GPS have been used in such situations.

The findings in this report are subject to at least four limitations. First, no stable population estimates existed, so the survey design was based on preexisting population distribution. Second, the response rate for the survey was 41%. The assessment was conducted during daytime hours, and the occupants of the selected homes and proxies might have been at work or might have evacuated the area. All information was obtained during a single attempt to locate and identify a household member or proxy to interview. No repeat attempts to visit the targeted households were possible. Third, because of a small sample size, the confidence intervals are wide, offering less precision in the results. Finally, the survey obtained household information and could not make inferences about individual persons.

More than 2 weeks after Hurricane Katrina struck, many residents were still without power, telephone service, and functioning indoor toilets. Trash removal posed an ongoing problem, and mosquitoes were a concern of many residents, despite distribution of insect repellent. In response to the survey findings, MDH implemented aerial pesticide spraying for the county and provided education on preventing mosquito breeding and bites and recognizing signs and symptoms of mosquito-borne illness. This assessment also revealed additional health needs (e.g., for prescription medication and medical care) in the community and led MDH to identify methods to assess and publicize available medical facilities, pharmacies, and mental health services.

Filling gaps in information during the response and recovery phases of disasters is critical to discovering and addressing any needs that might produce adverse human health outcomes. Rapid community needs assessments continue to be an important tool in this process.

Acknowledgments

The findings in this report are based, in part, on contributions by the Mississippi Hospital Augmentation Team, US Public Health Svc; and the Mississippi Illness and Injury Surveillance Team, CDC.

References

1. National Weather Service. Extremely powerful Hurricane Katrina leaves a historic mark on the northern Gulf Coast. Mobile, AL: National Weather Service; 2005. Available at http://www.srh.noaa.gov/mob/0805Katrina.
2. CDC. Rapid community health and needs assessments after Hurricanes Isabel and Charley—North Carolina, 2003–2004. MMWR 2004; 53:840–2.
3. CDC. Rapid assessment of the needs and health status of older adults after Hurricane Charley—Charlotte, DeSoto, and Hardee Counties, Florida, August 27–31, 2004. MMWR 2004;53:837–40.

Carbon Monoxide Poisonings After Two Major Hurricanes — Alabama and Texas, August–October 2005

Hurricanes Katrina and Rita struck the U.S. Gulf Coast on August 29, 2005, and September 24, 2005, respectively, causing widespread damage and leaving approximately 4 million households without electrical power (*1,2*). Despite public health measures to prevent carbon monoxide (CO) poisonings after major power outages, multiple CO poisonings were reported in Gulf Coast states in the wake of these hurricanes (*3*). The Alabama Department of Public Health and Texas Department of State Health Services asked CDC to assist in investigating the extent and causes of these hurricane-related CO poisonings. The investigation identified 27 incidents of CO poisoning resulting in 78 nonfatal cases and 10 deaths in hurricane-affected counties in Alabama and Texas, nearly all of which were caused by gasoline-powered generators. Most of the generators involved were placed outside but close to the home to power window air conditioners (ACs) or connect to central electric panels. Few homes had functioning CO detectors. CDC continues to recommend that generators be placed far from homes, away from window ACs, and that CO detectors be used by all households operating gasoline-powered appliances (e.g., generators and gas furnaces), with batteries replaced yearly. Although the risk for CO poisoning likely decreases as generators are placed further from the home, additional studies are needed to establish a safe distance for generator placement.

For this analysis, a case was defined as an illness among persons of any age residing in Alabama during August 28–November 1, 2005, or in Texas during September 20–November 1, 2005, with a diagnosis consistent with CO poisoning. Confirmed cases were those in which the affected person had an elevated blood carboxyhemoglobin (COHb) level (>2% for nonsmokers and >9% for smokers). Probable cases were those in persons who did not have an elevated COHb level or did not have a COHb level documented.

