



Abt Associates Inc.

Estimating Loss of Life from Hurricane-Related Flooding in the Greater New Orleans Area

Health Effects of Hurricane Katrina

Final Report

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1. Introduction

This document provides a review of literature that describes the actual and potential health and mental health effects of Hurricane Katrina on the city of New Orleans and surrounding areas. In this section we describe the specific aims of the review. In the next section, we describe the search strategies and sources used to identify the literature, and in the final section the findings of the review.

1.1. Objectives and Limitations

Literature reviews are always undertaken with one or more specific purposes in mind, and in the context of one or more challenges. The basic purpose of the reviews that are described in this report was to describe:

- (1) A wide range of specific exposures associated with Hurricane Katrina for people in New Orleans, including those who evacuated, those who remained in New Orleans through the storm, first responders, and those who came following the storm as part of the recovery efforts.
- (2) The health and mental health effects of the storm that have already been documented.
- (3) Other health and mental health effects that can be expected, in either the near or longer term, based on empirical studies of previous, similar disasters (e.g., other severe hurricanes, major floods).

One of the important challenges for the review described in this document is that only seven months have passed since the event, a very short timeframe for empirical articles to begin appearing in the scientific (i.e., peer-reviewed) literature. The impact of this timeframe on the search was to create an emphasis on the “grey literature” for the first and second components (as denoted above) of the review. For these components of the review we have searched newspapers, magazines, websites, and related information sources to compile a rich, though largely anecdotal, description of what happened in the storm, and how the storm and its aftermath affected the health and mental health of the people of New Orleans from August 29, 2005 until the present (through April, 2006).

A second important challenge to documenting the details of the storm and its aftermath is the monumental infrastructure damage (e.g., destruction of buildings, extended power outages, lack of drinking water) and displacement of the population that it created. Because the population remains so widely scattered – both those who evacuated prior to the storm and the much smaller group who were relocated afterward – the logistics of studying systematically the epidemiology of exposures and associated illnesses or disorders are unusually challenging. Although it remains a nearly daily topic for national news, the fact that much of New Orleans is in ruins and that only a small fraction of the pre-hurricane population has returned complicate population-based empirical documentation of the storm and its impact. This problem is exacerbated by the political aftermath at the local and national levels, in which many political interests seek to use the storm and governmental response to it for their own advantage.

The relocation of so many New Orleans residents, even for relatively short periods (e.g., weeks rather than months), represents a substantial barrier to the development of a comprehensive understanding of the storm and its impact on people for the short and

the longer terms. Comprehensive understanding of the exposures and health-and mental health-related outcomes of survivors requires structured assessment, which requires contact with victims, which requires knowing where they are. By December 2005, 33 states reported having received Hurricane Katrina evacuees, creating substantial challenges for sampling and assessing the victims.

The relocation also creates other health and mental health challenges. For people who had chronic health conditions that require regular medication and/or periodic professional monitoring (e.g., diabetes, cardiovascular disease, major depression, schizophrenia), relocation means quickly finding new providers who can fulfill the needed functions. For those who are also economically challenged (e.g., Medicaid recipients), the administrative challenges of moving to a different state can seem overwhelming.

Finally, because of the event's population-wide impact, another challenge is to document exposures and outcomes for both adults and children. Studies of recent disasters (e.g., the Oklahoma City bombing, the terrorist attacks of September 11, various prior hurricanes) have made clear that the reactions of children to disasters are different from those of adults, and may be more likely to have long-term implications. Therefore, it is important that information about children be included.

In summary, the purpose of the literature review is to provide as rich a description as possible of the exposures and health/mental health outcomes of Hurricane Katrina, and a forecast of additional health/mental health consequences that may not yet have come to the surface. Given that months, not years, have passed since Hurricane Katrina came ashore, much of the information for the rich description of what has already happened must rely on news reports and related sources, not systematic studies reported in peer-reviewed journals. As a result, much of that description is anecdotal. The description of additional, longer-term consequences that may not yet be apparent can, however, rely on extrapolation from empirical studies of outcomes from prior similar events. Therefore, our description of what happened from August 29, 2005 until today will come predominantly from the grey literature, and our forecast of other outcomes of potential concern will come primarily from the peer-reviewed literature, based on prior disasters with similar characteristics.

2. Health and Safety Exposures and Outcomes

2.1. Environmental Health Exposure and Outcomes

2.1.1. Introduction

Infectious and vector borne diseases are the primary causes of environmental health impacts due to hurricanes. Flooding exposes people to microbial contaminants that result in skin, diarrheal, and respiratory infections in survivors.(CDC 2005c, CDC 2006a, Dewan & Goodnough 2005)

The second significant risk is vector-borne disease, as stagnant waters provide breeding habitat for mosquitoes, which tend transmit diseases such as malaria, cholera, and West Nile virus.(Bourque et al. 2006c, Dewan & Goodnough 2005)

However, in developed countries, infectious and vector-borne disease outbreaks following natural disasters are rare. Instead, the potential threat occurs from the failure of the essential infrastructure that provides safe drinking water, wastewater removal, and power (electric and natural gas), combined with crowded and unsanitary living conditions in shelters, along with stagnant water. The existence of all these conditions after the extensive and prolonged flooding of Hurricane Katrina increased the risk of infectious and vector borne disease outbreaks (Bourque et al. 2006c, Dewan & Goodnough 2005, Peres & Janega 2005).

After acute exposures to floodwaters was no longer an issue it became apparent that mold-growth in the thousands of flooded structures had the potential to be both an acute and long-term environmental health problem. (CDC Joint Task Force 2005, CDC 2005e, Bennett 2006)

Public health professions were concerned about risk of exposure to chemicals and toxins in the floodwaters. The EPA identified 54 Superfund sites in the area affected by Hurricane Katrina, including sites with pesticides and dioxins. (Manuel 2006) Immersed vehicles could leak gasoline; demolished residences and business could have cleaning fluids, caustic drain cleaners, solvents, and other materials draining into the floodwaters. Skin exposure could potentially lead to burns, infections, and rashes. Finally, after New Orleans was dewatered, heavy metals, pesticides and petroleum products would settle into sediment. These contaminants present a potential long-term health risk. (CDC Joint Task Force 2005)

2.1.2. Exposure to Floodwaters

Immediately after the hurricane, two groups tested the floodwaters to provide a snapshot of the chemical and biological characteristics of the water immediately following the flood caused by Hurricane Katrina.

- (1) The EPA and Louisiana Department of Environmental Quality (LDEQ) analyzed the floodwaters for "more than 100 hazardous pollutants such as volatile and semivolatile organic compounds, metals, pesticides, herbicides, and polychlorinated biphenyls. ... They also tested for biological agents such as *Escherichia coli*." (Manuel 2006)
- (2) Pardue and colleagues also measured volatile and semivolatile organic compounds as well as microbial agents. Samples were collected in the main area of New Orleans, the East Bank, where human contact with floodwaters occurred during rescue operations, as well as from the 17th Street drainage canal. Samples were collected on September 3 and September 7, 2005. (Pardue et al. 2005)

A few months later, the Natural Resources Defense Council (NRDC) tested sediment from the floodwaters for arsenic and other carcinogenics. (Manuel 2006) The results of these three sets of tests are presented below.

Microbial contamination of floodwaters and infectious disease

The EPA/LDEQ reported "greatly elevated" levels of *E. coli*. (Manuel 2006, Kent 2005) Therefore, on September 6, 2005, the director of the Centers for Disease Control and Prevention announced the high levels of sewage-level bacteria in the floodwater and warned against contact with it. (Manjoo 2005)

Perdue *et al.* confirmed elevated fecal coliform bacteria (mid-city average of 1.4×10^5 MPN/100 mL), which was similar to levels historically observed in storm water runoff in the region, but still much higher than the water quality standard for primary contact (200 MPN/100mL). Fecal coliform is a general indicator of the presence of human pathogens. Another team of researchers found high concentrations (5.6×10^6) of *Aeromonas* spp. in water samples near the Superdome and Charity Hospital. EPA also conducted floodwater testing and reported that samples revealed elevated bacteria levels associated with untreated sewage.(Dewan & Goodnough 2005, EPA 2005b)

It is likely that rescue workers, emergency response personnel, and stranded populations had at least dermatological exposure to human pathogens and therefore increased risk of illness. For example, a study of beachgoers in Los Angeles reported a higher incidence of gastrointestinal illness and upper respiratory infections among individuals swimming in marine water impacted by storm-water runoff than among non-exposed populations.(Haile 1999, Dewan & Goodnough 2005)

CDC received reports of clusters of diarrheal disease among persons in evacuation centers in Louisiana, Mississippi, Tennessee, and Texas. Gastrointestinal illness was widespread in some areas, with as many as many as 21% of adults and 40% of children at one large evacuation center having acute gastroenteritis on any given day between September 2 and 12, 2005. About half the illnesses were demonstrated to be caused by norovirus. While the CDC suspects "substantial" secondary person-to-person transmission occurred in crowded evacuation shelters, many of the index cases may have been infected by contaminated food or water. For example, lack of electricity leads to food spoilage and potential for poisoning.(CDC 2005d) In addition to the food left in homes and over 300,000 now-useless refrigerators, large amounts of food in the delivery chain were deserted – for example, 40 tons of packaged chicken and more than six million dead poultry and livestock.(Dewan & Goodnough 2005, Manuel 2006)

On September 30, 2005, the CDC reported there were no confirmed cases of *Shigella* dysentery, typhoid fever, or infection by toxigenic *V.cholerae* O1, which in developing countries causes cholera, a severe diarrheal illness. In the United States, cholera is usually due to the consumption of contaminated shellfish, not contaminated water.(CDC 2006g, Dewan & Goodnough 2005)

Two cases of toxigenic *Vibrio cholerae* O1 infection were identified in a Louisiana couple; the cases were attributed to consumption of undercooked or contaminated seafood apparently due to disruptions caused by Hurricane Rita, not Hurricane Katrina.(CDC 2005i, Dewan & Goodnough 2005)

Among hurricane evacuees from the New Orleans area, a cluster of infections with methicillin-resistant *staphylococcus aureus* (MRSA) was reported in approximately 30 pediatric and adult patients at an evacuee facility in Dallas, Texas. In addition, 24 cases of *Vibrio*-related wound infections were reported, with six deaths.(CDC 2006d, Dewan & Goodnough 2005) CDC also received reports of tinea corporis and folliculitis, skin lesions with infectious etiology.

Heavy metal contamination of floodwaters

Preliminary results of the EPA/LDEQ study, particularly regarding elevated lead levels in the floodwaters, were widely reported. Community members became concerned about exposure to lead, which can result in severe neurological damage. In addition, seven

major oil spills¹ were reported and the media were aware that hazardous chemicals could be leaking into floodwaters from thousands of sources, including cars, homes, and businesses. (Loftis 2006, Loftis 2005, Chan & Revkin 2005, Dewan & Goodnough 2005)

Pardue et al. also found that lead, arsenic, and, in some instances, chromium approached and sometime exceeded drinking water standards. Lakeview surface samples for lead had a mean of 3.2 ug/L, SD=1.4, less than US EPA action level of 15 ug/L. In contrast, Mid-City surface samples for lead had a mean of 28, SD=31, which exceeds the action level. However, the Mid-City mean is being driven by a single test result of 111 ug/L, while the remaining eight of nine samples had lead levels of 26 ug/L or less. (Pardue et al. 2005)

The NRDC study found extremely elevated arsenic levels in the sediment, as much as 30 times EPA safety limits. Louisiana environmental officials stress that the state has "naturally" elevated arsenic levels, so the flooding is not necessarily to blame. (Manuel 2006)

The primary source of lead exposure for most children under normal circumstances is ingestion of deteriorating lead-based paint, lead-contaminated dust, or lead-contaminated soil. EPA estimates that 10 to 20 percent of human exposure to lead may come from lead in drinking water. Infants who consume mostly mixed formula can receive 40 to 60 percent of their exposure to lead from drinking water. Dermal absorption of inorganic lead compounds is generally considered to be much less than absorption by inhalation or oral routes of exposure; however, few studies have provided quantitative estimates of dermal absorption of inorganic lead in humans, and the quantitative significance of the dermal absorption pathway as a contributor to lead body burden in humans remains an uncertainty. The Agency for Toxic Substances and Diseases Registry has not established a minimal risk level for lead (Pb), nor has EPA developed a reference concentration. EPA has decided it would be inappropriate to develop a reference dose for lead because some of the health effects associated with exposure to lead occur at blood lead levels so low as to be essentially without a threshold. (ATSDR 2005, Dewan & Goodnough 2005)

Pardue et al. conclude that what distinguished Hurricane Katrina floodwater was its large volume and the extent of human exposure to toxic pollutants, rather than the elevated concentrations of the pollutants themselves. The extent of exposure was due in large part to the topography of New Orleans, which caused the standing water to remain, instead of draining away as it did in other urban areas. (Pardue et al. 2005) The absence of highly concentrated toxic pollutants was explained by dilution from the large volume of water, the absence of chemical plants or refineries in the area sampled, low supplies of gasoline due to the evacuation, and chemically stable (buffered) water that resisted drops in pH, which could otherwise have leached more metals.

Its possible that, had the flooding been less extensive and provided less dilution of microbial and chemical contaminants, the resulting concentrations could have been substantially higher, resulting in additional/more-severe illness and injury.

¹ These spills, combined with at least 4 medium and 134 minor spills, totalled 8 million gallons of oil. (Manuel 2006, Kent 2005)

Vector borne disease

Mosquitoes presented the most significant potential risk of vector borne disease. The disease risk is quite low in the developed world, and previous experience has shown that, as after Hurricane Andrew in 1992, increased numbers of mosquitoes does not necessarily lead to an increase in disease.(Bourque et al. 2006c, Dewan & Goodnough 2005) However, the enormous stagnant floodwaters left in the wake of Hurricane Katrina provided extensive breeding grounds for mosquitoes and raised concerns regarding West Nile virus (WNV) and viral encephalitis.(Erickson 2005, Peres & Janega 2005)

Most people (about 4 out of 5) who are infected with West Nile virus will not develop any type of illness (an asymptomatic infection). It is estimated that about 20% of people who become infected with WNV will develop West Nile fever. Symptoms include fever, headache, tiredness, and body aches, occasionally with a skin rash (on the trunk of the body) and swollen lymph glands. While the illness can be as short as a few days, even healthy people have reported being sick for several weeks. The symptoms of severe disease (also called neuroinvasive disease, such as West Nile encephalitis or meningitis or West Nile poliomyelitis) include headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, and paralysis. It is estimated that approximately 1 in 150 persons infected with the West Nile virus will develop a more severe form of disease. Serious illness can occur in people of any age, but the people at highest risk are those over age 50 and some immunocompromised persons (for example, transplant patients).(Dewan & Goodnough 2005, CDC 2004)

One mosquito-district in Louisiana reported that the number of trapped mosquitoes had increased 800 percent over pre-hurricane levels.(Erickson 2005) However, other researchers observed minimal activity at sampling sites in New Orleans.(Presley et al. 2006) In either case, people appeared to be at additional risk because they were spending extended time outdoors (e.g., relief and remediation operations), and even when they were inside, broken windows and screens did not keep mosquitoes from entering.(Cowan 2006, Sullivan 2005b)

A key factor in disease transmission appeared to be missing. The key vertebrate hosts, birds, which are required to transmit and maintain the viral reservoir, were almost non-existent in these areas, perhaps driven from the area or killed by Hurricane Katrina.(Sullivan 2005b, Erickson 2005) In addition, four traps operating overnight captured 47 mosquitoes, comprising 34 *Aedes* spp., 6 *Culex* spp., and 7 unidentifiable specimens; all the mosquitoes tested negative for the presence of West Nile virus and SLE.(Presley et al. 2006)

In the end, very little mosquito-borne illness was reported.(CDC 2005g, Dewan & Goodnough 2005, Bourque et al. 2006c, Wilson 2006)

2.1.3. Mold

Mold is a type of fungus, an organism that reproduces by creating spores that travel through the air. Spores typically range from 2 to 10 micrometers, and can settle in the upper and lower respiratory tracts. While the process of inhaling and absorbing fungal spores is "poorly understood," it is clear that cleaning mold carries particular risks, as it can aerosolize the mold, dispersing respirable spores. Molds produce characteristic volatile organic compounds that can indicate exposure.(CDC 2005e)

While mold has no established exposure limits, the key findings of a recent report from The Institute of Medicine (IOM) are:

- Mold presents a risk of opportunistic fungal infection in immunocompromised persons.
- There is sufficient evidence of an association between damp indoor spaces and:
 - upper respiratory symptoms, such as nasal congestion and throat irritation, and
 - lower respiratory symptoms, such as cough, wheeze, and exacerbation of asthma. (Institute of Medicine 2004)

There are no established health-based indoor exposure limits for the compounds resulting from mold, such as airborne endotoxins. However, measured indoor endotoxin levels in five homes were comparable to those of certain industrial settings in which declines in pulmonary function have been demonstrated. The CDC determined that “the findings of this assessment indicated that mold growth inside homes was likely at or above a level sometimes reported to be associated with certain health effects (e.g., cough; airway hyper-reactivity; influenza-like symptoms; ear, nose, and throat irritation; decreased lung function; and skin rash).” (Ratard et al. 2006)

Large sections of New Orleans were flooded for weeks, resulting in extensive mold growth in buildings. The CDC assessed the extent of mold growth in a sample (N=112) of households in the area (Orleans, Jefferson, Plaquemines, and St. Bernard Parishes), and collected indoor (N= 20) and outdoor (N=11) air samples. Air samples were analyzed for culturable fungi (1[®]3, 1[®]6)-b-D-glucan (a cell-wall component of many fungi) and endotoxin (a cell-wall component of gram negative bacteria). In addition, a questionnaire was administered to remediation workers and residents (not necessarily those of the 112 inspected homes) regarding demographics, home occupancy, and remediation activities (N=235 or 70.1% participation rate). (Ratard et al. 2006)

