HURRICANE ANDREW AND PREGNANCIES IN LOUISIANA

A Thesis

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By
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DEDICATION

I want to dedicate this thesis to my parents for their care and endless love for me.

I am also dedicating this thesis to my children, Xenia and Julia, who make me feel strong and who help me through the tough times.

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ABSTRACT

There are anecdotal accounts about the possible impact of a pregnant woman's mental health on her unborn fetus. This thesis investigates the possible association between hurricane-related stress experienced by pregnant women living in the area afflicted by Hurricane Andrew in Louisiana in 1992 and poor pregnancy outcomes such as preterm and Low Birth Weight (LBW) births. This is an important topic of research because by investigating past events one can better understand the pregnancy-related health issues for areas affected by extreme weather events such as Hurricanes Katrina and Rita.

This research analyzed birth data from Louisiana both before and after Hurricane Andrew. Two areas were compared: the area affected by the hurricane and a non-affected area. The affected area was within the hurricane-force winds zone, suffered damage, and had an order or recommendation to evacuate. The non-affected area was used as a control; it was outside of the hurricane's track, sustained no damage, and it had no mandatory evacuation order. Analogous statistical analyses were used to analyze birth data for both areas, namely, Chi-squared analysis, which was applied to find if there were statistically significant changes in the number of LBW and preterm deliveries for the periods following the hurricane compared to a period preceding Hurricane Andrew, which was considered a baseline for the analysis.

Results of the analyses have shown that hurricane-related stress while affecting preterm births, does not seem to have the same affect on LBW deliveries.

Ultimately, this research will lessen the negative health impact of the hurricanes, which in turn will lessen the economic burden on a society by decreasing total medical costs associated with caring for LBW and preterm babies.

CHAPTER 1. INTRODUCTION

1.1 Purpose

Although there are many examples of disaster epidemiology in the field of public health (Gregg et al., 1989; Bertazzi, 1989; Lechat, 1990; Noji, 1997), this thesis will explore a theme which has received alarming little attention, that of poor pregnancy outcomes in the wake of a natural disaster (Cordero, 1993; Buekens et al., 2006; Curtis, 2007). This thesis will specifically consider reproductive health outcomes in the aftermath of Hurricane Andrew in Louisiana, in order to determine whether a relationship exists between the natural disaster and adverse pregnancy outcomes. The time frame for the analyses conducted in this thesis covers the period 1990 to 1995.

The purpose of this study is to gain further insight into whether Hurricane Andrew caused an increase in adverse pregnancy outcomes in two categories: Low Birth Weight (LBW) and Premature or short gestation deliveries. Buekens et al. (2006, p.92) commented, "We know surprisingly little about the impact of hurricanes and other disasters on pregnancy." This study will benefit both the literature and society as it will help add to this gap in the literature, with the added benefit of collecting timely and relevant data for that area of the Gulf Coast devastated by Hurricanes Katrina and Rita.

1.2 Why Study Pregnancy Outcomes?

Deliveries of LBW infants (<2500 gram), as well as preterm deliveries (< 37 weeks of gestation) are important indicators of societal public health. It is important to study pregnancy in relation to a disaster not only because it is an under-researched area, but also because Louisiana traditionally suffers from poor birth outcomes (LA Health report card, 2005). For example, in 2003, Louisiana ranked third in the nation for premature deliveries (Hoyert et al., 2006). This has serious implications for an already impoverished state as research has found that mortality and morbidity likelihood is higher for premature and low birth weight infants (Goldenberg and Rouse, 1998; Mathews et al., 2004; MacDorman et al, 2002). Therefore, for locations with a high rate of poor pregnancy outcomes, excess costs are incurred, in terms of caring for these infants during the birth period, and continuing on into the adult life of the individual.

Obviously any advance that can be made to understand the causations and develop prevention strategies would be beneficial to all concerned (Johnston et al., 2001). This study concentrates on one potential causation, and seeks to identify whether the traumatic impact of Hurricane Andrew may be linked to poor pregnancy outcomes.

1.3 Investigating the Health Effects of a Disaster

As evident in the aftermath of Hurricane Katrina, a disaster can inflict a serious health impact on a large section of society. To effectively respond to a disaster and objectively evaluate its health effects, public health officials need timely and accurate information (Noji, 1997). Given accurate data it is possible to diminish adverse health outcomes by determining the spread and nature of particular health events, efficiently organize the relief response, and provide recommendations to reduce the consequences of future disasters (Glass and Noji, 1992). For example, a rapid health needs assessment following Hurricane Andrew in 1992 documented the percentage of households with acute needs such as injuries, need for medical services, availability of food, prescription medication, electricity, water supply, in Florida and Louisiana (CDC, 1992).

A post-disaster assessment should provide accurate information on the health of the affected population including the stressful experience of the population, which has further associations with health, both in terms of being a problem in itself, and exaggerating other existing health conditions, such as diabetes (Curtis, 2007).