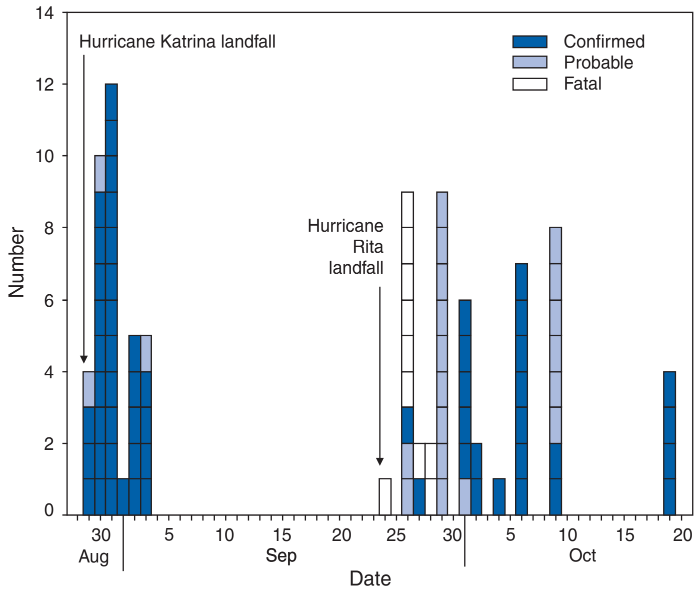
Eighteen counties were included in this investigation: the two Alabama counties* along the coast most affected by Hurricane Katrina and the 16 Texas counties† with peak wind gust from Hurricane Rita of >80 mph in the majority of the county (*4*) or with at least one media-reported CO poisoning fatality. Case finding was conducted through review of medical charts coded as CO poisoning on the basis of *International Classification of Diseases, Ninth Revision* (ICD-9) codes or external cause of injury codes§ from 28 hospitals in the 18 hurricane-affected counties. In Texas, emergency medical service (EMS) records were used to identify CO poisonings in counties where hospital records were not available. Demographic and clinical information was recorded from each medical record. Persons affected by CO poisoning were contacted and asked to participate in home interviews and generator inspections. Interviews were conducted in Alabama during October 20–November 2 and in Texas during December 5–15. CO poisoning fatalities were confirmed through medical examiner data obtained by the Consumer Product Safety Commission (CPSC). Families of persons who died from CO poisoning were not interviewed, but demographic and generator-location information was obtained from CPSC investigations.

Twenty-seven separate incidents of CO poisoning during August 29–October 19, 2005, were identified (Figure). Fifty-seven confirmed and 21 probable nonfatal cases were identified, associated with 23 incidents. Alabama had 37 nonfatal cases from 12 incidents, and Texas had 41 nonfatal cases from 11 incidents. The 10 fatal poisonings were associated with four incidents in Texas.

No statistically significant differences were observed by age or sex for the poisonings in Alabama and Texas, but the Texas cases were more racially and ethnically diverse. Among the 10 fatal cases, five were in females, six were in blacks, and four were in whites; median age was 34 years (range: 8–76 years).

Information regarding hospital outcomes was available for 68 (87%) of the 78 nonfatal cases. Ten (15%) of the 68 persons were hospitalized (mean: 2.2 days, range: 1–4 days), and 24 (35%) had poisonings severe enough to require hyperbaric oxygen treatment. A greater percentage of patients were hospitalized in Alabama (16%) than in Texas (8%); however, all of the CO poisoning fatalities occurred in Texas (Table 1).

FIGURE. Number of cases of carbon monoxide poisoning after Hurricanes Katrina and Rita,* by date of medical contact — Alabama and Texas, August–October 2005



* All cases during August 29–September 3 occurred in Alabama, and all cases during September 24–October 19 occurred in Texas.

A portable generator was implicated in 25 (93%) of the 27 incidents. Of the other two incidents, one involved a fixed generator and one involved a portable gas stove. The median number of persons poisoned per incident was three (range: one to eight persons).

Persons from the households involved in 18 (67%) of the 27 incidents were interviewed. Nine (50%) of the 18 households had generators placed outside in the open (not enclosed by a roof or walls); five (28%) generators were in a partially enclosed area (attached porch or carport), two (11%) were in a fully enclosed area (enclosed porch, garage, or shed), and two (11%) were inside the home. Generators placed outside were an average of 3.2 feet away from the home (range: 1–7 feet); a negative correlation (r = -0.75)¶ between the distances of generators from homes and the COHb levels of patients was observed. Among persons poisoned by outside generators, the median COHb was 10.7% (range: 0.3%–34.3%); nine (30%) of those cases were severe enough to require hyperbaric oxygen treatment for affected persons (Table 2).

* Mobile and Baldwin counties.

† Angelina, Chambers, Hardin, Jasper, Jefferson, Liberty, Montgomery, Nagadoches, Newton, Orange, Polk, Sabine, San Augustine, San Jacinto, Shelby, and Tyler counties.

§ ICD-9 code N-986 (toxic effect of CO exposure) was used to identify CO poisoning cases. External cause of injury codes that mentioned hurricane-related CO exposures (E867, E868.0, E868.1, E868.8, E868.9) or codes that indicated a possible hurricane-related CO exposure (E962.2, E981.8, E982.1) were also used to identify cases.

¶ Spearman's rank correlation coefficient.