Almost half the homes had “visible mold growth” and 17% had “heavy mold coverage,” defined as “>50% coverage on [the] interior wall of most-affected room.” Indoor and outdoor air sampling indicated that *Aspergillus* spp. and *Penicillium* spp. were the predominant populations (Ratard et al. 2006). Geometric mean glucan levels were 1.6 ug/m³ inside homes and 0.9 ug/m³ outside. Geometric mean endotoxin levels were 23.3 EU/m³ inside and 10.5 EU/ m³ outside (endotoxin units per cubic meter). The authors reported that differences between inside and outside mold concentrations were not statistically significant, but no information is provided on the statistics for this small sample size. (Ratard et al. 2006)

Hospitals in the area have reported seeing an increased number of patients with allergy and cold symptoms, and doctors have suggested that allergy to the mold and dust circulating in New Orleans is making residents susceptible to respiratory illness. (Wilson 2006) A nagging cough going around town has been nicknamed “Katrina cough”; this is believed to be caused by high levels of “dust” in the air—particles from construction debris and dried mud, coupled with high spore counts from fungi, and mites that feed on fungal spores. (Bennett 2006) This a particular concern for workers removing debris. (Wilson 2006)

The CDC survey results could underestimate the potential effect of mold, as only homes that were occupied were included in the study; more-damaged or longer-flooded homes could have even greater coverage of mold (Ratard et al. 2006). Furthermore, the interviews with residents and remediation workers during October 18-23 indicated low levels of correct use or even appropriate respirators (31% of residents, and 35% of workers

who had already cleaned up mold), in spite of high levels of belief that “mold can make people sick” (92% of residents and 95% of workers). (Ratard et al. 2006) In addition, many of the evacuees were from sensitive subpopulations such as the elderly, infirm, and immune-compromised, all of who may be more sensitive to mold exposures. (Dewan 2006c)

Overall, limited data indicate that indoor and outdoor environmental conditions in post-Hurricane Katrina New Orleans almost certainly lead to exposure to airborne mold, and may have people put at risk for the health effects identified by the IOM report. In addition, lax or inappropriate use of personal protective equipment may have undermined efforts to reduce these exposures. Mold is likely to be an ongoing problem. An estimated 30 million cubic yards maybe need to be removed from New Orleans and managed. The material will likely contain mold and hazardous materials (e.g., asbestos and lead paint) and will require appropriate safety precautions by remediation workers. (CDC 2005a)

2.1.4. Heavy metals in sediments and seafood

Hurricane Katrina has the potential to cause environmental health risk over the long term. Two major potential concerns have been identified, in light of New Orleans’ particular architecture and geography—it consists of wetlands and is below sea level—and in light of experience with hurricanes in general, and the extent of flooding after the hurricane. They are:

- exposure to elevated concentrations of heavy metals in soil and sediment deposited by receding floodwaters; and
- consumption of seafood that may have significant mercury and heavy metal accumulation from these sediments

As described above, the primary sources of lead exposure for most children are deteriorating lead-based paint, lead-contaminated dust, and lead-contaminated soil. Children are more vulnerable to lead poisoning than adults. A child who swallows large amounts of lead may develop blood anemia, severe stomachache, muscle weakness, and brain damage. If a child swallows smaller amounts of lead, much less severe effects on blood and brain function may occur. But even at much lower levels of exposure, lead can affect a child’s mental and physical growth. (ATSDR 2005)

To assess immediate and long-term public health implications, a research team collected soil and sediment samples during September 16-18, 2005 in the City of New Orleans and in the Louisiana Parishes of Orleans and St. Charles. The authors found that concentrations of aldrin, arsenic, lead, and seven semivolatile organic compounds in sediments/soils exceeded one or more USEPA thresholds for human health soil screening levels and high-priority bright-line screening levels. (Presley et al. 2006) The authors comment that while the lead concentrations in post-Hurricane Katrina samples are not the highest reported for urban New Orleans, they still might pose a significant health risk, particularly to children returning to highly contaminated areas. Given that a number of compounds exceeded screening values, the authors concluded that planning and execution of cleanup and rebuilding operations must include steps to protect construction workers, waste handlers, and residents. Schoolyards and athletic fields are of particular concern. (Lubell 2005)

A large oil spill from the Murphy Oil refinery also raised questions about health risk to people returning to residences in or near the spill zone. Storm surge from Hurricane

Katrina lifted and dislodged a 250,000-barrel above-ground storage tank at the Meraux Murphy Oil Refinery. At the time the tank reportedly contained 65,000 barrels of mixed crude oil, and approximately 25,110 barrels (1,050,000 gallons) was released. Visual inspection indicated the oil release impacted approximately 1,800 homes and an undetermined number of other structures in a 1-square mile area, as well as several adjacent canals. (Dewan & Goodnough 2005, Zarus & Fowler 2005)

A few weeks later, after floodwaters had receded from St. Bernard Parish, soil samples in a church yard, school yard, and other areas revealed high levels of arsenic, cadmium, chromium, and various benzene compounds, according to activists. This raised concerns about contamination from, for example, young children putting their dirty hands into their mouths. A company retained by Murphy Oil reported that "with limited exceptions," its tests of the area demonstrated results "below [Louisiana Risk Evaluation/Corrective Action Program (RECAP)] standards even before there is any cleaning of homes and lots". (Kaiser Family Foundation 2005b)

The Agency for Toxic Substances and Diseases Registry subsequently reviewed the results of sediment/soil sampling conducted at more than 800 properties. The conclusions of that analysis were that concentrations of oil-related chemicals in sediment and soil samples from most properties were below ATSDR comparison values and LDEQ RECAP standards for petroleum products. Short-term or long-term exposures to such sediments do not pose a public health hazard. The report also concluded that concentrations of petroleum products in sediment and soil samples from some properties exceeded LDEQ RECAP standards and that these properties should be remediated prior to re-occupancy. (Zarus & Fowler 2005)

In December 2005, EPA reported on results of environmental sampling of air, soil, water, and seafood in New Orleans independent of site-specific activities at industrial locations such as the Murphy Oil Spill. (Zarus & Fowler 2005) Some of EPA's summary findings were:

- Ambient air quality samples appear to be typical for this region of the state and pollutants are below any levels of health concern. The VOC samples and TAGA data showed some elevated reading of pollutants immediately after the storm. However, subsequent sampling has shown that the levels of pollutants have returned to pre-hurricane levels. A review of PM 2.5 (fine particulate) data shows concentrations below levels of concern. All concentrations of the toxic air pollutants are below the USEPA one-year screening levels and below the Louisiana ambient air standards.
- In general, the sediments located in areas flooded by the hurricanes in Orleans, St. Bernard and Plaquemines Parishes are not expected to cause adverse health effects, provided people use common sense and good personal hygiene and safety practices. The levels of fecal coliform bacteria and TPH in the sediments were initially elevated, but they are expected to decrease naturally over time.
- As expected in an old, densely populated urban area, a variety of chemicals were detected in the sediments. In general, other VOCs, SVOCs, pesticides, and metals were at levels that would not be expected to result in adverse health effects. However, in areas where sediment samples contained contaminant levels exceeding LDEQ and USEPA criteria, further investigation is underway to adequately characterize the nature and extent of contamination.
- As sediments dry out, the fecal coliform bacteria cannot be expected to survive, and the hazard represented by the bacteria will decrease. The elevated levels of

TPH are likely attributable to urban background TPH levels associated with surface runoff from roadways in combination with releases of petroleum products from vehicles submerged under floodwaters. In some localized areas, elevated TPH levels may be attributable to known releases of petroleum products.

- While the detected levels of contaminants may not pose an unacceptable health risk for most people, some individuals may be bothered by dust raised by disturbances of the sediment. It is therefore recommended that efforts be made to minimize contact and take measures to minimize dust (reestablish lawn, rinse off sidewalks and driveways, etc).
- Exposure to the majority of residual sediment contaminants is expected to decrease over time due to growth of vegetation and the degradation and dispersion of these chemicals from natural processes in the environment.
- As of December 9, 2005, the data show no reason for concern about consuming seafood from the Gulf region due to the hurricanes. The samples were analyzed for chemical and microbiological contaminants that the hurricanes could have introduced. The extensive seafood tissue sampling occurred in an area from the estuaries of New Orleans to Gulf Shores, Ala. The sampled areas included Lake Pontchartrain, Mississippi Sound, and Mobile Bay, as well as the offshore areas of the northern Gulf of Mexico. While many oyster harvest areas have been tested and re-opened, others remain closed until routine sampling by existing state-regulated Molluscan Shellfish Programs determines that oyster harvesting can resume. Current data from analyses of fish and other shellfish from these areas show no reason for concern.

EPA has continued to conduct analyses since the release of the data sampling results in December 2005. More recent re-sampling and evaluation in February 2006 led to the following conclusions. (EPA 2006)

- The results from the composite samples collected in February 2006 support the conclusions of the December 6, 2005 summary assessment that the sediments in most of the areas flooded by the hurricanes are not expected to cause adverse health impacts. The concentrations of arsenic detected in samples collected in Fall 2005 were not found to be representative of the average concentration of arsenic in the areas around the original sample locations. Similarly, the concentrations of benzo(a)pyrene at most of the Fall 2005 sample locations were not found to be representative of the benzo(a)pyrene concentrations in the areas around the original locations.
- Elevated concentrations of lead were detected in composite samples collected during February 2006 at several locations in older residential areas of New Orleans. However, the elevated levels of lead found in the February 2006 samples are consistent with pre-hurricane conditions. Studies conducted in New Orleans prior to Hurricane Katrina showed both elevated levels of lead and a similar distribution of lead in the soil.

2.1.5. Other potential environmental causes of morbidity and mortality

Other potential environmental causes of morbidity and mortality that have not been clearly established in the literature to be caused by Hurricane Katrina are:

- Smoke from fires and debris. Natural disasters such as hurricanes and floods can leave a lot of debris, some of which may be burned during cleanup. Smoke from

these outdoor fires is unhealthy to breathe and may cause cough, shortness of breath or tightness in the chest, and stinging of the eyes, nose, or throat. (CDC 2005b)

- Natural gas leaks. These are a potential source of poisoning and fires. (CDC 2005a)
- Accidents. Post-hurricane clean-up has been associated with numerous accidents involving chainsaws, electrocution, and fires. (Bourque et al. 2006c, Dewan & Goodnough 2005)
- Animal and insect hazards. An increased prevalence of dog and insect bites has been reported in prior hurricanes, and was observed to some degree in Hurricane Katrina relief workers. (Bourque et al. 2006c) Wild animals – especially snakes and rodents fleeing rising floodwaters – may come into closer contact with humans.
- Industrial fires/chemical emergencies. These were a potential risk given the number of oil refineries in the Gulf Coast area. EPA's environmental surveillance aircraft were used to assess spills and chemical releases. On Sept. 3, the aircraft surveyed the smoke plume of a large fire in the New Orleans warehouse district. The survey did not reveal any contaminants of undue concern in the smoke. (EPA 2005a)
- Residential/commercial fires. Fires did not appear to be a significant problem, but the lack of running water for fire suppression suggests that they had that potential.

2.2. Specific Health-Related Exposures

This report addresses the health outcomes among New Orleans residents and the emergency and relief workers who went to New Orleans immediately following Hurricane Katrina. The denominator cannot be determined exactly. The United States Census estimated that 462,269 people lived in New Orleans in 2004. (2006b) This report addresses health effects of the evacuation process for people who left before Hurricane Katrina landed, as well as an estimated 100,000 who had not left and remained in the city. (Manjoo 2005) Perhaps 10,000 remained a week later, some marooned and some refusing to leave. (Thomas & Padgett 2005)

Additionally, thousands of relief workers, paid and volunteer, could have been affected, including 1,580 Army Corps of Engineers workers (Cloud 2005), as many as 40,000 active-duty military and National Guard (Manjoo 2005), 148 CDC public health workers such as epidemiologists (CDC 2005h), approximately 500 SAMHSA mental health and substance abuse counsellors, (SAMHSA 2006) some 800 firefighters from New York and Illinois (Longman 2005), 303 New York police officers (Baker 2005), a sheriff and 33 deputies from Michigan (Lipton et al. 2005), and 38 Public Health Service physicians and nurses (Altman & Chang 2005). Another 40 FEMA medical teams were also expected. (Abelson & Feuer 2005) Finally, some tourists were stranded in New Orleans, including at least three physicians, a physician's assistant, and a pharmacist, all of whom got actively involved in emergency health care. (Henderson 2005a) (Volunteer physicians from outside Louisiana were not legally allowed to provide treatment until an executive order suspended medical licensing requirements on September 2. (Manjoo 2005) We found no reports of the volunteers being prosecuted.)

Following Hurricane Katrina, CDC immediately engaged in surveillance to determine the extent and cause of morbidity and mortality among people in the affected geographical regions. The result was a thorough assessment of infectious disease, injuries, morbidity, and mortality either immediately caused by or associated with Hurricane Katrina. However, the surveillance was limited to those geographic regions that were most immediately affected: Louisiana, Mississippi, Alabama, and Texas.

The summary of health effects below relies on reports from people who were in New Orleans during or immediately after the hurricane, typically as emergency workers, reporters, or residents hoping to return. There were reports of violence and injury during the hurricane that were based on hearsay and later proven to be untrue; there were also estimates of mortality that far exceeded the ultimate result. Therefore, we made every effort not to rely on hearsay evidence or projections in developing this summary. (See Appendix A: Search Methods and Results for a thorough description of the literature review.)

2.2.1. Mortality and its Causes

Determining the number and cause of deaths due to Hurricane Katrina proved quite challenging. Many people are missing; and, for those whose bodies have been found, no standardized, universally accepted method exists for determining whether deaths are caused by a natural disaster. Each state determines the cause of any death that occurred within its borders, and states use different criteria. Therefore, evacuee suicides were deemed "associated with" Hurricane Katrina in Texas, while none of 20 evacuee deaths in Atlanta were deemed "directly or indirectly related." (Possley & McCormick 2005) Similarly, Florida counts a death due to a pre-existing condition in an evacuee as "indirect," but Louisiana officials are "hesitant to count" similar deaths. (Dewan 2005a) Finally, many bodies were not autopsied quickly, making accurate assessments more difficult, and the quality of the autopsies was weak. (Fairbank 2005, Dewan 2005b, Dewan 2005c)

The CDC defines a directly related death as "a death caused by the physical forces of a hurricane" and an indirectly related death as "one caused by unsafe or unhealthy conditions that existed during the evacuation phase, occurrence of the hurricane, or post-hurricane/cleanup phase." A third category – "possibly related" – was used if "1) the death occurred in the hurricane-affected area during August 23-October 23, 2005, 2) the cause or manner of death was undetermined or pending, and 3) reviewers agreed that a possible relation between the death and the hurricane might exist." (CDC 2006d)

As of February 23, 2006, 950 bodies were examined at the St. Gabriel morgue. The results of the examinations are available for 750 victims. The identity and cause of death of the remaining victims have not been released. Of these 750 released cases, the Louisiana coroner determined that Hurricane Katrina explicitly caused 727 fatalities. As demonstrated in Table 2-1, the deaths were overwhelmingly among New Orleans metro area residents, with only 2% of deaths among residents of other areas in Louisiana, visitors from out of state, or people of unknown residence. Mortality was evenly distributed by sex. However, only 46.5% of New Orleans metro area residents prior to the hurricane were male, so males are somewhat over-represented among the identified dead. The Louisiana Department of Health and Hospitals coroner determined that about two dozen deaths were not "storm related," instead occurring by "violence or suspicious means." (Bourque et al. 2006b)

Table 2-1: Mortality by Sex for the 727 Storm-related Deaths Identified and Released by St. Gabriel Morgue

	New Orleans Metro ^a		Other Louisiana		Total	
Female	355	49.7 %	8	61.5 %	363	49.9 %
Male	359	50.3 %	5	38.5 %	364	50.1 %
Total	714	100.0 %	13	100.0 %	727	100.0 %

^a The five parishes making up metropolitan New Orleans include Jefferson, Orleans, Plaquemines, St. Bernard and St. Charles.

Source: Department of Health and Hospitals, State of Louisiana. 2006. "Vital Statistics of All Bodies at St. Gabriel Morgue 2/23/2006." http://www.dhh.louisiana.gov/offices/publications/pubs-192/Deceased%20Victims_2-23-2006_information.pdf. Accessed 3 April 2006.

Table 2-2 demonstrates that just over half the fatalities were among African-Americans, both in the New Orleans metro area and in the rest of Louisiana. This is somewhat surprising, given that the New Orleans metro area was 68% African-American prior to the hurricane. (Kaiser Family Foundation 2005b) However, the estimated 400 missing persons, who are likely to have died, are also likely to be from the areas with rapid flooding and delayed rescue, which were more heavily African-American. (Simmons 2006)

Table 2-2: Mortality by Race for the 727 Storm-related Deaths Identified and Released by St. Gabriel Morgue

	New Orleans Metro ^a		Other Louisiana		Total	
African-American	381	53.4 %	7	53.8 %	388	53.4 %
Asian/Pacific Islander	5	0.7 %	0	0.0 %	5	0.0 %
White	308	43.1 %	6	46.2 %	314	43.2 %
Hispanic^b	17	2.4 %	0	0.0 %	17	2.3 %
Native American	2	0.3 %	0	0.0 %	2	0.0 %
Other	1	0.1 %	0	0.0 %	1	0.0 %
Total	714	100.0 %	13	100.0 %	727	100.0 %

^a The five parishes making up metropolitan New Orleans include Jefferson, Orleans, Plaquemines, St. Bernard and St. Charles.

^b The data presented Hispanic as a race, not an ethnicity regardless of and separate from race.

Source: Department of Health and Hospitals, State of Louisiana. 2006. "Vital Statistics of All Bodies at St. Gabriel Morgue 2/23/2006." http://www.dhh.louisiana.gov/offices/publications/pubs-192/Deceased%20Victims_2-23-2006_information.pdf. Accessed 3 April 2006.