Unfortunately, there are several major problems with disaster-related health data (and investigations) conducted at or soon after an event, such as the absence of baseline information (Noji, 1997). For example, post- Hurricane Andrew data, collected in Florida by means of morbidity surveillance efforts, were found hard to interpret, specifically due to the absence of illness-related, pre-storm, clinical visits (Lee et al., 1993). With regard to the recent hurricanes – Katrina and Rita- The Centers for Disease Control and Prevention (CDC) reported a similar unavailability of baseline data (CDC, 2006b). This problem, in addition with many medical records missing, makes it hard to interpret the full health consequences of those afflicted by these devastating hurricanes. Other methodological issues often encountered in post-disaster surveillance include a lack of denominator data and an underreporting of health events (Noji, 1997). Despite such difficulties, post-disaster surveillance tends to provide much-needed information – not only for organizing relief operations, but also as an opportunity to gather important and sometimes crucial data on affected populations.

Numerous indicators are usually collected to measure the health effects of a disaster. These indicators include a) mortality, b) morbidity, c) an accurate count of damaged or destroyed houses, d) the demographics of homeless and/or displaced persons, and e) the infrastructure status (Noji, 1997). For examples, in 1992, after Hurricane Andrew, Louisiana rapidly responded to the state's devastation by means of an active emergency surveillance system. As a result, Louisiana's Office of Public Health (OPH) was able to glean information on injuries and illnesses related to the hurricane (CDC, 1993).

In those regions affected by natural disasters, the related trauma tends to have a lengthy impact on the population's well-being, both directly and indirectly. The direct result may be seen in fatalities, as well as lifetime disabilities (Gregg et al., 1989). The indirect result – perhaps less visible – manifests in society through individual breakdowns that lead to stress related illness. Similarly, disaster-related mortalities may emanate from primary exposure, such as deaths due to drowning or sustained injuries, or secondary exposure through post-disaster outbreaks of infectious diseases or from disaster-related stress (Cordero, 1993). According to Tierney (2003), disasters can negatively impact the entire affected area due to disruptions in families, neighborhoods and the service/economic (Tierney, 2003).

One approach to solving the problem of poor data quality at the time of the event, is to analyze previous disasters and infer forward. For example, by analyzing the results of previous hurricanes, further insight may be gained into what problems were experienced by the residents of the affected area. By using hurricane-related data it is also possible to generate hypotheses to stimulate research (Teutsch and Churchill, 2000). Specifically, this research will test the hypothesis that birth outcomes are negatively affected by the landfall of a major hurricane.

1.4 Problem Statement

It may be argued that events such as natural disasters are steadily increasing (Noji, 1997; Abramovitz, 2001). It is estimated that between the years of 1990-1999, approximately 2 billion people were impacted by natural or person-caused disasters on a global scale (WHO, 2002). According to the World Health Organization (2002), natural or person-caused disasters resulted in 600,000 casualties between the years of 1990-1999 Although flooding tends to affect the largest number of people, windstorms are the single largest loss of life (WHO, 2002).

It is important to recognize that Louisiana as a coastal state periodically experiences devastation on a massive scale, as evidenced by hurricanes Katrina and Rita. Although the literature is not in complete agreement, most believe this trend will continue and even worsen due to global warming trends. The two mentioned storms displaced more than 200,000 people, causing a huge physical and social impact on state residents (CDC, 2006a). It may be difficult to evaluate the full health impact of these hurricanes on this displaced population due to a lack of data (Kates et al., 2006; Wilson, 2006; Frey and Singer, 2006; Liu et al., 2006).

The total health effect of these storms cannot be calculated by storm related injuries alone, or even by adding in subsequent recovery and rebuilding casualties. When considering the total effect, research must consider beyond the physical harm caused by the storm and include the stresses experienced by the survivors (Burnett et al., 1997). Outcomes of these stresses may manifest as health problems in the months or even years after the event. Although there are different measures that might be indicative of stress, for example suicide, coping mechanism (alcoholism, drug arrests or even crime), spousal abuse, this thesis will consider birth outcomes as there is an established literature that links both stress and the coping mechanisms associated with stress to poor outcome deliveries.

1.5 Organization of the Thesis

This thesis consists of six chapters, including this introductory chapter.

Chapter 2 discusses the relationship between stress and adverse pregnancy outcomes. This chapter also provides a review of the literature examining the association between disasters and pregnancy outcomes.

Chapter 3 provides an overview of the events surrounding Hurricane Andrew with regards to Louisiana.

Chapter 4 presents the methodology of the thesis and describes the a) study area, b) materials, c) methods, d) data limitations and e) data manipulation. An explanation is also provided regarding the time intervals selected to investigate hurricane impact, as well as the chosen methods of statistical analysis.

Chapter 5 presents the results of the statistical analysis. Lastly, Chapter 6 discusses the findings and makes suggestions for future research.

CHAPTER 2. NATURAL DISASTERS, STRESS, AND PREGNANCIES

This chapter discusses health outcomes and disasters, with a particular focus on pregnancies. Previously found association between stressful life events and numerous diseases (Kune, 1993) might reflect serious health implications for pregnant women who are exposed to disasters. The chapter also provides a review of studies examining the association between hurricanes and pregnancy outcomes.