TABLE 1. Number and percentage of carbon monoxide (CO) poisoning cases, by selected characteristics — Alabama and Texas, August–October 2005

Characteristic	Alabama (n = 37) No	Alabama (%)	Texas (n = 51) No.	Texas (%)	Total (N = 88) No.	Total (%)
Sex						
Female	19	(51)	28	(55)	**47**	**(53)**
Male	18	(49)	23	(45)	**41**	**(47)**
Race/Ethnicity						
White, non-Hispanic	29	(78)	30	(59)	**59**	**(67)**
Black, non-Hispanic	8	(22)	12	(24)	**20**	**(23)**
Asian	0	(0)	3	(6)	**3**	**(3)**
Hispanic	0	(0)	5	(10)	**5**	**(6)**
Unknown	0	(0)	1	(2)	**1**	**(1)**
Age (yrs)						
Median	30	—	29	—	**27.5**	**—**
<18	14	(38)	22	(43)	**34**	**(39)**
18–65	20	(54)	26	(51)	**46**	**(52)**
>65	3	(8)	3	(6)	**6**	**(7)**
Outcome						
Hospitalized	6	(16)	4	(8)	**10**	**(11)**
Discharged from emergency department or mobile clinic	31	(84)	25	(49)	**56**	**(64)**
Treated by emergency medical services on site	0	(0)	2	(4)	**2**	**(2)**
Died	0	(0)	10	(20)	**10**	**(11)**
Disposition unknown	0	(0)	10	(20)	**10**	**(11)**
Severity of poisonings						
Median COHb level* (range) (%)	15.9 (0.3–41.0)†	—	11.6 (2.8–29.9)	—	**14.1 (0.3–41.0)**	**—**
Required hyperbaric oxygen treatment§	16	(43)	8	(16)	**24**	**(35)**

* n = 59 (Alabama 36, Texas 23).
† Two cases in persons in Alabama with normal carboxyhemoglobin (COHb) levels were considered probable cases because the clinical symptoms and exposure settings were consistent with CO poisoning.
§ n = 68 (Alabama 37, Texas 31).

Of the four fatal poisoning incidents, three involved generators and one involved a gas stove. In all four fatal incidents, the generator or gas stove was inside a home or garage.

Nine (50%) of the 18 households were operating a window AC powered by a generator when the poisonings occurred. Five (28%) of the 18 households reported that the generator was placed close to the home to connect to an electric panel. Six (33%) of 18 households had a CO detector at the time of poisoning, but only one of those detectors sounded an alarm. Four detectors contained dead batteries, and one detector sounded an alarm remotely to a security system that was unable to alert the household by telephone.

Reported by: *M Tucker, B Eichold, MD, Mobile Public Health Dept; JP Lofgren, MD, Alabama Dept of Public Health. I Holmes, MPH, D Irvin, MPH, Beaumont Public Health Dept; J Villanacci, PhD, J Ryan, MD, C Barton, DVM, PhD, P McGaha, DO, Texas Dept of State Health Svcs. R Funk, DVM, A Stock, PhD, L Fierro, MPH, J Ferdinands, PhD, K Dunn, MS, R Moolenaar, MD, C Pertowski, MD, Div of Environmental Hazards and Health Effects, National Center for Environmental Health; D Van Sickle, PhD, D Crocker, MD, EIS officers, CDC.*

Editorial Note: Unintentional, non–fire-related CO poisonings account for an estimated 500 deaths and 15,000–40,000 emergency department visits in the United States annually (*5*). Although CO poisonings caused by portable generators represent a small percentage of total CO poisonings, the number of generator-related CO poisoning deaths reported to CPSC doubled from 18 deaths in 2001 to 36 deaths in 2003 (*6*). Investigation of generator-related CO poisonings after hurricanes in Florida in 2004 revealed that 16 (34%) of 47 nonfatal poisoning incidents were caused by outdoor generators (*7*). In the study described in this report, even higher percentages (50%) of households were poisoned by outdoor generators, indicating that generators, even when placed outside, can be dangerous sources of CO. This study also found that placement of outdoor generators located up to 7 feet from the home resulted in CO poisonings.

Multiple other factors, in addition to distance from the home, might increase the risk for generator-related CO poisoning. More than half of the households affected by CO poisoning were using a generator to operate a window AC. Window ACs might allow infiltration of CO into the home

TABLE 2. Carbon monoxide poisoning case severity and outcome, by generator placement — Alabama and Texas, August–October 2005

Generator placement	No. of cases	Deaths No.	Deaths (%)	Median COHb* level (%)	Received HBO† treatment No.§	Received HBO† treatment (%)
Inside home	26	9	(34.6)	17.2	9/21	(42.9)
Outside, fully enclosed space¶	6	1	(16.6)	15.5	0/5	(0)
Outside, partially enclosed space**	19	0	(0)	13.7	6/19	(31.6)
Outside, open area	31	0	(0)	10.7	9/30	(30.0)

* Blood carboxyhemoglobin.
† Hyperbaric oxygen.
§ Denominators varied depending on the number of cases with outcome information available.
¶ Included garages, sheds, and enclosed porches.
** Included carports and open porches.

by bringing outside air into the home or by providing a leak path around the casing of the unit (*8*). Generators should be located on the opposite side of the home away from window ACs to avoid this possibility. Several households interviewed for this study had connected generators to a central electric panel because it was more convenient than using extension cords. This practice encourages improper placement of generators near the home and poses a serious electrocution risk to utility workers during power-line repair (*9*). In addition, a functioning CO detector was not present in most of the households that had CO poisoning cases. Although use of a CO detector is not a substitute for proper placement of a generator, a functioning CO detector might help prevent poisonings (*10*). Routine replacement of batteries is critical to proper function of a CO detector.