The age distribution of the fatalities was distinctly skewed towards older people, as seen in Table 2-3. There were very few children identified as killed: four girls and a boy in Orleans Parish, and an infant in St. Tammany Parish. The number of fatalities among 50-59 year olds and 60-69 year olds was distinctly higher among males (14.8% of male deaths and 18.7% respectively) than among females (11.0% and 10.7%, respectively). In the oldest age group, those 80 and above, the proportion of fatalities among females was much higher than among males (46.0% versus 28.3%). This could be due in part to a larger number of older women than of older men.

Table 2-3: Mortality by Age for the 727 Storm-related Deaths Identified and Released by St. Gabriel Morgue

	New Orleans Metro ^a		Other Louisiana		Total	
Female						
Infant-49	28	7.9 %	3	37.5 %	31	8.5 %
50-59	40	11.3 %	0	0.0 %	40	11.0 %
60-69	38	10.7 %	1	12.5 %	39	10.7 %
70-79	84	23.7 %	2	25.0 %	86	23.7 %
80+	165	46.5 %	2	25.0 %	167	46.0 %
Subtotal	355	100.0 %	8	100.0 %	363	100.0 %
Male						
Infant-49	61	17.0 %	3	60.0 %	64	17.6 %
50-59	53	14.8 %	1	20.0 %	54	14.8 %
60-69	67	18.7 %	1	20.0 %	68	18.7 %
70-79	75	20.9 %	0	0.0 %	75	20.6 %
80+	103	28.7 %	0	0.0 %	103	28.3 %
Subtotal	359	100.0 %	5	100.0 %	359	100.0 %
Total						
Infant-49	89	12.5 %	6	46.2 %	9	13.1 %
50-59	93	13.0 %	1	7.7 %	9	12.9 %
60-69	105	14.7 %	2	15.4 %	10	14.7 %
70-79	159	22.3 %	2	15.4 %	16	22.1 %
80+	268	37.5 %	2	15.4 %	27	37.1 %
Total	714	100.0 %	13	100.0 %	727	100.0 %

^a The five parishes making up metropolitan New Orleans include Jefferson, Orleans, Plaquemines, St. Bernard and St. Charles.

Source: Department of Health and Hospitals, State of Louisiana. 2006. "Vital Statistics of All Bodies at St. Gabriel Morgue 2/23/2006." http://www.dhh.louisiana.gov/offices/publications/pubs-192/Deceased%20Victims_2-23-2006_information.pdf. Accessed 3 April 2006.

It is interesting to look at the relationships between the sex, race, and age of the identified dead (see Table 2-4).

Table 2-4: Mortality by Race and Age, Within Sex for the 727 Storm-related Deaths Identified and Released by St. Gabriel Morgue

	≤49		50-59		60-69		70-79		80+		Total	
Female												
African-American	22	71.0%	20	50.0%	24	61.5%	37	43.0%	58	34.9%	162	44.6%
White	9	29.0%	17	42.5%	14	35.9%	44	51.2%	101	60.8%	185	51.0%
Other	0	0.0%	3	7.5%	1	2.6%	5	5.8%	7	4.2%	16	4.4%
Male												
African-American	48	75.0%	40	74.1%	41	60.3%	46	61.3%	51	49.5%	226	62.1%
White	13	20.3%	14	25.9%	26	38.2%	27	36.0%	49	47.6%	129	35.4%
Other	3	4.7%	0	0.0%	1	1.5%	2	2.7%	3	2.9%	9	2.5%
Total												
African-American	70	73.7%	60	63.8%	65	60.8%	83	51.6%	109	40.5%	388	53.4%
White	22	23.2%	31	33.0%	40	37.4%	71	44.1%	150	55.8%	314	43.2%
Other	3	3.2%	3	3.2%	2	1.9%	7	4.4%	10	3.7%	25	3.4%

Source: Department of Health and Hospitals, State of Louisiana. 2006. "Vital Statistics of All Bodies at St. Gabriel Morgue 2/23/2006." http://www.dhh.louisiana.gov/offices/publications/pubs-192/Deceased%20Victims_2-23-2006_information.pdf. Accessed 3 April 2006.

Lack of access to care

Before Hurricane Katrina, many hospitals and other health care providers evacuated some patients. However, many patients were too ill, disabled, or dependent on immobile technology to be evacuated. Some people looked for shelters that could accommodate the ill, such as a woman on oxygen, or a severely demented elderly woman, but could not find any. (Dewan & Roberts 2005, Shute 2005a, Salopek & Horan 2005)

The hospitals were required to have supplies to last for up to three days; they were not required to evacuate, but were expected to survive. (Rohde et al. 2005) As hospitals were flooding and backup generators failed – the legislature had repeatedly failed to allocate funds to move electrical equipment out of public hospital basements – or ran out of fuel, medical staff strained hard to care for patients. All electric-powered life-support systems were affected: suction machines, bedside monitors, intravenous fluid pumps, and dialysis machines. Without power, staff resorted to manually squeezing ventilator bags for both adults – including some who had been evacuated to the hospital from a flooded nursing home – and premature infants. Nurses held the infants, who typically have very sensitive immune systems, in their arms to keep them warm in lieu of their incubators. (Shute 2005a, Williams 2005, Manjoo 2005, Rohde et al. 2005, deBoisblanc 2005)

To avoid spreading infection when toilets at Charity Hospital failed, people used 5 gallon buckets lined with infectious waste bags as toilets. Bleach was poured over the waste and the bags were thrown out the window. (Berggren 2005, Rohde et al. 2005) The Memorial Medical Center in New Orleans flooded, drowning 45 people and trapping almost 2,000. (Manjoo 2005, Graham 2005) Only three hospitals remained fully functional throughout the hurricane: East and West Jefferson Medical Centers and the Ochsner Clinic Foundation. (Kaiser Family Foundation 2006a, Winslow 2005)

The hospitals ran out of food, water, and ice, putting patients at risk of starvation, dehydration, and heat stroke. (Shute 2005a, Shute 2005b) Patients became so weak that

when 110 were evacuated on Friday, September 2, 2005, along with some 500 staff and their families, three did not survive the evacuation. (Manjoo 2005) Even the lack of coffee proved problematic, as many staff at Charity Hospital reported having "severe caffeine-withdrawal headaches." (Berggren 2005)

The Louisiana Department of Health and Hospitals had set up seven "special-needs shelters" in the city. They were quickly overwhelmed as 6,000 people, many evacuees from failing hospitals, requested care. (Shute 2005a)

Because the hospitals were inoperable or inaccessible, an impromptu trauma center was set up at the Louis Armstrong International Airport. Rescued patients were delivered by helicopter, while others were delivered by truck. Supplies were extremely limited; one physician described "having no beds, no oxygen, no nothing except some nitro, aspirin, and all the good intentions in the world." In this situation, there was sometimes nothing they could do for severely ill patients except "providing morphine and a blanket to septic and critical patients and allowing them to die."² (Fischman 2005)

The Superdome and Convention Center, which held as many as 45,000 people, also had minimal supplies and extremely unsanitary and crowded conditions. Some 34 people died there, due to various causes, at least two to dehydration. (Manjoo 2005, Salopek & Horan 2005)

Some people did not reach the evacuation centers. Some died from lack of medication such as insulin, or from dehydration. (Dewan & Roberts 2005)

Common Ground, a loose coalition of nurses and medical assistants that typically provides medical care to protesters at anti-war demonstrations, arrived within days, followed by physicians, nurses, and grief counselors. They set up a free clinic that served more than 100 people a day in Algiers and "dozens more" at mobile clinics situated near the most intense clean-up efforts. (Shorrock 2006) On Friday, September 2, 2005, Governor Blanco had issued an executive order suspending the licensing requirement for medical personnel. If they could prove they were licensed in their home states, they could provide care in Louisiana during the declared public health emergency. Prior to that, volunteer physicians and the Red Cross (as well as firefighters, morticians, and a convoy of boats offering to help rescue those stranded in the floodwater) had been turned away. (Blumenthal 2005, Manjoo 2005)

Other health care providers apparently did not make such efforts. Seventy percent of the area nursing homes did not implement the standard evacuation procedures that they were required to have. (It is not clear whether they were required to follow Mayor Nagin's mandatory evacuation order.) Multiple facilities had contracted with the same bus service for evacuation services (and many drivers were not available), so thorough evacuation was impossible. (Janega 2005, Rohde et al. 2005, Lipton et al. 2005) (Municipal transit and city school buses were ruined by the flood instead of being pressed into earlier service. (Winslow 2005)) Many nursing home residents were evacuated to local hotels. At one, when broken windows left rooms unusable, over a thousand people – guests and patients – stayed in an exhibit hall with no power, air conditioning, or water, not to mention no regular care or functioning medical equipment. (Frohlich 2005) Thirteen nursing homes and six hospitals were investigated regarding possible euthanasia. (Roman & Baum 2005) The operators of one nursing home, which did not attempt to evacuate patients, and which turned down an offer of buses

² While there were anecdotal reports of euthanasia during the week after Hurricane Katrina, we found no documented reports.

from local officials, have been charged with 34 counts of negligent homicide. (Manjoo 2005, Rohde et al. 2005)

Drowning

Once the levees broke, the floodwaters overwhelmed adjacent neighborhoods with great speed. Louisiana State University's Geographic Information Center reports that the flood reached depths of as much as 19 feet, with a vast expanse of the city under seven feet. (Kent 2005) The majority of deaths in Orleans Parish were caused by drowning and pre-existing medical conditions, while deaths in St. Bernard Parish were primarily attributed to drowning in the storm surge. (Bourque et al. 2006a)

Some people lost hold of family members in the flood, or grabbed for them and drowned. Other people simply could not swim and were overwhelmed. Reports of the speed of the water rising – some roofs were reached within nine minutes; a hospital reception area was under five feet of water within 15 minutes; farther from the levees the water might rise a foot every ten minutes – suggest that some people could not get into their attics or other safe spaces quickly enough. Some attics filled with water, requiring residents to quickly break holes in their roofs; one woman had a heart attack trying. One man, not having time to help his partly paralyzed and bedridden wife, stayed with her until she drowned then joined his daughter in the attic. (Baum 2005c, Dewan 2006a, Dewan & Roberts 2005, Rohde et al. 2005)

Infection

Five deaths were caused by wound-associated *Vibrio*, defined by the CDC as “an illness that likely resulted from infection of a wound or abrasion acquired before or during immersion in floodwaters.” The deceased had lived in Louisiana and Mississippi; of the three case reports provided, two were from New Orleans. (CDC 2005i) Routine infections, such as a mastoid infection of the ear, became fatal in the absence of medical care in the days after the hurricane. (Dewan & Roberts 2005)

Suicide

There were some reports of suicide during the first days of the disaster, including two police officers and one man who threw himself from the Superdome. (Baum 2006, Manjoo 2005)

Access to mental health care prior to the storm was limited; only 28 percent of adults and 3.5 percent of children identified as having a mental illness in Louisiana received care. After the storm, the primary mental health crisis center, 96-bed Charity Hospital, was forced to close. With no local source of care for those who remained behind, and evacuees not necessarily knowing where to access local care, calls to a Louisiana suicide prevention hotline immediately almost tripled and to the National Suicide Prevention Hotline more than doubled. Six months later, calls to the city hotline remained at double pre-hurricane rates, despite the population being about a third the size. (Reuters 2006, Associated Press 2006, Kalb & Murr 2005)

In the months after the hurricane, suicides increased. While the numbers may seem low – seven in four months – they represent a rate two to three times New Orleans’ 2004 rate.³(Nossiter 2005)

Homicide

Despite early reports of mayhem at the Superdome and Convention Center, only one homicide occurred, at the latter.(Salopek & Horan 2005) The risk of homicide was also great in the flooded areas, where people desperately foraged for food and water and protected their property. “Of all the white people I met that week [following the hurricane],” wrote one reporter, “only two were unarmed.”(Baum 2006)

Some experts say that the hurricane would be the catalyst, but not the pure cause, of most suicides. Some suicides were preceded by homicides, perhaps born of despair. At least two cases were found in the grey literature in which a father shot his child and the child’s mother; only one child survived.(Associated Press 2006)

New Orleans had been known for an extremely high homicide rate, which was ten times the national rate before Hurricane Katrina.(Baum 2006) There is some evidence that evacuees are increasing the homicide rate in their new locations. For example, in Houston, 33 of 189 homicides (17%) involved Hurricane Katrina evacuees, although they increased the population by only about 7%.(2006a, Campo-Flores 2006) In addition to the increase in homicide itself, additional patrolling and detective work is expensive: \$6.5 million in Houston for six months, for example. These outlays leave less money available for regular public safety measures, and this in turn could affect the public’s health.(Campo-Flores 2006)

Accident

Carbon monoxide poisoning frequently resulted from running gasoline-powered generators to replace lost electric power. If generators are placed too close to the home, particularly near air conditioning vents that draw air into the home, the carbon monoxide can reach toxic levels. Other sources of carbon monoxide include gas stoves. Since the gas has no color or odor, in the absence of a detector it can be fatal without the victim being aware of it. Of the 14 documented cases of carbon monoxide poisoning among New Orleans residents – the CDC recognizes that the surveillance probably reflects underreporting – 5 resulted in death.(CDC 2006g) In nearby states where many evacuees fled, there were 10 deaths in Texas and Alabama, combined (Tucker et al. 2006), and 2 in Florida.(CDC 2006d)

All accidents are, in theory, preventable. Therefore, public health professionals usually use the term “unintended injury” instead. However, many of the major injuries that resulted in death among people who remained in New Orleans during Hurricane Katrina were no longer realistically preventable. Some were crushed under rubble, swept into trees, or trapped in attics or, wheelchair-bound, first floors, where they likely died of drowning or dehydration.(Glanton 2005)

Many people died while attempting to evacuate. One woman fell while being lifted into a rescue helicopter, possibly because her weight was too much for the cable. One bus with approximately 50 evacuees from the Superdome crashed, killing one passenger and injuring 17. Oxygen canisters exploded on another bus, killing 23 frail residents of a

³ Calculation of the rate depends on an estimate of the current population, which is not precise.

nursing home headed for Dallas.(Gross & Griffin 2005, Manjoo 2005, Dewan & Roberts 2005)

There were numerous reports of shooting during the days immediately following the hurricane. Police report being fired on, and shooting themselves. Of seven investigated shootings in which an officer hit someone, four were fatal. In a separate incident, police shot and killed "at least five residents" who had fired on government contractors. An officer was shot, non-fatally, in the head.(Barringer & Longman 2005, Manjoo 2005, Baum 2006)

2.2.2. Currently Evident Morbidity

Injury

Injury and soft tissue infections are expected to immediately follow a natural disaster.(CDC 2005g)

During September 8 to October 15, 2005, a total of 6,597 injuries were reported. The CDC reported the injuries in sets. The first wave of surveillance covered four New Orleans area parishes (Jefferson, Orleans, Plaquemines, and St. Bernard) over September 8-25.(Ferdinand 2005) The second wave added two parishes (St. Charles and St. Tammany) and lasted longer, September 25-October 15.(CDC 2006c) The results are summarized in Table 2-5.

Table 2-5: Selected injuries among New Orleans residents and relief workers, September 8-October 15, 2005

Injury/exposure	Relief Workers		Residents		Unknown		Total		Total
	Sept.8-Sept.25	Sept.25-Oct.15	Sept.8-Sept.25	Sept.25-Oct.15	Sept.8-Sept.25	Sept.25-Oct.15	Sept.8-Sept.25	Sept.25-Oct.15	
Injury									
Fall	46	64	196	449	222	479	464	992	1,456
Bite/Sting	67	52	92	114	152	173	311	339	650
Motor-vehicle crash	16	20	65	161	64	235	145	416	561
Intentional injury	4	11	20	32	18	46	42	89	131
Other unintentional injury	117	334	237	934	362	1,143	716	2,411	3,127
Undetermined etiology	72	44	99	96	128	158	299	298	597
Toxic exposure/Poisoning									
Carbon monoxide poisoning	5	1	3	1	6	3	14	5	19
Other toxic exposure	11	7	4	11	12	11	27	29	56
Total	338	533	716	1,798	964	2,248	2,018	4,579	6,597

Source: Injury and illness surveillance in hospitals and acute-care facilities after Hurricanes Katrina And Rita--New Orleans area, Louisiana, September 25-October 15, 2005. *MMWR Morb. Mortal. Wkly. Rep.* 55(2):35-8

In the days following the hurricane, New Orleans was rife with the potential for injury. The force of helicopter rotors "blew out the windows on at least two Corps SUVs parked in a bad spot," sent "loose roofing tiles knifing through the air and raising a rotor wash that nearly swamped" a boat of rescuers, and made "a frightening maelstrom of loosened pieces of wood.(Baum 2005c, Baum 2006, Cloud 2005)

There were numerous stories of people escaping the rising water in their homes by moving into attics or onto roofs. Even this straightforward maneuver was not without risk.