2.1 Medical Geography and Disaster Epidemiology

Due to recent catastrophes both in the United States and globally, most notably the World Trade Center terrorist attack of September 11, 2001, Indian Ocean tsunami of December 26, 2004, and Hurricanes Katrina and Rita, disaster related health outcomes have generated considerable research. Disaster epidemiology uses epidemiological methods to assess the needs of a population affected by a disaster and prevent further adverse health effects such as death and injury (Noji, 1997). Further, this subfield of epidemiology assesses the health consequences of natural and man-made disasters and identifies factors contributing to these consequences (Noji, 1997). Geographers have also contributed to the disaster-health literature (Foster, 1976, 1992**;** Gould, 1993**;** Campbell, 1999; Shrubsole, 1999; Eriksen et al., 2005; Curtis et al., 2007a; Curtis et al., 2007b). Medical geography often describes how mortality and morbidity are distributed across space and studies causative relationships between different environmental conditions and sickness, death and disease (Goodall, 1987, p.297). This approach can also be used as a tool to study health-related issues of those affected by disasters.

2.2 Background Information on Disasters

A disaster is defined by Fritz (1961, p.655) as “an event, concentrated in time and space”, when a society or its part experiences severe danger and incurs human and economic losses. Briere and Elliott (2000, p.661) define disasters as “large-scale, stressful environmental events that adversely affect a significant number of people”. Dominici et al. (2005, p.9) define disasters as “acute, collectively experienced traumatic events, with a sudden onset”. According to Barton (1969, p.38), a disaster is a situation of collective stress while “many members of a social system fail to receive expected conditions of life from the system”.

2.2.1 Classification of Disasters

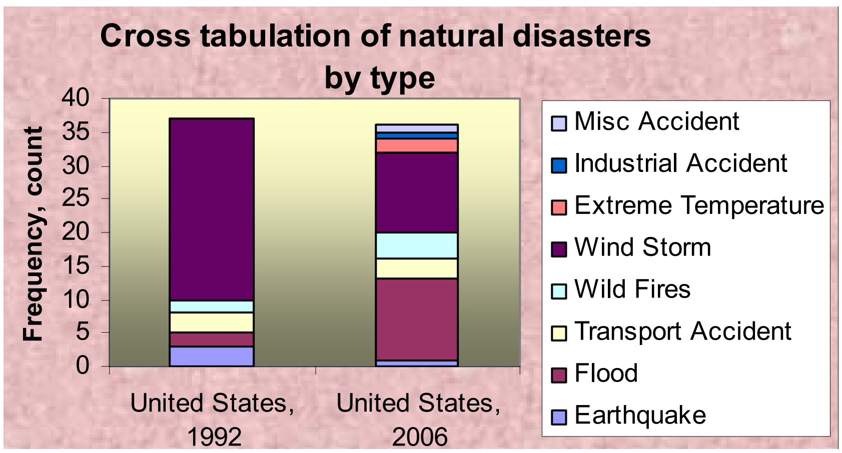

Figure 1. Natural Disaster Occurrence by Disaster Type in US: Comparison 1992 and 2006
Source: "EM-DAT: The OFDA/CRED International Disaster Database
www.em-dat.net - Université Catholique de Louvain - Brussels - Belgium" Last updated 2006.

In general, in the United States windstorms followed by floods and earthquakes occur more often than other disaster types (Figure 1). According to Solomon (1989), approximately 2 million people in the U.S. are impacted by a natural disaster annually. Among all of the recorded disasters there are only a few that are classified as “great”.

A disaster is classified as “great” when there are thousands of casualties, hundreds of thousands of people made homeless, substantial economic losses, and when the affected regions cannot recover from the damage inflicted by a disaster without interregional or international help (Table 1).

Table 1. Classification of disasters.

0	Natural Event	No property damage (e.g. forest fire with no damage to buildings)
1	Small-scale loss event	1-9 fatalities and/or hardly any damage
2	Moderate loss event	10-19 deaths and/or damage to buildings and other property
3	Severe catastrophe	20+ fatalities and/or overall losses $US >50m(200-2005), >40m(1990s), >25(1980s)
4	Major catastrophe	100+ fatalities and/or overall losses $US >200m(200-2005), >160m(1990s), >85(1980s)
5	Devastating catastrophe	500+ fatalities and/or overall losses $US >500m(200-2005), >400m(1990s), >275(1980s)
6	Great natural catastrophe	Thousands of fatalities, economy severely affected, extreme insured losses(UN definition)

Source: Munich Re, May 2006. P.171.