The findings in this report are subject to at least three limitations. First, the investigation was limited to cases diagnosed by medical providers in specific regions. Cases in other regions and persons with milder poisonings might have been excluded. Second, interviews were conducted 1–3 months after the poisonings, and only one household member was interviewed per incident. Therefore, information collected might have been inaccurate or incomplete. Finally, population denominators and a nonpoisoned comparison group were not available, so risks associated with specific practices (e.g., generator placement near the home or near window ACs) could not be quantified. Despite these limitations, the findings in this report confirm that generator-related CO poisonings after power outages can cause substantial morbidity and mortality, even when generators are used outdoors.

With the number of generator owners increasing (*7*) and the 2006 hurricane season approaching, public health campaigns should emphasize placement of generators far from homes. According to the study described in this report, placement of generators further from the home tended to result in fewer CO poisoning fatalities and lower COHb levels. However, because the minimum safe distance for generator placement has not been determined, all households should have a functional CO detector when operating a generator or other gasoline-powered appliance. Emergency response personnel should consider touring neighborhoods undergoing power outages to locate homes with improperly placed generators and nonfunctioning CO detectors. Use of multiple surveillance sources at state and local levels, including hospitals, EMS providers, hyperbaric oxygen chamber facilities, media reports, and poison control centers, might help estimate the extent of CO poisonings after hurricanes and focus interventions (*3*). Although proper placement of generators and use of CO detectors are important, design modifications (e.g., weatherization and CO emissions reduction) ultimately might prove more effective in reducing CO poisonings from generators.

Acknowledgments

The findings in this report are based, in part, on contributions by CPSC; T Betz, MD, M Fussell, D Zane, MPH, and BA Kohl, Texas Dept of State Health Svcs; J Garcia, Springhill Medical Center, Mobile, Alabama; S Ibrahim, MD, and A Livingston, Montgomery County Health Dept, Conroe, Texas; M Wynn, Beaumont Emergency Medical Services, Beaumont, Texas; S Disler, G Crawford, M Mercier, A Lanum, J Kattan, and A Asare, National Center for Environmental Health, CDC; and health departments and hospital staff from the 18 Alabama and Texas counties.

References

1. Office of Electricity Delivery and Energy Reliability, US Department of Energy. Hurricane Rita situation report #3; September 23, 2005. Available at http://www.electricity.doe.gov/documents/rita_092305.pdf.
2. Office of Electricity Delivery and Energy Reliability, US Department of Energy. Gulf Coast hurricanes situation report #2; September 23, 2005. Available at http://www.electricity.doe.gov/documents/gulfcoast_report_092505.pdf.
3. CDC. Carbon monoxide poisoning after Hurricane Katrina—Alabama, Louisiana, and Mississippi, August–September 2005. MMWR 2005;54:996–8.
4. Federal Emergency Management Agency. Estimated peak gust wind speeds: Hurricane Rita; 2005. Available at http://lagic.lsu.edu/images/hurricanes/fema_advisories/rita/peakgusts.pdf.
5. CDC. Unintentional non–fire-related carbon monoxide exposures—United States, 2001–2003. MMWR 2005;54:36–9.
6. Consumer Product Safety Commission. Portable generators: CPSC staff report. Washington, DC: Consumer Product Safety Commission; 2004. Available at http://www.cpsc.gov/library/portgen.pdf.
7. CDC. Carbon monoxide poisoning from hurricane-associated use of portable generators—Florida, 2004. MMWR 2005;54:697–700.
8. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. ASHRAE handbook on heating, ventilating, and air-conditioning systems and equipment. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.; 2004: 46.1–46.4.
9. National Institute for Occupational Safety and Health. Preventing worker deaths from uncontrolled release of electrical, mechanical, and other types of hazardous energy. Atlanta, GA: US Department of Health and Human Services, CDC; 1999. DHHS (NIOSH) publication no. 99-110.
10. CDC. Use of carbon monoxide alarms to prevent poisonings during a power outage—North Carolina, December 2002. MMWR 2004;53:189–92.

Mortality Associated with Hurricane Katrina — Florida and Alabama, August–October 2005

On August 25, 2005, Hurricane Katrina made landfall between Hallandale Beach and Aventura, Florida, as a Category 1 hurricane, with sustained winds of 80 mph. Storm