For the very heavy or the very old, climbing a ladder and getting through a hatch present challenges. For the more able-bodied, swinging axes and hammers or breaking attic windows while desperate is dangerous. (Baum 2005c, Treaster & DeSantis 2005, Harris 2005a)

After days spent actually in water, or in wet footwear, some people developed trench foot, a condition in which blisters and fungus develop, causing swelling and blotching, tingling, itching, and numbness, and sometimes pain. (Treaster & DeSantis 2005, Harris 2005a)

Whether driven by fear, hunger, or greed many people looted stores and many were armed. Some people were threatened and assaulted. Police and looters both fired into the air. (Barringer & Longman 2005, Harris 2005b)

Many pets were left behind, often by owners who were forced to evacuate without them. (Baum 2005c, Associated Press 2005c, Reuters 2005) Many were swept into trees and onto roofs or flotsam. By late September, "wild dogs," possibly including pets that were now becoming feral, raised concerns about dog bites. Even some pets whose owners stayed, responding to the tension and circumstance, bit. (Baum 2005a, Cloud 2005, Cox 2005)

Six weeks after the hurricane, tensions remained high in New Orleans, as demonstrated by a well-publicized case of police officers punching a man so he required stitches. (Associated Press 2005d)

Even attempting to get care for an injury could result in additional trauma. One quickly established evacuation center had only a teenage lifeguard to provide any medical care. After treating a man with a broken spine, the boy reportedly grumbled, "He could have told me his back was broken before I moved him." (Boo 2005)

Illness

The types of illness that resulted, either directly or indirectly, from Hurricane Katrina fall into the following, somewhat overlapping, categories:

- infectious disease
- gastrointestinal
- dermatologic
- respiratory
- exacerbation of underlying illness due to disruption in care
- underlying illnesses that are diagnosed during medical care provided at emergency care centers or evacuation centers
- **site-specific illness**

Many of these illnesses are directly or indirectly caused by environmental exposures. The exposures, etiology, and potential outcomes are specifically addressed in a separate section.

Summary of major illnesses

During September 8 to October 15, 2005, a total of 13,166 illnesses were reported. The CDC reported the illnesses to the public in sets. The first wave of surveillance covered four New Orleans area parishes (Jefferson, Orleans, Plaquemines, and St. Bernard) over September 8-25.(Ferdinand 2005) The second wave added two parishes (St. Charles and St. Tammany) and lasted longer, September 25-October 15.(CDC 2006c) The results are summarized in Table 2-6.

Table 2-6: Selected illnesses among New Orleans residents and relief workers, September 8-October 15, 2005

Selected Illness	Relief Workers		Residents		Unknown		Total		Total
	Sept.8-Sept.25	Sept.25-Oct.15	Sept.8-Sept.25	Sept.25-Oct.15	Sept.8-Sept.25	Sept.25-Oct.15	Sept.8-Sept.25	Sept.25-Oct.15	
Infectious-disease-related									
Skin or sound infection	101	62	192	361	347	459	640	882	1,522
Acute respiratory infection	119	179	158	538	228	587	505	1,304	1,809
Diarrhea	11	18	52	92	83	123	146	233	379
Other infectious disease	36	28	109	219	143	223	288	470	758
Noninfectious-disease-related									
Rash	67	59	87	170	146	290	300	519	819
Heat-related	34	28	80	86	93	118	207	232	439
Nondiarrhea gastrointestinal	23	24	77	200	108	253	208	477	685
Renal ^a	8	11	44	49	35	104	87	164	251
Other classifiable illness ^b	22	76	52	758	88	1,030	162	1,864	2,026
Other illnesses	107	217	649	1,166	870	1,469	1,626	2,852	4,478
Total	528	702	1500	3,639	2,141	4,656	4,169	8,997	13,166

^a Includes kidney stones and renal failure (i.e., chronic and acute).

^b Includes diabetes, cardiovascular conditions, obstetric/gynecologic conditions, and dental problems.

Source: Injury and illness surveillance in hospitals and acute-care facilities after Hurricanes Katrina And Rita--New Orleans area, Louisiana, September 25-October 15, 2005. *MMWR Morb. Mortal. Wkly. Rep.* 55(2):35-8

Although infectious disease outbreaks rarely follow natural disasters in developed countries, when they do occur, the most common are skin, diarrheal, and respiratory infections. In addition, airborne, waterborne, and foodborne diseases are expected to occur up to a month following the disaster.(CDC 2005g)

The CDC engaged in numerous surveillance efforts, with the cooperation of local, federal, and voluntary organizations. The results are very well documented cases of numerous diseases. However, the incidence rates are extremely difficult to estimate, as demonstrated by the surveillance implemented on September 8, 2005 in 489 evacuation centers (EC) in Louisiana. Each EC served from 10 to approximately 7,000 people. On the one hand, the majority of large clusters of some illnesses, such as influenza-like illness and rash, were attributed to overreporting. Given that an EC was defined as "any facility that housed displaced persons overnight," many would be staffed by people with little, if any, medical experience. On the other hand, there could have been significant underreporting. The system was encouraged, not mandatory. No training was provided. EC staff/volunteers experienced rapid turnover, and many staff did not have a health care background. Some ECs did not provide any medical care onsite, and the ECs themselves were not static, but changed location and number.(CDC 2006h)

A Dallas evacuation shelter reported an outbreak of methicillin-resistant *Staphylococcus aureus* (MRSA), which can cause skin infections of "a particularly deadly form of pneumonia." (Beil 2006) In some areas with large populations of evacuees, the rate of sexually transmitted diseases is increasing. Health officials in Houston hypothesize it could be "an outgrowth of high rates in New Orleans." (Campo-Flores 2006)

An HIV-infected Orleans Parish Prison patient who was being cared for at Charity Hospital exemplifies the degree to which Hurricane Katrina raised and intensified health issues. Because he was shackled to the bed and watched by two armed guards, the prisoner's bloody diarrhea presented no risk to other patients during regular medical care. However, after one guard left, the other became lax, and the prisoner's shackles were removed. Medical staff became concerned.(Berggren 2005)

Gastrointestinal

Very careful surveillance of the 24,000 evacuees sheltered at Reliant Park in Houston, most from Louisiana, demonstrated that fully 18% (1,169) people reported symptoms of gastrointestinal illness on September 2, 2005. The proportion peaked on September 5, and as many as 21% of adults and 40% of children had acute gastroenteritis on any given day through September 12, 2005. In the United States, acute gastroenteritis, which the CDC defines as "diarrhea and/or vomiting," is most commonly caused by noroviruses. Outbreaks can result from exposure to contaminated food or water supplemented by secondary, person-to-person contact and fomite transmission. (Fomites are inanimate objects that can transmit infectious agents from one person to another.) Preliminary testing confirmed the presence of norovirus by reverse transcription-polymerase chain reaction testing in half the selected specimens; no other enteropathogen was identified. Given the large number of relief, medical, police, and other personnel who came in contact with many infected people, the CDC suspects "substantial" secondary spread. The spread was limited by isolating some of the ill and implementing extensive disease control measures: education; ensuring soap and water were available in medical, food preparation, and personal hygiene areas; and disinfection.(CDC 2005f)

Of the approximately 1,000 cases of diarrheal disease and vomiting among evacuees in Mississippi and Texas by September 30, causes included sporadic nontyphoidal *Salmonella*, nontoxigenic *V.cholerae O1*, in addition to norovirus, as described above.(CDC 2005g)

Dermatologic

Eighteen cases of wound-associated *Vibrio*, defined by the CDC as "an illness that likely resulted from infection of a wound or abrasion acquired before or during immersion in floodwaters," as well as four cases of non-wound associated *Vibrio* infections, were found among former residents of New Orleans.(CDC 2005i)

The CDC performed surveillance on over 200,000 evacuees at 750 evacuation centers in 18 states, and rescue workers. It is not known how many of these people were in New Orleans on August 28-29. In addition to the *Vibrio* infections noted above, an outbreak of methicillin-resistant *Staphylococcus aureus* (MRSA) affected 30 adult and pediatric evacuees in Dallas.(CDC 2005g)

Among rescue workers, the CDC identified the following:

- Tinea corporis, a skin lesion with infectious etiology.

- Three non-infectious rashes: "1) prickly heat (malaria crystalline, rubra, and pustulosa); 2) two clusters of nonpruritic erythematous papular, nonfollicular lesions ... presumed to have been caused by arthropod (likely mite) bites; and 3) circumferential lesions, appearing as bands of macerated skin at the waist, attributed to excessive chafing." (CDC 2006h)

People who waited on a roof for days developed rash on their arms and legs from contact with the hot tar roof. (Baum 2005c) Two evacuees to Colorado sought emergency care for "rash illness" such as rash with fever. (CDC 2006b)

Respiratory Disease

Tuberculosis is a particularly infectious disease of the lungs that can be controlled by early detection and treatment of new cases. Interruptions in treatment are important, not only for the health of the patient, but because they can encourage multiple-drug resistant forms of the disease. One hundred-thirty people were being treated for tuberculosis in New Orleans before Hurricane Katrina landed. Fourteen were incarcerated. Most⁴ were transported (with continued treatment) to other facilities before the hurricane landed. After the hurricane, a nationwide initiative was immediately implemented to locate the other 116 patients and ensure continuity of care. By October 13, 2005, all were located and had resumed treatment if it was indicated. (CDC 2006i)

Two evacuees to Colorado sought emergency care for possible tuberculosis. (CDC 2006b) The diagnosis was apparently not confirmed. (CDC 2006i)

One two-month-old infant was diagnosed with pertussis after being evacuated from a rooftop in New Orleans. Two other cases of respiratory disease, one streptococcal pharyngitis and one respiratory syncytial virus, were reported by September 23, 2005. (CDC 2005g)

There was widespread reporting of "Katrina cough," a constellation of symptoms thought to be related to dust and mold. A small case control study (n=201) by the Louisiana Department of Health and Hospitals in early 2006 found that a history of respiratory conditions such as asthma, chronic obstructive pulmonary disorder, or tobacco smoking was a stronger predictor of requiring emergency medical care than exposure to dust or mold. (Golden & Ratard 2006) The study did not investigate the effect on requiring non-emergency care.

Morbidity due to disruption in care during the hurricane

As noted above, in "Mortality-Lack of access to care," the entire health care system in New Orleans was in tatters. Due to the overwhelming volume of medical need, and sudden lack of basic necessities for nutrition, hygiene, or medical care, healthy people became ill and ill people got more sick or died. (Shute 2005a, Shorrock 2006, Shute 2005b) Medical staff in hospitals were overtaxed. One physician noted that the nurses immediately applied a disciplined schedule of 12 hour shifts, rotating staff, while physicians worked around the clock, potentially "compound[ing] the danger with our incoherence." (Berggren 2005) Additionally, a large number of professional staff who normally would be available to identify people in need and provide emergency care

⁴ The CDC reported that all tuberculosis patients were evacuated prior to the hurricane, but a teaching physician of infectious disease at Charity Hospital reports four patients with active tuberculosis being cared for during the hurricane. (Berggren 2005)

were gone or incapacitated: 150-250 police deserted, and over 500 firefighters were displaced (although the latter had a lower desertion rate). (Baum 2006, Longman 2005, Barry & Longman 2005, Hancock 2005)

The situation was so difficult that the Air National Guard surgeon assigned to "manage public health and force protection issues" stated that "[n]either civilian nor military personnel had ever been required to conduct operations under circumstances seen with Hurricane Katrina." (He, and many others, also called the living conditions worse than those in Afghanistan, Iraq, or Haiti. (Graham 2005, Fischman 2005, Winslow 2005))

Morbidity due to disruption in care or medication after the hurricane

As noted under subhead "Respiratory Disease" above, 116 non-incarcerated people were being treated for tuberculosis in New Orleans before Hurricane Katrina landed. (An additional 14 were incarcerated.) (CDC 2006i) Four were in Charity Hospital, which lost power, requiring them to don N95 masks. (Berggren 2005) To ensure continuity of care – and to control the spread of tuberculosis and help prevent development of multiple-drug-resistant strains – a "national network of TB control programs" implemented a variety of measures to identify patients. (CDC 2006h) By October 13, 2005, all were located and had resumed treatment if indicated. Continuity of care was ensured, in part, by free shipments of replacement medications by a pharmaceutical provider, and by health departments in 14 states assuming responsibility for tuberculosis case management while patients were in their jurisdiction. (CDC 2006i)

Tuberculosis care, however, was the exception.

Hurricane Katrina quite simply sent all components of health care to the winds: health care facilities closed; health care providers dispersed throughout the country; people with serious or chronic medical conditions fled without, or with inadequate, medical supplies; and medical records and proof of insurance, even of identity, were lost. Adding to this confusion, evacuees encountered the fact that each state determines its Medicaid and AIDS Drug Assistance Programs (ADAP) eligibility and coverage, and many of the states receiving large numbers of evacuees had already strained health care systems. Finally, in some cases people did not know their medical history or pharmaceutical needs.

Care for specific medical needs was also disrupted. All the major HIV/AIDS care providers were significantly damaged and closed for "several weeks." (Wockner 2006) MCLNO, in partnership with LSU School of medicine, ran the HIV Outpatient Program (HOP). The HOP Clinic was the "primary provider of HIV/AIDS care" in New Orleans, with 3,300 patients in 2005. (Kaiser Family Foundation 2006a) As of April 13, 2006, the HOP Clinic, at a temporary location, had seen only 850 patients. Community-based NO/AIDS Task Force resumed services in mid-March, having lost a third of its staff. (Wockner 2006)

Diabetes requires daily care; supplies of insulin and other medication, which requires a supply of clean syringes; glucose monitoring; and careful attention to comorbidities. (Handling of the waste, particularly syringes, also presents health risks.) Vigilance regarding nutritional intake protects diabetics against hypoglycemia and hyperglycemia. The latter would put the diabetic at risk of conditions such as skin infections, a particular concern for those exposed to floodwaters. Many evacuees experienced periods of no or inadequate food during the week after the hurricane. As a result, "[w]hile statistics for the prevalence of these problems are currently unavailable, [there are] anecdotes about the high frequency and severity of both [hypo- and hyperglycemia], which may have resulted in some deaths." (Cefalu et al. 2006)

Many diabetics' dialysis treatment was interrupted, a particularly dangerous situation as diabetes can lead to heart disease, blindness, kidney damage, and lower-limb amputation due to circulatory problems. Some nursing home patients were evacuated to a local hotel, then transferred days later to a local hospital dialysis center. Anecdotal reports describe people rowing, wading, and being wheeled to treatment facilities as their serum potassium levels peaked. As of mid-October, as many as half the New Orleans dialysis patients were not located and their treatment status was unknown. Other conditions, such as seizure disorder and cardiac disease, also require constant care. (Greenough & Kirsch 2005, Spake 2005, Frohlich 2005, Cohen 2005)

Some people were scheduled for surgery, which had to be postponed. For some, the loss of medical records forced them to repeat costly, time-consuming testing before being able to get surgery elsewhere. (Glanton 2006, Murphy 2006)

While pregnancy is not a critical condition, the extreme stress related to evacuation could have contributed to premature birth. (Montero 2006)

Health care facilities closed.

Most hospitals in New Orleans were crippled or destroyed. The two large state hospitals in New Orleans were destroyed, and were shut down after Hurricane Katrina. (Kalb & Murr 2005) The Medical Center of Louisiana at New Orleans (MCLNO), which included Charity and University hospitals, was central to providing care to the most needy: 51% of Charity's patients were uninsured and another 32% were covered by Medicaid. (Kaiser Family Foundation 2006c) This was possible in part because these hospitals trained health care professionals, including residents of two medical schools, Louisiana State University and Tulane. (Thomas 2005) The schools were also devastated, affecting the flow of trainees. As of April 22, 2006, the LSU Schools of Medicine, Allied Health and Nursing were being renovated or environmentally remediated. (Kaiser Family Foundation 2006a)

Only two of the eight hospitals in New Orleans were open in the months following the hurricane. In mid-November, they had to serve a day-time population of as many as 150,000 people. (Thomas 2005) Of 15 adult acute-care facilities, only 7 remained open, with a third the number of beds (1,750 compared with 5,063). (Barringer 2006) The closure of Charity Hospital also affected access to emergency care, as it was the Level I Trauma Center for "the entire Gulf Coast region." The closest other Level I facilities are in Shreveport, Louisiana, Birmingham, Alabama, and Houston, Texas, all over 300 miles away. (Kaiser Family Foundation 2006a, Thomas 2005)

Health care providers dispersed throughout the country.

Health care providers were also dispersed throughout the country, including 6,000 physicians from Louisiana and Mississippi, "the largest displacement of doctors in U.S. history." (Adams 2005, 2005) The entire Louisiana State University School of Medicine department of family medicine, which served 10-15,000 patients, was displaced. (Lubell 2005) By mid-November, only 15% of physicians had returned to the city, and "nurses are in short supply." (Thomas 2005) By April, health care providers remained so rare that Orleans Parish was declared a Health Professionals Shortage Area, with fewer than one primary care physician per 3,200 residents and less than one psychiatrist for every 21,000 residents. (La. Dept. of Health and Hospitals 2006) In contrast, New Orleans had a very high rate of approximately 9.6 physicians per 3,200 residents in 2001 (more typically presented as 300/100,000). (Kaiser Family Foundation 2006d) Some physicians could not be located to confirm prescriptions. ([No byline] 2006)

People with serious or chronic medical conditions fled without, or with inadequate, medical supplies.

Immediately following the hurricane, many people at the New Orleans Convention Center, where as many as 15,000 gathered, had run out of medication within days. They included the elderly, some wheelchair-bound, and children, including two with known seizure disorders and a third with a severe asthma attack. (Henderson 2005b) The situation was similar at the Superdome, where people reported not having medication for conditions such as cancer, asthma, and seizure disorder. (Associated Press 2005b, Treaster 2005)

CDC surveillance of Mississippi residents immediately following Hurricane Katrina found that medication refills were in high demand, constituting approximately one-third of frequently requested illness-related services at hospital emergency departments and federal Disaster Medical Assistance Team operation sites. The proportion dropped to about 18% in the second week. (CDC 2006g) In another Mississippi county, surveillance in mid-September showed that, of the 41% of homes that were inhabited, 29% had a household member with a prescription that would need to be refilled within three days. (CDC 2006f) Among former New Orleans residents evacuated to Colorado, the "majority of visits" to an outpatient medical clinic between September 7 and 21 and 13% of emergency room visits between September 1 and 23 were for medication refills. (CDC 2006b)

Others missed medication because treatments that required a viable health care infrastructure – such as HIV experimental treatment or chemotherapy infusions – were not available. (Kalb & Murr 2005) Others simply expected a shorter evacuation period and took an inadequate supply of medication, or ran out during evacuation. (Wockner 2006)

Mental health patients who run out of medication risk causing themselves physical harm. They, and older patients, are likely to get confused by not being able to get care at their usual facility. Some refuse care, make themselves vulnerable by, for example, sleeping outside in nothing but a "half-open housecoat," or otherwise descend into psychosis. (Lutz 2006) Others were coherent but confused. One woman was able to understand the concept of needing to evacuate in a hurricane but responded to the news of suspended postal service saying, "Well, no one informed me!" (Lewis 2005) Others put other people at risk, as demonstrated by the woman who, while in a shelter, threatened her daughter with a knife for "opening her legs when she's not fixed." (Boo 2005)

By October 15, a website containing medical histories and pharmaceutical requirements was on-line, enabling physicians and pharmacists to access information on some people. While this was an important step, the source data covered many states affected by the storm. Additionally, even one million patient records would not include many evacuees. (Schneider 2005)

In some cases, obtaining access to good medical care could require such extraordinary and disruptive action as to create new risks. For example, a 22-month-old with an asthma attack was airlifted from a rooftop to a hospital, but separated from his mother and brother for days. (Kher et al. 2005) Stress is known to increase the likelihood of a repeat asthma attack. (Cleveland Clinic 2003, Hitti 2004)

Medical supplies such as wheelchairs were also left behind (Thomas & Padgett 2005) or hard to replace. (Ripley 2005)

Supply shortages abounded.