2.2.2 Factors Contributing to Disasters

Natural disasters include land failure (e.g. erosion, land subsidence, landslide), earthquakes, volcanic activities, droughts, floods, hailstorms, hurricanes (including storm surge), wildfire, tornadoes, and severe winter storms, etc. However, social, political, and economic systems contribute to these occurrences (Bolin, 1998; Wisner et al., 2004; Cutter, 2001; Tierney, 2003). Natural disasters must be considered within the general social framework, because this influences the ways that disasters affect people (Wisner et al., 2004). For instance, poor economic situations might force people to live in areas prone to disasters (land use); additionally, uneven access to knowledge and information by residents may contribute to a disproportionate impact of the event (Wisner et al., 2004). Other factors that may contribute higher damage to a region would be poor design and construction of buildings, non-effective warning systems, non-compliance with the orders of evacuation, and ineffective sheltering (Tierney, 2003, p.12; Shultz et al, 2005). For example, it was estimated that between 25 and 40% of insured losses caused by Hurricane Andrew (the focus of this thesis) in South Florida were avoidable and were related to lax compliance with building codes (Pielke, 1996).

2.3 Public Health Consequences of Disasters

Ideally, to determine the causation of a certain health risk factor, one should consider two populations and compare the different frequencies of certain health outcomes, e.g. poor pregnancy outcomes, and find the presence of an adverse health condition causing this factor (Meade and Earickson, 2000, p.418). However, for different reasons it is often difficult to trace a health impact resulting from an exposure to certain hazards (Meade and Earickson, 2000, p.217). One reason is population mobility, e.g., a person exposed to a natural disaster may move to another place. Another reason is that many diseases take time to manifest. Still another factor is that there maybe several different causations for a disease or a poor health outcome.

2.3.1 General Public Health Effects

The most easily quantified disaster-related health impacts are deaths and injuries attributed to the event (Tierney, 2001, p.6). Various social and demographic factors can increase a population's vulnerability to disaster related mortality. For example during heat waves, limited access to air conditioning (Greenberg et al., 1983), the demographic change (greater number of people who live alone), cultural conditions (fear of crime), and a "gendered condition" (e.g., older men, in particular, lose social support as they get older) (Klinenberg, 2002) were found to be contributing factors to mortality.

Hurricane-related mortality is often grouped as pre-impact, impact, and post-impact (CDC, 1989a; 1989b; 1996). In the US, before 1990 most hurricane-related deaths occurred due to storm surges (CDC, 1996; Shultz et al., 2005). Significant improvements in hurricane forecasting and population evacuation have changed this mortality trend. Most deaths occurring during the impact phase are physical injuries and are attributed to high-speed winds (MMWR, 1992; Meredith and Bradley, 2002). However, the majority of total deaths occur during the post-impact period (Shultz et al, 2005). The most common cause of these deaths include electrocutions, blunt traumas caused by falling trees, chain-saw injuries and car fatalities (JAMA, 1989; Philen et al., 1992). A distinction is also made between direct and indirect hurricane-related deaths. Direct mortality is associated with the physical forces of the hurricane while indirect deaths are related to unsafe circumstances during preparations for a disaster or during the impact (Combs et al., 1998).

2.4 Stress and Disease

One of the adverse health impacts of a disaster is stress. Psychological factors such as social and family support, self-esteem, and stress have previously been identified to be important determinants of health (Wilkinson, 1992).

Medical and health geographers contributed to studies of mental health (Faris and Dunham, 1965; Matthews, 1989; Adler et al., 1994; Macintyre, 1994; Evans, 1994; Moore et al., 1997; Bhana and Pillay, 1998; Emslie et al., 2002; Foley and Platzer, 2007).

Studying mental health-related issues seems all the more important because of increasing trends of the risk factors such as terrorism threat and natural disasters, which have serious mental health implications.

Kune (1993), offers a simple five-step model for how stressful events such as financial problems, changes of residence, a loss of a loved one, etc., can lead to disease (Figure 2):

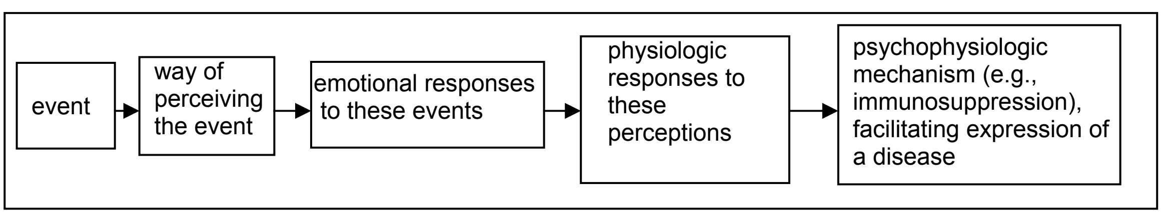

Figure 2. Five-step Model of Stress Leading to a Disease.
Source: based on Kune (1993)

The interaction between a persons' social and cultural environment may influence how an individual will cope with and respond to stress, with these environments either serving as a buffer protecting from diseases or increasing the likelihood of illness (Berkman and Syme, 1979; House et al., 1982). For example, in a nine-year study on the relationship between health and the social and cultural environment in Alameda county, California, persons with strong social support in the community were less likely to die from different illnesses than those without such social ties (Berkman and Syme, 1979). House et al., (1982) similarly found those without a strong social network, were at two to three times higher mortality risk.