The evacuation centers were hard-pressed to provide the necessary medications and medical supplies. In Houston, after a federally deployed Disaster Medical Assistance Team did not deliver supplies as anticipated, a physician “ended up raiding his own hospital’s pharmacy to try to get through the night.” Private suppliers filled the void. In this case, 20 CVS corporation pharmacists with a “complete mobile operation” arrived to disseminate medications. (Spake 2005) The Wal-mart corporation and Sam’s Club also provided supplies such as food, water, and ice. (Shute 2005a)

Medical records and proof of insurance, even of identity, were lost.

Many New Orleans residents evacuated without proof of identity, or lost it during the confusion of the storm and evacuation. Louisiana drivers’ licenses were computerized, so people who could provide basic personal information and looked reasonably like the saved image could receive a new license. (Sullivan 2005a) However, many people – particularly the young and the poor – did not have licenses in the first place, leaving them without proof of identity and thus exposing them to many health risks.. Many shelters required identification, although some relaxed their rules (Sullivan 2005a), and housing is fundamental to health. Similarly, in some cases, proof of identity ensured continuity of coverage. For example, if evacuees claimed that they were on tuberculosis medication, the TB program in that state could confirm this through a special “Katrina TB help desk” in Atlanta. The help desk would facilitate the interjurisdictional transfer form allowing public health authorities in the index state to provide treatment. (CDC 2006i)

The 12,849 people (Kaiser Family Foundation 2005a) with HIV/AIDS in Louisiana were also in a disease-specific registry, but have been far harder to locate. Two months after the hurricane, only half had been located. (Kalb & Murr 2005) Those who lived in New Orleans may be harder to locate; by late April, the state had “up-to-date information on 2170 of the 7,432 people with HIV [29%] who lived in metro New Orleans before the storm.” (Wockner 2006) Anecdotal reports indicate that HIV/AIDS patients did not seek care, have been refused shelter after disclosing, or have not sought new sources of medication because they have not disclosed their status to people whose homes they evacuated to. (Kalb & Murr 2005, Wockner 2006) Since they may be financially eligible for state-subsidized medication, not disclosing could have serious health ramifications.

People with diseases and conditions that do not have targeted funding streams need health insurance. Before Hurricane Katrina, 134,249 New Orleans residents were covered by Medicaid and, assuming that the Louisiana rate of being uninsured applied to New Orleans, approximately 93,000 additional residents were uninsured. (Kaiser Family Foundation 2005b) Almost one-third of the workers in the state lived in New Orleans; many lost their jobs, and subsequently their insurance coverage, when many businesses were forced to close. (SAMHSA 2005a)

Within six weeks after the hurricane, approximately 8,400 Louisiana households had sought Medicaid coverage. Of the 6,700 completed applications, well over half (58%) were not approved. Due to the unique circumstances, after September 16 eligibility workers gave unapproved households a “pending” status, not “screened out,” to facilitate subsequent approval when criteria were met. (Ross 2005)

Evacuees who went, or were taken, to other states faced similar hurdles. A survey of evacuees in Houston⁵ revealed that “half” the respondents had no health insurance, although 41% had a chronic condition such as heart disease, hypertension, asthma, diabetes, or cancer. (Kalb & Murr 2005) While they could apply for Medicaid, each state

⁵ This survey was reported in Newsweek; the sampling methodology and sample size were not provided.

determines eligibility criteria, coverage, and benefits. Many evacuees did not meet local eligibility criteria, or had certain uncovered conditions. (Ross 2005) Some families found that children who had been covered by SCHIP in Louisiana did not meet the host state age requirements. (Kaiser Family Foundation 2006d)

As a result of all these factors, many people went without care. A spring, 2006, study of evacuees showed that 14% of children had gone without prescribed medication during the three months prior to the study. (Dewan 2006c) A second study, of people who remained in FEMA housing in the February 11-20 period, revealed that many children had been hospitalized or repeatedly visited the emergency room for asthma care, as their caregivers could not get medication. Nearly half who had had a pediatrician before Hurricane Katrina no longer had one. ([No byline] 2006)

Some did not know their medical needs or medical history.

Many patients do not know the names of medications they are on, or where in a course of treatment – such as radiation – they are. ([No byline] 2005) “They would tell the physician, ‘I take a blue pill,’” health care providers report. (Kalb & Murr 2005) Children’s vaccination histories were also lost, which compounded with multiple moves made it difficult for many to remain on their schedule. (Spote 2005)

New and expectant mothers were particularly affected.

Many women about to give birth, or who had just given birth, had to evacuate. One arguably lucky woman was airlifted with her 2 ½ pound premature son to Baton Rouge, wearing just her hospital robe. (Mercy Corps 2006) Other mothers watched their premature, incubated infants flown out to undetermined sites. (Barringer & McNeil 2005) Over the months following the exodus, the Houston Fire Department reports numerous calls for rides for sick children or women going into labor. (Shamlan 2006) In Arkansas, a physician who operates the only abortion clinic offered to perform free abortions on hurricane evacuees, if they chose, because late-term abortions carry more risk for the mother. (Associated Press 2005a)

Withdrawal

Some people, suddenly without a supply of drugs or alcohol, went into withdrawal. (Boo 2005, Baum 2006) Hospital pharmacies were threatened by armed assailants. (Graham 2005) There were stories of people wading through deep water, holding large amounts of alcohol and little else. (Baum 2006)

Previously Undiagnosed Morbidity

Some evacuees were diagnosed with illnesses for which treatment would be critical to their health. Four cases of tuberculosis were identified among evacuees, widely dispersed in California, Connecticut, Pennsylvania, and Texas. (CDC 2006i) Others were suspected in Colorado. (CDC 2006b)

Site-specific Morbidity

Many Hurricane Katrina evacuees were sent to geographical regions with characteristics vastly different from those of New Orleans. Approximately 6,000 evacuees were distributed throughout Colorado in September, 2005, and as many as 9,000 were there in December. The most common medical needs were related to altitude sickness, as demonstrated by two measures. A survey of 106 households evacuated to Colorado between September 4 and 9 shows that the “most common acute medical conditions

among households reporting one or more conditions were related to altitude sickness (e.g., dehydration, lightheadedness, or problems breathing)." A review of the 124 emergency room visits by evacuees between September 1 and 23 also demonstrates prevalent symptoms related to altitude sickness: 20% of visits were for pain or headache and 15% for an "other" reason, including dizziness.(CDC 2006b)

Many minor physical problems resulted from being in an unfamiliar climate: the cold and dryness of Montana, the dry air of Albuquerque, the "chill in the air and it wasn't even autumn yet" of Baltimore. One can only imagine the reaction of the 180 evacuees to Alaska.(Baum 2005b, Dewan & Roberts 2005, Dewan et al. 2006)

Other site-specific health outcomes involve regional attitudes, not geographic realities. For example, one AIDS patient reported being refused shelter in Baton Rouge, Louisiana, only 80 miles from New Orleans.(Kalb & Murr 2005)

2.2.3. Potential Future Morbidity or Mortality

New Orleans

Health care in New Orleans remains seriously unavailable. By late March, there were only 456 staffed hospital beds, one-fifth the number prior to the hurricane.(Kaiser Family Foundation 2006b) The Tulane University School of Medicine, whose residents supplied a large proportion of care to the uninsured, is operating in Houston through at least the 2005-2006 academic year.(Mangan & K.S. 2005)

Need for psychiatric services is expected to increase as a result of the "psychological stress and trauma caused by the destruction of homes, the loss of jobs, the separation of families, and the death and devastation surrounding those in the areas hit by Hurricane Katrina." (Kaiser Family Foundation 2006c) In December, some psychiatrists in New Orleans reported that clients who had been stable before the hurricane were "preoccupied with death and suicide." (Nossiter 2005) One survey indicated that 39% of Louisiana residents reported feeling angry, and 53% depressed, following the hurricane season.(Kalb & Murr 2005)

But availability of services decreased. In mid-February, only ten psychiatric beds in local hospitals were staffed. As a result, mental health patients are referred to emergency rooms (creating even more pressure on them).(Reuters 2006, Barringer 2006) For patients who are referred to care, just three city psychiatric clinics are open, raising concerns about potential suicides. Funding care is a challenge, as FEMA money may be used for referral, but not treatment, and private care providers are eligible for Medicaid reimbursement only if they served Medicaid patients before the hurricane.(Reuters 2006, U.S. DHHS 2006)

HIV prevention efforts were interrupted by the hurricane, to the great concern of U.S. Surgeon General Richard Carmona, M.D.(Kaiser Family Foundation 2006c) Five of the Louisiana Office of Public Health community-based HIV prevention contractors went out of business because they lost facilities and staff.(Wockner 2006)

Even activities that would normally be construed as healthy may involve increased risk. As described in Section 3.1: Environmental Health Exposure and Outcomes, playgrounds and athletic fields may have been contaminated by heavy metals, stable organics, phenyls, distillates, pesticides, chlorinated hydrocarbons, and other chemicals. Normal abrasions could increase an athlete's exposure.(Bruce 2005)

Nationwide

Health insurance coverage

As discussed in “morbidity due to disruption in care” above, the mass interstate migration had a significant impact on Medicaid and on systems for providing care to the uninsured in many states. The Centers for Medicare and Medicaid Services (CMS) implemented emergency mechanisms to provide states with some flexibility and financial support to provide coverage to evacuees. However, these mechanisms are short-term.

CMS approved 17 waivers (from 15 states, the District of Columbia, and Puerto Rico). These waivers provided temporary Medicaid or the State Children’s Health Insurance Program (SCHIP) to eligible evacuees – parents, pregnant women, children, disabled people, Medicare beneficiaries, and people in need of long-term care who meet income criteria. States cannot extend Medicaid or SCHIP to adults without dependent children or to “certain groups of immigrants, regardless of income.” Sixteen of the 17 states that requested this waiver can provide coverage through June, 2006. (Ohio’s waiver only allowed temporary coverage through December 31, 2005.) (Kaiser Family Foundation 2005a)

To ensure service to the uninsured, eight waivers allow states⁶ to reimburse providers “that incur uncompensated care costs of furnishing services to uninsured evacuees (including adults without dependent children) and to pay for services not covered under the states’ Medicaid or SCHIP programs that are provided to evacuees. (Kaiser Family Foundation 2005a) Some of these states had extremely high numbers of uninsured residents before Hurricane Katrina. Texas ranked first with 28% of the population uninsured; 20% of Arkansas’ had no coverage. (Kaiser Family Foundation 2006c) The uncompensated care pool coverage will end on June 30, 2006. (Kaiser Family Foundation 2006d)

An additional significant change to the United States health insurance system is that, as of January 1, 2006, Medicaid drug coverage was terminated for low-income elderly and disabled Medicare beneficiaries who had been dually eligible. There were only four months between Hurricane Katrina and the scheduled implementation of the Medicare Part D prescription drug program. While a large proportion of the dually enrolled will have been automatically enrolled in Medicare Part D, there will inevitably be a great deal of confusion regarding coverage. Additionally, others were terminated from Medicaid but not eligible for Medicare Part D. (Kaiser Family Foundation 2006c)

People with HIV/AIDS can be eligible for medication through the AIDS Drug Assistance Programs (ADAP). However, each state also determines financial eligibility and covered medications. Patients may not qualify in new states, or may have to change drug regimens. (Wockner 2006) Louisiana residents who go to Texas, for example, will face more-restricted coverage. Additionally, the federal AIDS initiative was not renewed, forcing some people from federal into state systems after October 1, 2005. ([No byline] 2005)

Among those who evacuated to states where they were eligible for insurance (and food stamps), some who returned to New Orleans found they were not eligible in Louisiana, despite their changed circumstances. (Dewan 2006c)

⁶ Alabama, Arkansas, Georgia, Louisiana, Mississippi, South Carolina, Tennessee, and Texas.

The dispersion of hundreds of thousands of people across the country will have effects on many areas other than New Orleans. Cities and states that welcomed evacuees on an emergency basis are facing the reality that many evacuees may not want to – or cannot – return to New Orleans. Medical professionals believe that the “city’s sickest residents were among the first to leave New Orleans after Hurricane Katrina and should be the last to return.” (Barringer 2006) These people will need medical care in their host locations.

Health care needs

A survey of 1,335 New Orleans households that had evacuated to San Antonio, Texas, demonstrates significant medical needs among some evacuees. Fully 42% (563) of households reported having a family member with chronic illness and 28% (367) had a family member with physical or mental disability. These rates are extremely high, so it should be noted that the survey was administered to the 3,700 evacuees who remained by September 14, 2005, out of 12,700 who were there on September 3. That is, the more healthy households may have been able to move out of the evacuation centers more rapidly than households with greater medical needs or less physical mobility. Of the remaining households, “approximately half” plan to settle in San Antonio. Of these, half the heads of household had held unskilled jobs, and one-third were “unemployed, retired, or on disability assistance before evacuation.” (CDC 2006e)

A similar review of approximately 6,000 evacuees in Colorado during September 7-21, 2005, demonstrated that 10.5% had a chronic disease – including hypertension (28%), asthma or chronic lung disease (21%), cardiovascular disease (18%), and diabetes (14%) – and 49% planned to remain in Colorado.(CDC 2006b)

People who left the evacuation centers first, finding housing and possibly jobs, are healthier than people who continued to rely on evacuation systems. Those who remained in FEMA-funded hotel rooms as long as December, 2005, tended to be elderly, disabled, mentally ill, or felons who were “routinely rejected” for other housing. Some, having been homeless before the hurricane, are not eligible for FEMA rental assistance, so have few options.(Wilgoren 2005)

A March, 2006 study of people currently in FEMA housing supports this theory: “nearly half” of adults said they have at least one chronic condition such as diabetes. The children among these evacuees show increased rates of asthma, anxiety, and behavioral problems: 34% report these conditions compared with 25% before the hurricane.(Dewan 2006c)

The influx of evacuees without health insurance has increased the demand for emergency medical services in many areas, such as Houston.(Shamlian 2006) Some experts predict that those who were homeless in New Orleans will become homeless in their new locations (Wilgoren 2005), increasing pressure on local emergency services.

Stress from living conditions

Missing children

Compounding these stressors were the 4,710 Louisiana children who were missing in the aftermath of the storm. These children were mostly from New Orleans, “where heavy flooding and frantic rescues separated families.” (This number includes some children displaced by Hurricane Rita.) Even premature infants evacuated in incubators were separated from parents(Barringer & McNeil 2005) All the children were ultimately

identified, the last after 6 ½ months.(Plaisance 2006) While reunited with at least one guardian, many were missing at least one other family member as of early March.(Dewan 2006b)

In addition to separating families, Hurricane Katrina separated as many as 3,400 children from their "Big Brothers" and "Big Sisters," adult volunteers who provide the children with a stable role model. Still other children were transferred from the New Orleans juvenile detention facility to Baton Rouge.(Kelly & Boyle 2005)

Adults were also separated, and many lacked the mental or physical resources to help themselves or find their family and friends. An elderly woman went to the bathroom in the Superdome and, being in the early stages of dementia, could not find her husband. They were airlifted to different states, and ultimately reunited.(Wilkerson 2005)

Many people had to choose to leave pets behind to escape the flood.(Baum 2005c, Associated Press 2005c, Reuters 2005, Reuters 2005) Others were forced to leave them behind. One young boy, whose dog was taken by police as his family boarded a bus to evacuate the Superdome, cried until he vomited.(Associated Press 2005c) This extreme reaction could be an indicator of the child's baseline mental health, but could be an indicator of the high level of stress and uncertainty he felt.