2.4.1 Stress and Disasters

Due to the huge psychosocial stress generated by disasters (Buekens, 2006; Curtis et al., 2007), victims are likely to suffer from post-event mental health problems. These include but are not limited to Posttraumatic Stress Disorder (PTSD), (Erickson, 1976; Logue et al., 1979; Dynes et al., 1987; Lindell and Perry, 1992; McFarlane et al., 1992; Spurrell and McFarlane, 1993; Fukuda et al., 1999; Greenough and Kirsch, 2005; Bourque et al., 2006; Madrid et al., 2006; Curtis et al., 2007; Straker and Finister, 2007; Combs, 2007; Mosca et al., 2007). Post-disaster stress symptoms typically manifest as depression, recurrent nightmares, emotional detachment from others, etc. (Benight and Bandura, 2004; Williams, R., 2006). Posttraumatic Stress Disorder (PTSD) affects even previously healthy functioning adults, making the recovery process from the effects of a disaster more difficult (McMillen et al., 2000; Harvey et al., 2007). Table 1 presents a selection of studies concerning the relationship between various natural disasters and their impact on mental health. For example Erickson (1976), in a study of the consequences of the Buffalo Creek flood, found that people who experienced the loss of the community suffered long-term mental health impacts. With regards to this thesis, Norris et al. (2002) found that Hurricane Andrew delivered an atypically severe psychological impact because it caused wide destruction, threat to life, loss of resources, and disruption of the social support and financial system. Shelby and Tredinnick (1995), also report that Andrew's victims experienced a sense of loss and a lack of control from the hurricane. Survivors experienced similar negative reactions such as sadness, anxiety, and numbness after other natural disasters, such as Hurricane Hugo in 1989 (Freedy, 1993; Freedy et al, 1992). Fifty-one percent of Hurricane Andrew survivors developed a psychiatric disorder, with PTSD being most common (36%), followed by major depression (30%), and anxiety disorder (11%) (David et al., 1996). Unfortunately, early Hurricane Katrina research has found similar impacts. For example, Berggren and Curiel (2006), noted a 25% increase in mortality rate after Hurricane Katrina, at least in part associated with stress experienced by the storm's victims.

2.5 Natural Disasters and Pregnancy Outcomes

As discussed in the previous subsection, the huge psychological and physical stress factors (Buekens et al., 2006; Curtis and Leitner, 2006; Curtis et al., 2007a) generated by disasters are particularly relevant for less healthy and/or vulnerable populations (Fukuda, et al., 1999). A pregnant woman is particularly vulnerable during a disaster for a variety of reasons including healthcare availability concerns, and fears for the subsequent health of her baby in the event of a forced, often stressful and traumatic, relocation due to a disaster (Curtis and Leitner, 2006).

However, only a few studies exist on the specific relationship between disasters and pregnancy outcomes (Cordero, 1993; Curtis and Leitner, 2006; Buekens et al., 2006). Chang et al. (2002) studied the relationship between disasters, psychiatric illnesses, and pregnancy outcomes following an earthquake in Taiwan. The researchers reported that a spousal death, abdominal injury, or unstable living could predict low birth weight. Following the earthquake, their study sample experienced 7.8 % LBW deliveries, showing a higher percentage of LBW deliveries than the average LBW rate in Taiwan.

Table 2. Research on Effect of Disasters, by Type, on Mental Health.

Author/s, year	Name of the article	Type of disaster
Logue et al., 1979	Emotional and physical distress following Hurricane Agnes in Wyoming Valley of Pennsylvania.	Hurricane
Hardin et al., 1994	Psychological distress of adolescents exposed to Hurricane Hugo.	Hurricane
Thompson MP, et al.,	Age differences in the psychological consequences of Hurricane Hugo.	Hurricane
Eustace K, et al.,	Cyclone Bola: a study of the psychological after-effects.	Hurricane
Caldera T, et al. 2001	Psychological impact of the hurricane Mitch in Nicaragua in a one-year perspective.	Hurricane
Suar D, et al., 2002;	Supercyclone in Orissa: an assessment of psychological status of survivors.	Hurricane
Staab JP, et al. 1996;	Acute stress disorder, subsequent posttraumatic stress disorder and depression after a series of typhoons.	Hurricane
Garrison CZ, et al ,1993	Post-traumatic stress disorder in adolescents after a hurricane.	Hurricane
Goenjian AK, et al 2001	Posttraumatic stress and depressive reactions among Nicaraguan adolescents after Hurricane Mitch	Hurricane
La Greca AM, 1998	Children's predisaster functioning as a predictor of posttraumatic stress following Hurricane Andrew	Andrew
Ironson G, et al. 1997	Posttraumatic stress symptoms, intrusive thoughts, loss, and immune function after Hurricane Andrew.	Andrew
Shaw JA, et al. 1995	Psychological effects of Hurricane Andrew on an elementary school population	Andrew
Pickens J, et al. 1995	Posttraumatic stress, depression, and social support among college students after Hurricane Andrew	Andrew
Vernberg EM, et al 1996	Prediction of posttraumatic stress symptoms in children after Hurricane Andrew.	Andrew
La Greca AM, et al.1996	Symptoms of posttraumatic stress in children after Hurricane Andrew: a prospective study.	Andrew
David D, et al 1996	Psychiatric morbidity following Hurricane Andrew.	Andrew
Garrison CZ, et al, 1995	Posttraumatic stress disorder in adolescents after Hurricane Andrew.	Andrew
Perilla JL, et al., 2002	Ethnicity, culture, and disaster response: identifying and explaining ethnic differences in PTSD six months after Hurricane Andrew.	Andrew
Shaw JA, et al.,1996	Twenty-one-month follow-up study of school-age children exposed to Hurricane Andrew.	Andrew
Norris FH, et al. 1999	Stability and change in stress, resources, and psychological distress following natural disaster: findings from Hurricane Andrew.	Andrew
Ironson et al., 1997	Posttraumatic Stress symptoms, intrusive thoughts, loss, and immune function after hurricane Andrew.	Andrew
Burnett K, et al. 1997	Measurement of perceived disruption during rebuilding following Hurricane Andrew.	Andrew
Greenough and Kirsch, 2005	Public Health Response – assessing needs.	Katrina
Madrid PA, et al., 2006	Challenges in meeting immediate emotional needs: short-term impact of a major disaster on children's mental health: building resiliency in the aftermath of Hurricane Katrina.	Katrina
Curtis, et al., 2007	Katrina and Vulnerability: The Geography of Stress.	Katrina
Mosca et al., 2007	Dental Care as a Vital Service Response for Disaster Victims	Katrina
Combs, 2007	Mental Health Interventions by Telephone with Katrina Survivors.	Katrina
Freedy et al., 1994	Understanding acute psychological distress following natural disaster.	
Goenjian et al., 1994	Posttraumatic stress disorder in elderly and younger adults after the 1988 earthquake in Armenia.	Earthquake
Goenjian AK, et al 1995	Psychiatric comorbidity in children after the 1988 earthquake in Armenia.	Earthquake
Goenjian AK, et al , 2000	Prospective study of posttraumatic stress, anxiety, and depressive reactions after earthquake and political violence.	Earthquake

Najarian L, et al. 1996	Relocation after a disaster: posttraumatic stress disorder in Armenia after the earthquake.	Earthquake
Armenian HK, et al, 2000	Loss as a determinant of PTSD in a cohort of adult survivors of the 1988 earthquake in Armenia: implications for policy.	Earthquake
Nolen-Hoeksema S, Morrow J. 1991	A prospective study of depression and posttraumatic stress symptoms after a natural disaster: the 1989 Loma Prieta earthquake.	Earthquake
Madakasira S, O'Brien KF., 1987	Acute posttraumatic stress disorder in victims of a natural disaster.	Earthquake
Carr VJ, et al., 1995	Psychosocial sequelae of the 1989 Newcastle earthquake: I. Community disaster experiences and psychological morbidity 6 months post-disaster	Earthquake
Carr VJ, et al.. 1997	Psychosocial sequelae of the 1989 Newcastle earthquake: III. Role of vulnerability factors in post-disaster morbidity	Earthquake
Durkin ME, 1993	Major depression and post-traumatic stress disorder following the Coalinga and Chile earthquakes: a cross-cultural comparison	Earthquake
Bodvarsdottir I, Elklit 2004	A Psychological reaction in Icelandic earthquake survivors.	Earthquake
Kwon Y, et al., 2001	Life events and posttraumatic stress in Hanshin-Awaji earthquake victims.	Earthquake
Inoue-Sakurai C, et al., 2000	Posttraumatic stress and lifestyles are associated with natural killer cell activity in victims of the Hanshin-Awaji earthquake in Japan.	Earthquake
Kato H, et al. 1996	Post-traumatic symptoms among younger and elderly evacuees in the early stages following the 1995 Hanshin-Awaji earthquake in Japan.	Earthquake
Kuo C, et al., 2003	Prevalence of psychiatric disorders among bereaved survivors of a disastrous earthquake in Taiwan	Earthquake
Laor N, et al. 2002	Posttraumatic, dissociative, and grief symptoms in Turkish children exposed to the 1999 earthquakes.	Earthquake
Basoglu M, et al., 2002	Traumatic stress responses in earthquake survivors in Turkey.	Earthquake
Kilic EZ, et al., 2003	The psychological effects of parental mental health on children experiencing disaster: the experience of Bolu earthquake in Turkey	Earthquake
Kilic C, Ulusoy M 2003	Psychological effects of the November 1999 earthquake in Turkey: an epidemiological study.	Earthquake
Salcioglu E, et al., .2003	Long-term psychological outcome for non-treatment-seeking earthquake survivors in Turkey	
Wang X, et al. 2000	Longitudinal study of earthquake-related PTSD in a randomly selected community sample in North China	Earthquake
Chang C, et al. J 2003	Posttraumatic distress and coping strategies among rescue workers after an earthquake.	Earthquake
Kato et al., 1996	Posttraumatic symptoms among younger and elderly evacuees in the early stages following the 1995 Hanshin-Awaji Earthquake in Japan.	Earthquake
Najarian et al., 1996	Relocation after a disaster: Posttraumatic stress disorder in Armenia after the 1988 earthquake.	Earthquake
Fukuda et al., 1999	Posttraumatic Stress and Change in Lifestyle among Hanshin-Awaji Earthquake Victims	Earthquake
De La Fuente R, 1990	The mental health consequences of the 1985 earthquakes in Mexico.	Earthquake
Sharan P, , et al 1996	Preliminary report of psychiatric disorders in survivors of a severe earthquake.	Earthquake
Cao H, et al., 2003	Prevalence of psychiatric disorder following the 1988 Yun Nan (China) earthquake.	Earthquake
North CS, et al. 2004	The course of PTSD, major depression, substance abuse, and somatization after a natural disaster.	
McFarlane AC. 1988	The phenomenology of posttraumatic stress disorders following a natural disaster.	
McFarlane AC, Papay P 1992	Multiple diagnoses in posttraumatic stress disorder in the victims of a natural disaster.	
Spurrell MT, McFarlane AC. 1993	Post-traumatic stress disorder and coping after a natural disaster.	