Housing and food instability

Between Hurricane Katrina and April, 2006, families had moved an average of 3.5 times, often between evacuation centers.(Dewan 2006c, Cowan 2006, Dewan & Roberts 2005) While many people who received temporary housing from FEMA were able to return to their homes or find longer-term housing, many remained on FEMA housing. For these people, the threat of losing housing subsidies could be quite stressful. Approximately 5,000 evacuees had either not received an extension or had not contacted FEMA before the February 14 deadline. More than 20,000 had received extensions, but likely face tighter housing markets than people who found housing quickly.(Easton 2006)

Nearly 400,000 hurricane evacuees remained unemployed (including those affected by Hurricane Rita) on March 6, 2006. The benefit period was extended, so Hurricane Katrina evacuees can collect disaster unemployment assistance through June 4, 2006.(Kaiser Family Foundation 2006c) Employment may be difficult for the approximately 40% of the population that returned to New Orleans(Dewan et al. 2006, Rivlin 2006) as well as those who entered other job markets. Although there is significant clean-up work, a far smaller proportion of sustainable jobs than people have returned. Many local businesses have lost their base: "What's a neighborhood pharmacy without a pharmacy?" asked one former owner.(Rivlin 2006, Seelye 2006)

Food shortages are an unexpected consequence of Hurricane Katrina relief efforts, as food pantries and shelters around the country found themselves in competition for donated food.(Salzman 2005) Many evacuees will find themselves needing the assistance of these pantries and shelters. Six months after the hurricane, 10% of evacuees surveyed said they were homeless or still needed a permanent place to live, and "a majority of whites and blacks reported that they had depleted their savings since the storm." Since the poorest evacuees were not reached by this survey, the true number of needy will be higher.(Dewan et al. 2006) Food shortages will affect new as well as the regular users. Some people who were homeless in New Orleans have already appeared in official counts of the homeless elsewhere.(Horner 2006) In order to avoid a flood of new homeless when FEMA aid is cut off, Houston sent housing inspectors to determine whether evacuees could be returned to their New Orleans homes.(Nichols 2006a)

Overcrowded conditions

According to a CDC Survey of households in Jefferson and Orleans Parishes between October 17 and 22, 2005, approximately a quarter of households "included a person not present in the household before Katrina struck," implying substantial migration within New Orleans as well as from New Orleans.(CDC 2006a) It also implies that crowding may have increased in habitable buildings. In fact, six months after the hurricane, a survey of people who were in a Web database of evacuees – which by definition does not include the poorest people – demonstrated that one-fifth were living in someone else's home.(Dewan et al. 2006) The sudden influx of evacuees to small towns as well as large cities has certainly caused local overcrowding. There are numerous stories of people housing large numbers of family, friends, and even pets.(Steinhauer 2005, Shamlan 2006, Nichols 2006b, Griffin et al. 2005, McKinney 2005) The additional residents also caused shortages of everyday supplies, as demonstrated in Baton Rouge, which added 100,000 evacuees to its 225,000 residents.(Campo-Flores 2006, Egan et al. 2005) The Wal-Mart was forced to close for a few hours each night to restock. "It has been like Christmas every day," said a spokeswoman. Lines at stores are longer, and with increased traffic came a doubling in traffic accidents.(Steinhauer 2005)

Resentment

During the evacuation, resentment built among evacuees and hosts. People in host cities and towns began to lose their patience with the crowding, high level of need among evacuees, and perceived increasing crime.(Steinhauer 2005, Shamlan 2006, Nichols 2006b, Montero 2006) Evacuees, meanwhile, learned that twists of choice – about whether and when to leave New Orleans – and fate led them to their current state, and different states offered vastly different levels of support and services. In addition to varying medical coverage, described in Section 3.2.2 (subhead "Morbidity due to disruption in care or medication after the hurricane") above, states had vastly different degrees of preparation, coordination, and of course ratio of evacuees to residents. In South Carolina, a volunteer group provided evacuees in FEMA-funded hotels with meals prepared by a local restaurant chain. Free public transportation – which was re-routed to accommodate evacuees – provides access to a local thrift shop and church groups collected furniture for future homes. Finally, the state Emergency Management Department provided the volunteer group with a three-month contract to support its efforts in finding housing and convincing evacuees to move.(Wilgoren 2005, Bartels 2005, Working 2005) In contrast, evacuees who landed "miles from the edge of nowhere in the middle of eastern Oklahoma" where cell phones were out of range were treated – with apparently good intentions – like "summer campers," with scheduled meals and strict rules.(Wilkerson 2005)

A final source of stress comes from the feeling among many refugees that they have been "left behind." As discussed in the *American Journal of Public Health*:

"Katrina highlighted a population already left behind by government, civic, and corporate leadership.... [D]istrust of the government by racial and ethnic minority groups is a critical concern in the context of terrorism, when adherence to government directives may be essential to protect the health of Americans."(Quinn 2006)

Watching news media receive gasoline while evacuees could not, leaving them stranded in emergency shelters with inadequate food and water, contributed to angry helplessness.(Mieszkowski 2005, Quintero & Prieto 2005, Treaster 2005) Medical staff and patients stranded at Charity Hospital could see their compatriots at Tulane Hospital,

which served primarily insured patients and was able to hire helicopters, get airlifted as “our 250 patients were evacuated by twos or threes in boats sent to lead to buses that sometimes did not appear.” (Altman & Chang 2005, Berggren 2005) When buses arrived to take evacuees to safety, evacuees were not told where the buses were going. Many of them made several trips over subsequent weeks, through vastly different environments than they were used to. (Barry 2005, Dao et al. 2005, Dewan & Roberts 2005) “They’re treating us like cattle,” complained one. (Johnson 2005) Passing through an arid state, seeing no non-whites and few cars or traffic lights, frightened some. “They trying to slave us,” thought one, “They going to make us pick cotton. We goin’ die.” (Wilkerson 2005) Many people, both residents and reporters, who attempted to evacuate from New Orleans on their own were treated with suspicion at best. Police in surrounding communities turned them back, and some people escaping in a milk truck were forced to lie on the ground, face down. (Herbert 2005, Harris 2005b, Baum 2006)

One evacuee reported that “[w]e are enveloped in collective community blues, manifested by increased fatigue, sleeping disorders, anger and shortened triggers. We are the laboratory rats of a medical specialty heretofore unknown to most of us – disaster psychology.” (Lutz 2006)

3. Mental Health Exposures and Outcomes

In this section, we summarize what is known to date about traumatic exposures resulting from Hurricane Katrina and mental health outcomes associated with those exposures. As used by mental health practitioners, the term ‘trauma’ describes “a wide range of intensely stressful experiences that involve exposure to levels of danger and fear that exceed normal capacity to cope” (Fairbank et al. 2001). The brain’s response to cues that suggest imminent loss of control is believed to be responsible for the structural and functional changes (in the hypothalamic-pituitary-adrenal [HPA] axis and in multiple neurotransmitter systems) that produce the symptoms of posttraumatic stress disorder (PTSD) in a subset of those who have been exposed. (Bremner et al. 1999)

The basic epidemiology of exposure to a wide variety of potentially traumatic events (PTEs) – including such diverse events as natural disasters (e.g., hurricanes, floods, earthquakes, fires), serious accidents (e.g., industrial, auto), physical or sexual assault, combat--has been well documented in recent decades. Findings from this body of research suggest that, even in the US, the majority of people will be exposed to at least one PTE in their lifetime, and many to more than one. (Kessler et al. 1994) Further, across a wide range of PTEs, most of those exposed do not have any clinically significant mental health sequelae, and the likelihood of such sequelae is closely related to the details of an individual’s specific exposure. (Green 1993) Additionally, “human made” events (i.e., purposeful, or intentional, violence) have been shown to be more malignant in this regard than natural disasters. (Norris et al. 2001b) Also, although most people exposed to a PTE experience some distress – e.g., feelings such as fear, anger, uncertainty, and sorrow – the clinically significant reactions that occur typically include PTSD and its frequent comorbidities: depression and substance use disorders.

3.1. Mental Health Outcomes: PTSD and Other Clinically Significant Consequences of Disaster Exposure

The PTSD syndrome describes the most common human response following exposure to life-threatening experiences. PTSD is a specific psychiatric disorder whose official definition in the US is provided by the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV). (Norris et al. 2001a) The current definition of PTSD comprises five major criteria that include both exposure to a PTE and the presence of a specific constellation of symptoms that was not present before the exposure.

Specifically, the formal definition requires:

- Exposure to an event that involves high potential of serious harm or death, combined with peritraumatic experience of specific emotional responses, including intense fear, helplessness, or horror.
- Involuntary reexperiencing of the PTE, via distressing dreams about it, distressing intrusive recollections of it while awake, or "flashbacks" (perceived reliving) of it.
- Active avoidance of reminders of the PTE, and emotional numbing (attempts not to feel anything).
- Symptoms of hyperarousal, such as sleep disturbance and exaggerated startle response.
- The symptoms must have been present for at least one month and have caused significant distress or impaired functioning.

Several excellent summaries of the current knowledge about the epidemiology, etiology, and treatment of PTSD are available. (Schnurr & Friedman 2001, Fairbank et al. 2001, Yehuda 2002) Community epidemiologic studies indicate that about 8% of the US population has had PTSD at some time in their life, and more than 10% of men and 6% of women report having been exposed to four or more PTEs in their lifetime. (Kessler et al. 1994) Fortunately, there are a number of treatments available today whose efficacy for PTSD has been demonstrated empirically. These include a variety of psychotherapeutic approaches, and two pharmacologic agents (sertraline [Zoloft] and paroxetine [Paxil]) have recently been approved by FDA for the treatment of PTSD. Additionally, two sets of practice guidelines for clinicians have recently been published. (Foa et al. 2000, Foa et al. 1999)

A second clinically significant mental health outcome associated with exposure to PTEs is depression. Major depressive disorder is a specific psychiatric disorder characterized by a constellation of affective (dysphoric mood, anhedonia), cognitive (trouble concentrating, indecisiveness), somatic (fatigue, disturbed appetite and sleep), and behavioral (irritability, feelings of guilt or worthlessness) symptoms, with associated functional impairment.

Community epidemiologic studies indicate that the lifetime prevalence of major depressive disorder (MDD) is 16.2% and the 12-month prevalence 6.6%. (Kessler et al. 2003) Additionally, it is estimated that depression costs U.S. employers \$44 billion per year in lost productive time, which represents \$31 billion dollars more than the lost productive time of their non-depressed coworkers. (Steward et al. 2003) Further, epidemiologic and clinical studies document that depression is typically a chronic condition. Among

individuals who have an initial major depressive episode, 80% will have at least one more episode in their lifetime, with 25% having six or more episodes total. (Angst 1995, Judd et al. 1996) The average number of major depressive episodes experienced over their lifetime among people with MDD is about four. (Angst 1995) The comorbidity of depression and PTSD is thought to result in part from the many losses that people exposed to large-scale disasters typically experience (e.g., death of loved ones, loss of home and/or job, loss of social support).

The third primary outcome associated with exposure to disasters and other trauma is substance use disorders, particularly alcohol abuse. Community epidemiologic studies indicate that more than half of men and more than one-quarter of women who have had PTSD have lifetime histories of drug or alcohol abuse, or both. (Kessler et al. 1994) One hypothesized mechanism for the relationship between PTSD and substance use is the self-medication hypothesis, i.e., that people with PTSD use alcohol and drugs to reduce the impact of their intrusive symptoms (i.e., their recurrent, distressing thoughts and dreams about the traumatic event).

3.2. Evidence Concerning Prevalence of Specific Mental Health-Related Exposures

The literature that describes the details of specific exposures from Hurricane Katrina – i.e., what was your exposure to specific aspects of the storm? – is currently very limited. In broad strokes, however, the answer to this question is obvious. Those who remained in New Orleans and the surrounding area were exposed to very high winds, torrential rains, and an unusually high storm surge. In addition to the usual problems of blowing debris, trees falling on houses, and power lines downed and arcing, the confluence of these three factors also caused breaches in protective levees that produced widespread, rapid-onset flooding. Given these storm characteristics, it is clear that those who remained in New Orleans had a very high likelihood of exposure to levels of danger and fear consistent with the current use of the term “trauma.” In addition, given the death toll attributed to the storm and the large number of people who were classified as “missing,” many New Orleans residents were exposed to the death or missing status of one or more family members or close friends who died or were missing following the storm.

Although the grey literature provides many anecdotes about storm-related experiences, there is little systematic information available that describes exposure to psychological trauma. We were able to identify only three reports of systematically collected information that was even marginally relevant in either the scientific or grey literature. One of these was a telephone survey conducted by the Gallup Organization for CNN, USA Today, and the American Red Cross. The survey was conducted between September 30 and October 9, 2005, and consisted of telephone interviews with a “random sample from all individuals who contacted the Red Cross since Hurricane Katrina” (n = 1,510). The fact that the sample includes both people who evacuated and those who did not is an important strength of this survey, but the fact that it contains people from the whole geographic region affected by the storm is a weakness with respect to the objectives of this review.

To enhance its information value for this review, we obtained a public use file of the survey responses from the Roper Center for Public Opinion Research, an archive for public opinion research located at the University of Connecticut. Because the survey is an opinion poll, the psychometric properties of its items are unknown, and because the focus is primarily on survivors’ reactions to the storm, the assessment of exposures is less precise than we would have liked.

Given those caveats, some findings are informative with respect to exposure. Just over half of survey respondents reported having feared for their lives during the storm. In addition, about 7% reported being injured or hurt during the storm, and 8% reported having been a victim of a crime during or immediately after the storm. Also, in addition, half reported being separated from family members for at least one day, more than 70% reported being worried about elderly family members, and about 20% reported losing a pet. Further, about one-quarter of respondents reported having spent at least one night in a shelter during or after the storm.

A second source was a telephone survey conducted by and reported in the *New York Times* during the period February 16 through March 3, 2006. (Boo 2005) Although this survey focused largely on what had happened to evacuees *since* the storm, it also documented some exposure details. The sample was selected at random from a list of more than 160,000 Hurricane Katrina evacuees (and therefore includes evacuees from all affected areas, not just New Orleans). Responses from the 337 participants indicated that African-American evacuees were more likely than whites to report that: their former homes had been destroyed; a close friend or relative had died in the storm; and that they had been separated from family members by the storm. These kinds of exposures have been found to be associated with higher levels of PTSD and depressive symptomatology in empirical studies of other large-scale disasters.

Additionally, two thirds of respondents in the *Times* survey reported that their former residence had been rendered unlivable by the storm. About 40% indicated an intention to return to their former residences, with those aged 40 and over most likely to be planning to return, and those aged 20 –39 most likely to indicate that they did not plan to return (most out of fear of another hurricane/flood disaster).

The third source of more systematic exposure information comes from reports by survey teams sent by CDC to Jefferson Parish and Orleans Parish, which were among the first areas to re-open after the storm, during the week of October 17-22, 2005. (CDC 2006a) The purpose of the survey was to find out about conditions in those areas. The sample was housing-unit based, and was drawn in 45 randomly generated Census blocks in the two parishes. Among respondents in New Orleans Parish, which comprises the city of New Orleans, 46% described their homes as having "very much damage," and 52% rated their homes as being "not safe." In addition, 60% indicated that at least one person in the household had a pre-existing chronic illness, and 41% reported a new illness since the hurricane. More than two-thirds of Orleans Parish residents reported no electricity, no gas, no telephone service and no garbage removal, and more than half reported no running water and no working toilet. One-third reported problems obtaining medical care.

Anecdotal evidence from newspaper and other reports, however, does provide some clues about other kinds of exposure associated with Hurricane Katrina. For example, one report described outrage on the part of relatives of the deceased upon receiving death certificates for their loved ones. (Dewan 2005b) Examples of points of contention include that: bodies were sent to the morgue without notification of kin; there has been no DNA matching to confirm identities of the dead, leaving open the possibility of mis-identification; the place of death listed on the death certificate was incorrect; "decomposition" was frequently listed as a cause of death; and the perception of "enormous sloppiness in record keeping and procedures at the morgue." Such events can easily extend and complicate the bereavement.

Beyond the severity of the storm and flooding, however, extrapolation from studies of prior disasters suggest that two aspects of Hurricane Katrina will influence the mental

health and other psychosocial outcomes over the long term. The first is the monumental infrastructure damage inflicted over a very large area. This suggests that many people have very substantial property and other losses, and these losses have been shown repeatedly to be correlates of poorer psychosocial outcomes. Hobfoll has conceptualized these kinds of losses in a comprehensive theory of the role of diverse resources (e.g., financial, emotional, social, intellectual) in determining psychosocial adjustment. (Hobfoll & Lilly 1993)

The second factor that can be expected to influence the mental health of Hurricane Katrina survivors over the long term is the massive relocation of the affected population, and the wide spread of that relocation. Both of these aspects predict poorer psychosocial outcomes for the evacuees, particularly the children.

Additionally, it is important to note that the infrastructure damage and massive relocation of Hurricane Katrina victims are major barriers to the development of an empirical database about the psychosocial impact of Hurricane Katrina. As an example, in the 12 months following the September 11 terrorist attacks, findings from four major community epidemiologic studies of their mental health impact were published in top-tier journals. (Silver et al. 2002, Schuster et al. 2001, Galea et al. 2002, Schlenger et al. 2002) Among the most important reasons why this was possible was the relatively limited and circumscribed impact – in terms of the residents of New York and Washington, DC – which the attacks had. All four studies were based on interviews conducted via telephone or the internet. Given the widespread infrastructure damage and relocation of Hurricane Katrina survivors, rapid-response empirical research was feasible after September 11 in ways that it was not in response to Hurricane Katrina.

3.3. Evidence Concerning Mental Health Outcomes

3.3.1. PTSD

As with exposure, we found very little scientific literature that provided empirical findings about the psychosocial impact of Hurricane Katrina. The only systematic, empirical study we found was an *MMWR* report that described screening results from the area probability sample study conducted by CDC in Orleans and Jefferson Parishes. (CDC 2006a) Participants in the study were screened for mental health service needs with the Short Post-Traumatic Stress Disorder Rating Interview (SPRINT), a brief screener with documented relationship to mental health service utilization in clinical and community samples. Based on the SPRINT screen, 35% of respondents had screening scores suggesting high need for mental health services, and another 50% had scores suggesting possible need. These are very high proportions, suggesting a substantial need for mental health treatment and case management.

Some preliminary findings from studies of Hurricane Katrina's psychological impact have begun to be reported in the news media, however. Most have focused on the impact of the storm and its destruction on children. For example, one report described a three-year-old who screams and cries as her grandmother fills the bathtub. (Callimachi 2006) The child was at home with her family when the storm surge destroyed the house, and she was swept out of the house underwater. Although she was fortunate to have been saved by an alert neighbor, her fear of water is clear. The report went on to note that of the first 1,000 children evaluated at the LSU Health Sciences Center following the storm, 27% displayed symptoms of PTSD. Additionally, it noted that a study conducted by Columbia University's Mailman School of Public Health found that children who lived

through Hurricane Katrina were more than twice as likely as a comparison group of urban children assessed in 2003 to develop conduct problems, depression, and anxiety.

Although not providing new empirical information about the mental health consequences of Hurricane Katrina, Bourque and her colleagues (Green et al. 1990) reviewed the hurricane literature and used the findings to forecast Hurricane Katrina impacts. Interestingly, they conceptualize Hurricane Katrina as not just a natural disaster, but a natural disaster confounded with human-initiated technological disasters, referring to the slow governmental response to the storm and the wide dispersion of evacuees. They note that the poverty levels among evacuees, the disruption of support systems that evacuation has exacerbated, and the multiple resource losses that many evacuees experienced suggest that Hurricane Katrina will have a strong and long-lasting effect on many evacuees.

The existing literature includes studies of prior hurricanes and floods that are informative. The best studied flood is the Buffalo Creek dam collapse in 1972. (Gleser et al. 1981, Bourque et al. 2006d) An extended period of heavy rain in a strip mining area of West Virginia resulted in the collapse of a mining company-created dam in Buffalo Creek, which unleashed a 15-20 foot wall of water through a narrow valley with no advance warning to residents downstream from the dam. In the course of the next hour, more than 132 million gallons of water rushed through 17 miles of Buffalo Creek hollow and emptied into the Guyandotte River. In its wake, the flood left behind 125 deaths, more than 1,100 injuries, and more than 4,000 people homeless due to 546 houses demolished and 943 damaged. Gleser and her colleagues assessed the mental health status of survivors two years after the flood and found two thirds of the adults and one third of the children to be moderately or severely impaired. (Gleser et al. 1981) The PTSD syndrome was not yet recognized at the time of the study, but a retrospective estimate of the probable PTSD rate two years post flood was 44% for adults and 32% for children, and a follow-up assessment more than a decade later found a 25% PTSD prevalence for adults. (Bourque et al. 2006d) This carefully conducted longitudinal study provides strong evidence of the lasting effects that floods can produce.

From the broader perspective, Norris and her colleagues reviewed two decades (1981-2001) of published literature on disasters and mental health outcomes. (Norris et al. 2002b, Norris et al. 2002a) They reviewed about 250 articles, chapters, and books, which included 160 distinct samples of disaster victims with more than 60,000 research participants. The identified literature included 15 studies of floods and 25 studies of hurricanes (most of which focused on either Hurricane Hugo or Hurricane Andrew).

Based on the review, they found that natural disasters as a class were less traumatogenic than disasters involving mass violence. (Norris et al. 2002a) Longitudinal studies of the aftermath of disasters typically document a decrease over time in PTSD and related symptomatology in the post-exposure period, and symptom levels in the early post-exposure period are typically good predictors of later symptomatology. (Norris et al. 2002a) Intensity of exposure to the disaster is typically the strongest correlate of post-exposure symptomatology, but multiple studies document that the following factors are also consistently associated with post-disaster mental health outcomes:

- gender (females more symptomatic following exposure)
- age (younger people more symptomatic)
- prior trauma exposure (more symptomatic)

- pre-exposure psychiatric disorder (more symptomatic)
- socioeconomic status (lower more symptomatic)
- social support in the post-exposure period (lower more symptomatic)
- resource losses (those with more losses more symptomatic).(Norris et al. 2002a)

In thinking about the implications of the review findings, Norris et al. concluded that early intervention is necessary following disasters, “especially when the disaster is associated with extreme and widespread damage to property, ongoing financial problems for the stricken community, violence that resulted from human intent, and a high prevalence of trauma in the form of injuries, threat to life, and loss of life” (p. 260). Most of these characteristics pertain to Hurricane Katrina. In addition, Norris et al. noted that “family context is central to understanding and meeting those needs,” and that “Altogether, the research demands that we think ecologically and design and test societal- and community-level interventions for the population at large and conserve scarce clinical resources for those most in need” (p. 260).(Norris et al. 2002b)

Among the most important lessons of the past two decades of epidemiologic research on the psychological aftermath of large-scale PTEs is that although very high proportions of the exposed population may experience distress of various kinds (e.g., fear, anger, uncertainty, sorrow) at the time of and/or in the wake of the exposure, most of this distress proves to be both self limiting and not clinically significant. For a subset of the exposed, however, the distress will be clinically significant, and will typically take the form of PTSD. Even among this subset, though, epidemiologic evidence suggests that for many, their clinically significant reaction will also prove to be self-limiting. The net result is that although typically the vast majority of those exposed to large-scale PTEs are distressed in some way by the exposure, the subset that ultimately develops a long-term, clinically significant reaction is likely to be a relatively small proportion of all of those who were exposed.

Because of the large numbers of people exposed inherent in large-scale PTEs, however, even a small proportion of clinical cases among those exposed can mean an epidemic. As a specific example, Schlenger et al. estimated that 11.2% of adults in the New York metropolitan area were probable cases of PTSD in the second month after the September 11 attacks.(Schlenger et al. 2002) Even if only 10% of those cases prove ultimately to be chronic, because there are more than 10 million adults living in the New York metropolitan area, that would mean *more than 100,000 adults with chronic, clinically significant reactions following the terrorist attacks* in the New York metropolitan area alone. This is clearly an important public health problem.

The existing literature also documents a decline in the prevalence of disaster-specific PTSD over time. One of the most striking demonstrations of this is found in a series of studies conducted in New York by Galea and his colleagues following the September 11 terrorist attacks.(Galea et al. 2002) In a series of three cross-sectional, community epidemiologic studies conducted in New York at 2, 4, and 6 months after the attacks, the prevalence of attack-related PTSD reduced from about 8% to about 1%. This pattern of relatively rapid resolution of PTSD following single-event disasters have been shown form multiple types of disasters (e.g., terrorist attacks, earthquakes, hurricanes).

Nevertheless, it is clear from the literature that not enough is currently known about the details of the *course* of PTSD. The available empirical information clearly suggests that for many who develop PTSD symptomatology in the weeks and months following exposure

to a disaster, the condition will prove to be self-limiting – i.e., the symptoms will resolve within 3-6 months without clinical intervention. For these people, “returning to normal” in the aftermath of trauma is a reasonable and attainable goal. What remains unclear, however, is what proportion of disaster-related PTSD cases will prove to be chronic, what are the appropriate interventions for them, and how can we identify them early?

Additionally, although severity and characteristics of the specific PTE exposure has repeatedly been shown to be the strongest predictor of post-exposure PTSD prevalence, a number of other risk factors for the development of PTSD have also been identified. The best established of these include that: women are more likely to develop PTSD than men; minority group members (e.g., African-Americans, Hispanics) more likely than majority group members; those with history of prior PTE exposure more likely than those without; and those younger at time of exposure more likely than those older. Given the substantial minority population of New Orleans and the relatively high level of poverty, these characteristics suggest a relatively high prevalence of PTSD from Hurricane Katrina.

Furthermore, recent research has focused on the association of disaster-caused relocation (e.g., evacuation) with post-disaster mental health outcomes. Riad & Norris found that relocation was related to psychosocial outcomes, including psychological symptom levels. They further found interactions with ecological stress (i.e., poor living conditions), such that those who relocated to poor living conditions had worse outcomes than either those who did not relocate and lived under comparable conditions, or those who relocated but lived under better conditions. (Riad & Norris 1996) These findings add to the concern over the Hurricane Katrina evacuees.

3.3.2. Depression

As was true for PTSD, we could find no empirical findings about depression directly associated with Hurricane Katrina. The disaster literature, however, documents clearly the frequent comorbidity of these conditions with PTSD. (Keane & Wolf 1990) The substantial death toll from the storm, the lingering number of persons unaccounted for, the many separations of family members (caused by the storm, the evacuation, or both), the major relocation of population, and the screening results from the CDC study (CDC 2006a) all point to a likely high prevalence of both depressive and substance use disorders in the wake of Hurricane Katrina.

3.3.3. Substance Abuse

Similarly, we could find no studies documenting substance use in the aftermath of Hurricane Katrina, and somewhat surprisingly no mention of substance use in the grey literature. Nevertheless, substance abuse has been shown to be a robust correlate of PTSD in studies of a wide variety of traumatic exposures. What remains unclear, however, is whether exposure to PTEs has a direct effect on substance use, independent of the psychological distress it causes, or whether increased substance use post-exposure reflects victims’ attempts to medicate their psychological distress.

3.3.4. Interruptions in Mental Health Service Delivery

Among the many problems resulting from Hurricane Katrina, one of the most serious is the decimation of the health and mental health service systems. Because PTSD, major depression and the substance use disorders can all be chronic, episodic disorders, the lack of mental health care is an important problem.

Federal agencies, however, worked in partnership with state governments to address some of the mental health service needs of Hurricane Katrina survivors. SAMHSA immediately made responding to the devastation caused by Hurricane Katrina its top priority, working in partnership with FEMA and the affected state governments. In September 2005, SAMHSA announced that: "In collaboration with State, local and Federal partners, our missions are to: 1) "ensure that mental health assessment and crisis counseling are readily available to residents and evacuees of areas impacted by Hurricane Katrina and establish a longer term plan to assure Post Traumatic Stress Disorders (PTSD) are addressed with this population, and 2) ensure that people impacted by Hurricane Katrina who have serious mental illness and/or addictive disorders and children with serious emotional disturbances continue to receive ongoing treatment for their chronic disorder." (SAMHSA 2005b)

In this same month, SAMHSA began to put these aims into practice. It awarded \$600,000 in SAMHSA Emergency Response Grants (SERG) to provide clinical services and pharmaceuticals to those affected by Hurricane Katrina. The state of Louisiana received one-third of this grant money to provide counseling services to disaster workers and first responders. (SAMHSA 2005c)

In addition to this grant, the Department of Health & Human Services (HHS) provided SAMHSA with a \$6 million contract to assist in identifying, credentialing, and deploying mental health professionals. SAMHSA identified 194 chaplains, mental health workers, psychologists, and social workers eligible to provide services in the disaster-stricken areas. One hundred of these mental health professionals were deployed to the state of Louisiana. (SAMHSA 2005c)

SAMHSA also worked with the National Suicide Prevention Line to extend its services to people impacted by Hurricane Katrina. From the onset of the hurricane to September 26, 2005, the 110 certified crisis centers involved in the hotline received an average of 173 calls daily; 35 percent more daily calls were received after the onset of the hurricane. (SAMHSA 2005b)

SAMHSA and the Federal Emergency Management Agency (FEMA) also partnered to administer the FEMA Crisis Counseling Assistance and Training Program (CCP). These grants are being used to benefit evacuees through outreach, counseling, and public education service. The state of Louisiana in particular was awarded \$1 million to provide assistance to hurricane victims after Federal workers leave the area. (SAMHSA 2005b)

In addition to these efforts, the SAMHSA Emergency Response Center (SERC) was launched in September to assist state officials, support staff deployed in the field, and to be a liaison to other Federal and voluntary agencies involved in the public health response to the disaster. SERC deployed teams of people to support state and local efforts, including the provision of: substance abuse/methadone treatment expertise to Louisiana; mental health clinical services to police officers and fire fighters and their families housed on the two Carnival cruise ships in New Orleans; and stress management services to first responders in Mississippi. By the end of September 2005, SAMHSA successfully deployed 63 people (including 12 SAMHSA staff and 7 NIH staff) to the state of Louisiana. (SAMHSA 2005b)

By mid-September 2005, SAMHSA estimated that the agency had served 23,500 individuals affected by Hurricane Katrina. (SAMHSA 2005a) Subsequently, SAMHSA reported that by February, 2006 it had:

- Coordinated the mobilization of more than 500 people to work in the field on mental health and substance abuse issues.
- Provided more than 17,000 counseling sessions (91% with individuals).
- Of these individuals, 26% presented problems requiring a referral to local mental health resources for ongoing treatment, and 5% required a referral for ongoing substance abuse treatment. These are new cases to an already burdened system.

Despite these important contributions, the fact remains that the health and mental health service systems in New Orleans have been decimated by the combination of: (a) massive facility damage or destruction (e.g., hospitals, practitioner offices), and (b) the departure of the majority of virtually all kinds of clinical service providers, from primary care physicians to optometrists to pharmacists to psychotherapists. Therefore, other mental health issues have resulted from the destruction caused by Hurricane Katrina, beyond the trauma created and people's responses to it.

The publicly funded mental health system in the U.S. is focused on the traditional concept of "serious mental illness," comprising people with chronic disorders, including schizophrenia, bipolar disorder (formerly called manic depressive illness), and borderline personality disorder. These disorders require long-term medication use (antipsychotics, antimanic, and antidepressants), periodic personal contact with mental health professionals, and assertive case management. People with these disorders who either stayed in New Orleans to ride out the storm or who quickly returned face difficult challenges in adhering to their established treatment regimens, given the current lack of mental health providers, facilities, and pharmacies. The inability to obtain needed medication alone is a very serious problem, but in combination with the current life stressors (home uninhabitable, relatives or friends dead or missing, no job) and lack of clinical resources it becomes a public health disaster.

Those who evacuated and have not returned face possibly greater challenges in establishing new therapeutic alliances in their new residences. Although the population prevalence of serious mental illness is relatively low (about 3-5%, depending on the specific definition), given the pre-hurricane size of the New Orleans population, this is another important public health problem. Obviously, many important needs must be addressed to re-establish New Orleans as a viable community, but it is clear that establishing fully functioning health and mental health service systems in New Orleans is one of the multiple foundations on which recovery of the city will be built.

Additionally, however, studies of recent disasters have made it clear that the reactions of children to mass disaster differ from those of adults. Studies of both the bombing of the Murrah Federal Building in Oklahoma City (Pfefferbaum et al. 1999, Pfefferbaum et al. 2001, Pfefferbaum et al. 2000) and the September 11 terrorist attacks (Hoven et al. 2006) have provided empirical documentation of serious impact of these events on children and adolescents, even those who were not directly affected. Given the large number of children directly affected by Hurricane Katrina, and the life disruptions created by evacuation, it is reasonable to anticipate the possibility of long-term consequences of Katrina for both directly and indirectly affected children and adolescents.

4. Pre-Literature: Studies Currently in the Field or Recently Completed

In addition to searching the scientific and grey literatures, we attempted to identify studies currently underway or soon to be underway that may produce findings of relevance to this report. We contacted relevant funding sources and key researchers in the field to identify current and/or planned studies about Katrina and its health and mental health impacts.

In what follows, we describe major studies that we identified that are relevant to the health and mental health effects of Hurricane Katrina. We organize the studies by the organization(s) conducting the work.

4.1. Harvard University

With funding primarily from NIMH, Dr. Ronald C. Kessler of the Department of Health Care Policy, Harvard Medical School, is conducting a longitudinal study of the impact of Katrina. The study sample of about 2,000 people was selected via a mixture of area probability and list sampling methods. About half the sample lived in New Orleans when the storm hit and the other half lived in the other areas hit (Alabama, Louisiana, Mississippi). Dr. Kessler calls the study sample the "Hurricane Katrina Community Advisory Group," and they are interviewed every three months for a period of two years. The study aims to document the experiences of a broad cross-section of people affected by Katrina – their experiences during the storm, their emotional reactions, and problems that they may have faced in the aftermath. Although no findings have been released yet, the plan is that information will begin to be released when the first scientific article of findings has been accepted for publication, which may be as early as June, 2006.

4.2. Columbia University

A group at Columbia University's National Center for Disaster Preparedness (Mailman School of Public Health), led by Drs. David Abramson and Richard Garfield, along with The Children's Health Fund, is studying the health and psychosocial status of people who were exposed to Hurricane Katrina. The researchers conducted interviews with a probability sample of 665 households of people who had evacuated New Orleans and were living in trailers or hotels in Louisiana during February of 2006. Preliminary findings indicate that nearly half of parents report new emotional or behavioral problems in their child(ren) since the storm, and that more than half of mothers assessed had mental health screening results consistent with probable clinical diagnosis. Additionally, about 25% of the school-aged children were not enrolled in school or had missed 10 or more days of school in the past month.

In addition, another group at the Mailman School, led by Dr. Neil Boothby and working with Save the Children, has conducted psychological evaluations with about 1,400 children in school-based psychosocial programs in New Orleans. This group intends to conduct more than 50,000 evaluations between January and June of 2006. An early finding from the screenings is a relatively high prevalence of pre-Katrina exposure to other trauma, mostly violence.

4.3. Johns Hopkins University

A group of experienced investigators from the Bloomberg School of Public Health has recently completed a set of five coordinated studies referred to collectively as the Johns Hopkins Public Health and Safety Consequence Analysis and Projection, funded by FEMA. Dr. Tom Burke, Professor of Health Policy and Management and co-director of the Risk Sciences and Public Policy Institute, served as principal investigator for the effort, and each of the five studies was led by an expert in its topic area (pathogens and disease, Dr. Kellogg Schwab; environmental toxins, Dr. Mary Fox; psychological impact on resident populations, Dr. Donald Steinwachs; physical injuries, Dr. Adnan Hyder; and Continuity of care, Dr. Gerald Anderson). The reports of the studies have recently been submitted to FEMA, where they are under review.

4.4. Rand Corporation

In collaboration with seven local universities, The RAND Corporation, a private, not-for-profit research firm headquartered in Santa Monica, CA, has created the RAND Gulf States Policy Institute. The Institute's mission is to facilitate recovery from the devastation of Hurricanes Katrina and Rita by "providing evidence-based policy guidance to facilitate and speed regional recovery and growth, re-establish services and result in a wise investment in infrastructure." Funded in part by RAND donor contributions and unrestricted funds, RAND and its partner universities implemented quickly a set of studies aimed at important policy issues for recovery. These studies address diverse issues, including: dealing with uninsured losses; safety planning for healthcare structures; recruitment/retention of high-quality healthcare workforce; options for education in New Orleans; the housing crunch in Mississippi; Katrina's effect on the health of first responders and residents; mental health needs of students; the effect of hurricane-related displacement on schools and students; and documenting lessons learned from the public health response.