Benight CC, et al. , 1999	Coping self-efficacy as a mediator of distress following a natural disaster.	
Johnsen BH, et al. 1997	Posttraumatic stress symptoms in nonexposed, victims, and spontaneous rescuers after an avalanche.	Avalanche
Erickson and Lundin, 1996	Early traumatic stress reactions among Swedish survivors of the m/s Estonia disaster.	
Green BL, et al. 1990	Buffalo Creek survivors in the second decade: stability of stress symptoms.	Flood
Erickson, 1976	Everything in Its Path: Destruction of Community in the Buffalo Creek Flood	Flood
Green BL, et al 1994	Children of disaster in the second decade: a 17-year follow-up of Buffalo Creek survivors	Flood
Morgan IA, et al., 1995	Coping and personality as predictors of post-traumatic intrusions, numbing, avoidance, and general distress: a study of victims of the Perth Flood.	Flood
McMillen C, et al. 2002	Untangling the psychiatric comorbidity of posttraumatic stress disorder in a sample of flood survivors.	Flood
Ginexi et al., 2000	Natural disaster and depression: A prospective investigation of reactions to the 1993 Midwest floods.	Flood
Tobin GA, Ollenburger JC. 1996	Predicting levels of postdisaster stress in adults following the 1993 floods in the Upper Midwest.	Flood
Catapano F, et al. 2001	Psychological consequences of the 1988 landslide in Sarno, Italy: a community study	Landslide
Koopman C, et al., 1994	Predictors of posttraumatic stress symptoms among survivors of the Oakland/Berkeley, Calif., firestorm.	Firestorm
Briere and Elliott, 2000	Prevalence, characteristics, and long-term sequelae of natural disaster exposure in the general population.	
Norris et al., 2002	60,000 disaster victims speak: Part 1. An empirical review of the literature, 1981-2001.	

A potential association has also been found between increased seismic activity and fetal distress and premature delivery. For example, Weissmann et al. (1989) conducted a study on the effect of seismic activity on pregnancy outcomes in Haifa, Israel. Data consisting of all births and more specifically premature rupture of membranes (which is one of the main causations of preterm delivery) during the 48 hours following five earthquakes were compared to those during the two-week period before the seismic activity. An increase in birth rates was found during the 48 hours period after the earthquake. Similarly, there was also a significant increase in the preterm birth rate.

Studies have considered the effects of the Chernobyl disaster on pregnancy outcomes, including pregnancy loss, stillbirths, and induced abortions (Ulstein et al., 1990; Kulakov et al., 1993; Auvinen et al., 2001). There was a statistically significant increase in spontaneous abortions in the areas which received the highest dose of radiation in Finland ($p=0.0001$) (Auvinen et al., 2001). A higher occurrence of spontaneous abortions was also found in Norway following the Chernobyl accident (Ulstein et al., 1990). Incidences of miscarriages three years after the disaster were compared to three years before in the most heavily affected county. The study found an increasing trend of spontaneous abortions.

There is evidence of an association between exposures *in utero* to a natural disaster and children's cognitive and language development later in life (Laplante et al., 2004; King and Laplante, 2005). The Quebec Ice Storm in 1998 resulted in hardships such as hypothermia, accidents, injuries, and power outages, which in some cases lasted as long as five weeks. The Ice Storm study followed women who were pregnant during or shortly after the storm. Mothers who reported medium-to-high storm-related stress during their pregnancy tended to have children who experienced problems with intellectual development and reduced language skills at two years of age (Laplante et al., 2004).