Several of the studies currently in the field are relevant to this review. The study of mental health needs of students is focused on developing an infrastructure in the New Orleans school system to address the needs of flood-affected students. The study of hurricane-related displacement will document where displaced students went and for how long, and will compare achievement and psychosocial outcomes of displaced versus not displaced students over time. The study of lessons learned, funded by DHHS's Office of Public Health Emergency Preparedness, is focusing on documenting and assessing specific aspects of the public health response, including: communications, disease surveillance and investigation, laboratory capacity, provision of essential medical services to affected people, and planning and policy development.

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Appendix A: Search Methods and Results

We took a multi-pronged approach to the literature search, because:

- (a) The search was to include both empirical literature that described the exposures and health/mental health effects of Hurricane Katrina *and* empirical literature that described exposures and health/mental health effects of similar past disasters (e.g., hurricanes, floods).
- (b) The search was to cover both the scientific (peer-reviewed) literature and the “grey” literature.

Because of the limited time between the occurrence of the storm and the conduct of the review, it was clear that the scientific literature describing Hurricane Katrina and its effects would be quite limited. The grey literature, on the other hand, is enormous but anecdotal.

Our approach to this dilemma was as follows. First, we used findings from the post-Hurricane Katrina scientific literature to identify documented effects, and we used grey literature descriptions of these documented effects to provide additional details about them. Second, we used the similar-disaster scientific literature to identify likely other effects of Hurricane Katrina, and grey literature to add details. Third, we used the grey literature to identify potential other effects that were not mentioned in the Hurricane Katrina-specific or the similar-disaster literatures. Finally, we searched what might be thought of as the “pre” literature, i.e., we contacted investigators who we knew were currently conducting studies of Hurricane Katrina and its impact, to learn some details of what they were studying and any early findings.

A) Peer-Reviewed Literature

As noted above, the basic purpose of the literature review is to provide as rich a description as possible of the actual exposures and health and mental health outcomes of Hurricane Katrina observed to date, and also a forecast of additional health and mental health consequences that may not yet have become evident. We searched five major literature review databases:

- PubMed, medical and public health literature
- Medline, medical and public health literature
- PsychInfo, psychiatric and psychological literature
- SocialSci, social science literature
- TGG Health & Wellness, health and wellness literature

For all databases except PubMed, the Abt Associates library staff performed searches of “Hurricane Katrina and (health or mental health).” Research staff reviewed the resulting lists of summary information about each selected item and identified specific items to be downloaded. Table A-1 demonstrates the results of this process.

Table A-1: RESULTS OF LITERATURE REVIEW

Literature review database	Number of results selected by broad search	Number of results downloaded	
		Health	Mental Health
Medline	95	47	29
PsychInfo	5	0 ^a	5
SocialSci	7	2	7
Health & Wellness	110	86	32

^a One article had many references of interest; four were accessed from the Internet.

As anticipated, a search using the standard literature review databases yielded just a handful of results. Also as expected, the vast majority of published literature with respect to exposures and health effects is from the Centers for Disease Control and Prevention (CDC), which quickly established surveillance centers in affected areas to identify and report reliably on morbidity and mortality outcomes.

For PubMed, the searches were performed directly from Reference Manager, the database in which all results were collected. After performing a set of initial searches, using terms known to be associated with hurricanes, we reviewed the CDC reports and broadened our set of search terms. Each term was linked with the phrase “Hurricane Katrina” to increase the specificity of the results. The final terms, and number of results, are shown in Table A-2.

The results are relevant for people who moved to New Orleans as part of the relief and reconstruction efforts as well as for those living there when Hurricane Katrina hit. As many as 40,000 active-duty military and National Guard (Manjoo 2005), 1,580 Army Corps of Engineers workers (Cloud 2005), 148 CDC public health workers such as epidemiologists (CDC 2005h), approximately 500 SAMHSA mental health and substance abuse counsellors (SAMHSA 2006), some 800 firefighters from New York and Illinois (Longman 2005), 303 New York police officers (Baker 2005), a sheriff and 33 deputies from Michigan (Lipton et al. 2005), and 38 Public Health Service physicians and nurses (Altman & Chang 2005) were dispatched to the region.

The CDC surveillance methods have two significant limitations. First, they involve the geographic areas most directly impacted by the hurricane: Louisiana, Mississippi, Alabama, and Texas. Before the hurricane struck, about three-quarters of New Orleans residents heeded the recommendation to evacuate, and dispersed, planning to stay with family or friends or in hotels during the height of the storm. It appears from anecdotal reports and evacuee dispersion data (Kent 2005) that most of these people stayed within a moderate driving distance from their point of origin. However, many sanctuaries were also damaged by the storm or not available for extended stays. As a result, many of these evacuees needed to move again.

Second, of the additional 50,000-100,000 New Orleans residents stranded in the city, most were relocated in large groups (i.e., hundreds or thousands). Although the four-state region that CDC focused on got the largest share of evacuees – almost a quarter of a million were immediately housed in Houston (CDC 2005f) – every state received some evacuees. Currently available data do not distinguish between evacuees from New Orleans and from other areas of Louisiana, but FEMA reports that approximately 800,000 Louisiana citizens requested FEMA assistance⁷ by September 20, 2005 from every

⁷ Applications for FEMA assistance could be requested to cover expenses associated with disruptions other than leaving one's home. For example, college students arriving for their first year who had to turn away from New Orleans were encouraged by at least one institution to apply for assistance to pay for the cost of, for example, additional travel and ruined clothing. (Minton 2006) Therefore, it is possible that some applications do not reflect evacuations.

state.(Kent 2005) These data suggest that the majority of Louisiana residents who evacuated are not currently under surveillance by CDC.

Table A-2: PEER-REVIEWED LITERATURE SEARCH TERMS AND RESULTS

Date	Search term used with phrase ("Hurricane Katrina" and)	Number of results
4/13/2006	Health	48
4/13/2006	Disease	25
Causes of disease		
4/13/2006	Vector	0
4/13/2006	Insect	0
4/13/2006	Chemical	1
4/13/2006	Toxin	0
4/13/2006	Pathogen	0
4/13/2006	Carbon monoxide	1
Mortality		
4/13/2006	Drown	0
4/13/2006	Homicide	1
4/13/2006	Suicide	0
4/13/2006	Injury	12
4/13/2006	Cardiovascular	0
4/13/2006	Sepsis	0
4/13/2006	Alcoholism	0
4/13/2006	Cerebral palsy	0
4/13/2006	Suffocation	0
4/13/2006	Pneumonia	0
Currently Evident Morbidity/Injury		
4/13/2006	Poison	0
4/13/2006	Wound	6
4/13/2006	Laceration	0
4/13/2006	Strain	0
4/13/2006	Hernia	0
4/13/2006	Broken bone	0
Currently Evident Morbidity/Illness		
4/13/2006	Nausea	0
4/13/2006	Gastrointestinal	0
4/13/2006	Respiratory	3
4/13/2006	Dermatolog [-y, -ic]	0
4/13/2006	Cardiovascular	0
4/13/2006	Norovirus	2
4/13/2006	Infection	7
4/13/2006	Cellulites	0
4/13/2006	Bite [insect or animal]	0
4/13/2006	Headache	0
4/13/2006	Hypertension	1
4/13/2006	Altitude sickness	1
4/13/2006	Dehydration	0
Potential future morbidity or mortality:		
4/13/2006	Tuberculosis	0
4/13/2006	Asthma	0

B) Similar-Disaster Scientific Literature

In order to determine the types of health effects that have been found to be associated with prior hurricanes, floods, and similar events, we researched the major federal agencies responsible for hurricane preparedness and response:

- National Hurricane Center
- National Oceanic & Atmospheric Administration (NOAA)
- Centers for Disease Control and Prevention (CDC)
- American Red Cross

As we anticipated, CDC had the most thorough information, with numerous fact sheets for the public:

- Prevent Illness
- Keep Food & Water Safe
- Environmental Concerns
- Animal & Insect Hazards
- When the Power Goes Out
- Returning Home after a Hurricane
- Prevent Injury
- Clean Up Safely
- Hurricane Katrina & Other 2005 Hurricanes

CDC also provides fact sheets for groups with specific concerns such as:

- Response & Cleanup Workers
- Evacuation Centers
- Volunteers

Finally, CDC also makes information from other federal agencies available. This includes, for example, a report on the effects of the Murphy Oil Spill, which had been prepared by the U.S. Department of Health and Human Services' Agency for Toxic Substances and Disease Registry (ATSDR).

On the mental health side, we searched the PILOTS database, maintained at Dartmouth College by the National Center for Posttraumatic Stress Disorder (NC.PTSD). PILOTS is an electronic index to the worldwide literature on post-traumatic stress disorder (PTSD) and other mental-health consequences of exposure to traumatic events. The database is updated bimonthly, and it currently contains more than 28,000 references, almost all of which include abstracts.

We searched PILOTS for mental health information using keywords "disaster" and each of the following: hurricane, flood, tsunami, mental health, PTSD, depression, and substance abuse. Table A-3 shows the number of relevant articles identified in each of these

categories (relevance was assessed from the title and abstract of each article; “hurricane” and “flood” each produced more than 100 articles, many of which were clearly not relevant). The terms “mental health” and “PTSD” produced far too many hits to be useful.

Table A-3 PILOTS data base search results

Topic: Disaster And ...	Number of Relevant Articles
Hurricane	49
Flood	21
Tsunami	2
Depression	61
Substance Abuse	6

The data set that resulted from these activities provides a comprehensive description of the potential health and mental health effects that existing empirical evidence suggests may result from Hurricane Katrina-related exposures.

C) Grey Literature

To identify and collect evidence of potential health effects of Hurricane Katrina not identified via CDC’s surveillance system, we turned to the “grey literature.” There are many shades of grey, from high-quality reporting with solid fact-checking to immediate reports based on little more than hearsay. We established a rigorous, systematic approach that ranked types of sources (e.g., magazines, newspapers) and, within types, grouped specific sources. The searches were parallel. When possible, we cite numerous sources. In the rare cases where sources conflicted – e.g., on the number of Level I trauma centers “nearest” New Orleans – we found independent confirmation.

Magazine search

To select a broad set of news magazines, we selected two lists. One, www.magazine-directory.com, has 320 titles, some specialized and many general-interest. The other, www.magazines.com, has over 1,500 titles, but a sub-request for news magazines brought the list to 77. Many of the titles are on both lists; we ultimately searched over 360 news magazines. The magazine search took place on April 5, 2006.

Although many of the magazines are widely respected for their journalistic quality, many have a distinct political identity or target audience. The magazines reviewed represent a broad range of political spectrums and readership, as demonstrated in Table A-4. Reviewing a broad range of magazines was essential to collecting diverse information.

Since Hurricane Katrina evacuees have been dispersed across the country, we thought there might be some interesting articles in regional magazines. By searching the Internet site Google for “regional magazines”, we found www.bookmarket.com, which claims to list all regional magazines published in the U.S. We examined all 187 magazines listed. Some, which were extremely specialized within a geographical region (e.g., “Divorce Chicago,” “Florida Small Business”), we did not investigate further. Many were promotional, or “lifestyle,” magazines. By definition, these magazines do not run articles that present the region in a negative light. Many ran articles about local volunteers helping on hurricane relief efforts; none had substantive commentary on health effects.

Of the remaining magazines, we searched for “Katrina” in internal searches, when these were available, and, if not, reviewed the entire website.

Seven regional magazines had articles with adequately specific results to be included in the database. They are listed in Table A-4.

Finally, some additional sources were identified through methods similar to the “snowball technique.” Some websites provide links to other sources of interest. These sources are also listed in Table A-4.

Table A-4: IDENTIFICATION AND SELECTION OF MAGAZINE ARTICLES

Title	Description	Number of articles downloaded
News Magazines		
The Atlantic	"Contemporary issues"	44
Baltimore Afro-American Newspaper	"Black owned and operated newspaper has crusaded for racial equality and economic advancement"	0
Discover	"General interest magazine devoted to the world of science and technology"	0
Ebony	"Magazine for African-American men and women"	
The Economist	"International newsweekly on politics, business, finance"	0
Essence	"For the African-American woman who is looking for a source of useful, provocative information"	0
Independent Review	"Devoted to excellence in the critical analysis of government policy and current affairs"	1
Frontpage	"World news politics and features. Lots of conservative commentaries."	0
Harper's Magazine	"Original journalism"	1
The Humanist	"Magazine of critical inquiry and social concern"	0
Jet	"Written for an African-American audience and focuses on news and features that fuse Black history and contemporary living"	0
MacLean's	"Weekly wrap-up and analysis of news events"	0
Mother Jones	"A magazine of provocative and unexpected articles"	7
Ms. Magazine	"Feminist"	0
National Geographic	"Rare look at the drama of humanity and the wonders of nature"	0
National Review	"Premier journal of conservative political opinion"	0
Newsweek	"A weekly news magazine that reports and analyzes today's most important events"	24 ^a
People Magazine	"Amazing stories about ordinary people"	4
Reason	"Covers politics, culture, and ideas"	0
Saturday Evening Post	"Family magazine"	0
Salon	"This Internet media company produces 10 original content sites"	12 ^b
Science Magazine	"Covers the most important research in all fields of science"	0 ^c
Smithsonian	"Regularly covers topics such as Americana ...and contemporary society"	0
The Nation	"Unconventional wisdom since 1865"	8
The New Republic	"One of America's opinion magazines"	0
The New Yorker	"Commentaries and reporting on politics, culture, and events" (Amazon.com)	21
The Week	"The best of U.S. and international media"	0

continued

Title	Description	Number of articles downloaded
The Weekly Standard	"Commentary and articles"	0
Time	"Insightful analysis of today's important events"	8
U.S. News and Weekly Report	"Articles on national and world events"	12
Regional Magazines		
Atlanta Magazine		2
Chicago Magazine		1
Louisiana Life		5
New Orleans Magazine		2
New Orleans Tribune		2
New York Magazine		1
Texas Monthly		0
Other sources identified through snowball technique		
Center on Budget and Policy Priorities	"Nonpartisan research organization and policy institute that conducts research and analysis"	1
EndHomelessness.org	"A nonprofit organization whose mission is to mobilize the nonprofit, public and private sectors of society in an alliance to end homelessness"	1
MercyCorps.org	A voluntary organization that provides disaster relief	9
PBS.org	The public broadcasting system	2
RedCross.org	A voluntary organization that provides disaster relief	770
The Henry J. Kaiser Family Foundation	"Non-profit, private operating foundation focusing on the major health care issues facing the nation"	10

^a Many articles found in Newsweek were credited to MSNBC.

^b Searched for "Katrina and health"; narrowed results to 61.

^c Searched in "medicine, diseases" section.

Newspaper search

As with the magazine search, the objective of the newspaper search was to get (a) the highest-quality, most reliable reports of health effects and (b) thorough coverage of regions to which evacuees were dispersed, as the health effects could differ by region. We implemented a hierarchical approach to the search. First, we selected the top three newspapers in the U.S.⁸ Second, we selected six nationally ranked newspapers from regions with a heavy influx of evacuees. Third, we recognized that evacuees may have different health outcomes in different areas, due to climatic and other regional characteristics or due to the evacuees' differing impact on local health systems. We selected newspapers from four additional cities, based on the rate of applications for FEMA assistance per 10,000 people in the state and unique geographic characteristics. For example, we knew from CDC reports that altitude sickness was common among evacuees in Colorado. The selection criteria are demonstrated in Table A-5.

⁸ Columbia Journalism Review, November/December 1999. Available at <http://archives.cjr.org/year/99/6/best.asp>. Accessed 4/5/2006.

Table A-5: IDENTIFICATION OF NEWSPAPERS

Newspaper	National Ranking	Applications for FEMA assistance per 10,000 people
Top three newspapers		
The New York Times	1	
Washington Post	2	
Wall Street Journal	3	
Nationally ranked newspapers from regions with a heavy influx of evacuees		
Los Angeles Times	4	
Dallas Morning News	5	
Chicago Tribune	6	
St. Petersburg Times	9	
The Atlanta Journal-Constitution	19	
(New Orleans) Times-Picayune	"singled out for 'most improved'"	
Newspapers from selected regions		
Detroit Free Press	n/a	78.9/10,000
(Memphis) Commercial Appeal	n/a	32.4/10,000 in Tennessee; 145.5/10,000 in Memphis
Anchorage Daily News	n/a	2.5/10,000
(Denver) Rocky Mountain News	n/a	6.8/10,000

Because the number of newspaper articles was potentially extremely large, we developed a set of parameters designed for high specificity and low sensitivity. They are represented in Table A-6.

Table A-6: IDENTIFICATION AND SELECTION OF NEWSPAPER ARTICLES

Set 1: Causes of Disease	"Hurricane Katrina" and (vector or chemical or toxin or pathogen or "carbon monoxide" or insect)
Set 2: Mortality	"Hurricane Katrina" and (drowning or homicide or suicide or injury or "underlying cardiovascular" or disease or sepsis or "chronic alcoholism" or "cerebral palsy" or suffocation or pneumonia)
Set 3: Morbidity / Injury	"Hurricane Katrina" and (poisoning or wounds or lacerations or strains or sprains or hernia or "broken bones")
Set 4: Morbidity / Illness	"Hurricane Katrina" and (gastrointestinal or nausea or vomiting or diarrhea or "acute respiratory" or cough or fever or "skin infection" or rash or cardiovascular or norovirus or infection or cellulitis or bites or "heart attack" or headache or hypertension or pneumonia or "altitude sickness" or dehydration or tuberculosis)

Pre-Literature Search

As noted above, in addition to the searches of already published literature (grey or otherwise), we also attempted to anticipate future literature by identifying studies that were currently in the field but had not yet disseminated findings. To do so we talked with knowledgeable colleagues in the public health and mental health fields and with officials at several relevant funding sources (e.g., NIMH, SAMHSA) to get a sense of what is going on in the field, and what might be currently in the pipeline. Because these studies represent the intellectual property of the investigators, we provide only general descriptions of the study aims.