Ruvalkaba (1987) stated that after a major disaster, women might experience cessation of lactation. He reported about two patients having experienced strong psychological stress following the 1985 Mexico City earthquake, both of whom ceased to produce milk/colostrum. One patient was 39 weeks pregnant, and the second had recently delivered her baby. The former patient successfully breast-fed her older three children – at the time of the earthquake, the children were 8 years, 6 years, and 3.5 years of age, respectively. However, after the woman had witnessed the earthquake destroying part of their house, and then grieved for her younger sister and her husband who had died during the earthquake, her production of colostrum ceased for at least 16 days. The second patient, who previously has been successful in the breastfeeding of her older children well beyond the first year of life (by now, these children were 5 years and 3 years of age, respectively), reported seeing several buildings collapse and heard the cries of the injured. The emotional trauma resulted in her being unable to breast-feed her three-month old infant, even after vigorous nursing. This suggests that psychological factors might play a significant role in lactation. Therefore, stress might prevent milk production. However, an inability to produce milk becomes an important problem, since breastfeeding provides the best nutrition for the newborn (Forste et al., 2001) and might prevent him or her from diseases which may become more prevalent in post-disaster environments.

Buekens et al. (2006) also noted that a disaster might affect the health of pregnant women by changing behavioral habits and nutrition. A number of studies stated that women who experience stress have a higher likelihood to return to smoking as a coping mechanism (Levine and Marcus, 2004; Ludman et al., 2000; Fukuda et al., 1999; Curtis and Leitner, 2006). As previously stated in this chapter, smoking has been linked to LBW and preterm deliveries.

2.5.1 Hurricanes and Pregnancies

Buekens et al. (2006) noted a lack of research concerning the impact of hurricanes on pregnancy. This knowledge gap has serious implications for events such as Hurricanes Katrina and Rita (Curtis et al., 2007b). At least 10,000 pregnant women were displaced because of Hurricane Katrina (Buekens et al., 2006). Knowing the possible health consequences of maternal exposure to hurricanes will help planning agencies better organize relief operations and improve health outcomes in women and babies.

Among the few epidemiological studies focusing on relationships between hurricanes and adverse pregnancy outcomes, there is research on increased cases of fetal deaths after a flood caused by Hurricane Agnes in Western New York in 1972 (Janerich et al., 1981). After having examined reproductive characteristics, i.e., spontaneous abortions (Janerich et al., 1981, p.353), they found that the year following the flood disaster, 1973, had a statistically significant increase in spontaneous abortions in comparison with the average rates for other years ($P<0.01$). Spontaneous abortions are defined as the "spontaneous expulsion from the mother's body of dead products of conception of all gestational ages" (Janerich et al., 1981).

In this case-control study, for each case which represented a woman who experienced fetal deaths between 1972 and 1973, there were three age-matched controls, women who had delivered live infants. The time of delivery and place of the residence was the same for both groups. However, no evidence was found for an excess in fetal deaths to the evacuation. The authors noted that this might be due to the small numbers and further argued that the increased occurrence of abnormal reproductive outcomes may have been caused by the dramatic physical or psychological stress that people experienced during the flood (Janerich et al., 1981).

Duff et al. (1994) investigated an increase in incidences of live-birth neural tube defects (e.g. spina-bifida) following Hurricane Gilbert, on September 12, 1988, in Jamaica. Hurricane Gilbert destroyed both crops and livestock, and had a huge impact on the Jamaican people's diet. In this case-control study, the cases focused on seventeen mothers, who delivered babies with neural tube defects in the third and fourth quarters of 1989 and the first quarter of 1990. For each case, there were three individuals as controls. These were mothers who bore children with no obvious developmental or physical defects and with a weight of >2.5 kg. Both groups were matched for age, time of conception, residence, parity, level of education, and socioeconomic and ethnic status. A personal interview was conducted, providing a 56-item questionnaire with questions about personal information, antenatal care, baby characteristics, hurricane experience, and information about mother's preconception period – defined as an eighteen-week period that starts twelve weeks before conception and ends six weeks after conception. The study found a significant increase in cases of neural tube defects ($P < 0.005$). The authors associated the outcome with mothers' diets, which were low in folate for at least three to four months.

In a recent study, Curtis et al. (2007a) investigated the relationship between Hurricane Katrina and birth outcomes in relation to social vulnerability. Curtis et al. (2007a) contended that because Hurricane Katrina affected an already at-risk population, the vulnerability of pregnant members in this group was already at an elevated level. The authors point out that during the stages of response and initial recovery stresses could be generated due to reasons such as lengthy evacuation, and the necessity of staying in secondary shelters before moving to more permanent housing. Curtis et al. (2007) specifically noted that stresses and anxieties related to the loss of one's neighborhood and possessions, as well as the inability to come back home, could all result in poor birth outcomes. They also stated that many communities that actually experienced the storm were already reliant on social welfare programs such as Women, Infants and Children (WIC), Medicaid, and food stamps. Therefore, once these programs suffered disruption, vulnerability was further amplified. The study was based on a survey of 204 women of whom 66 were pregnant when Hurricane Katrina struck, and 21 became pregnant in the months following Katrina. Approximately 30-50% of them reported participation in either WIC or Medicaid.

The study conducted a series of interviews from September 2005 to January 2006. The resulting survey has shown that many women did not have proper prenatal care which represents a risk factor for poor birth outcomes. Additional, the interviewees showed an increased level of mental disorders, e.g., depression and stress, as well as self-destructive and aggressive behavior. In regard to stress, participants of the survey reported that during the initial stages of relocation, there was a lack of aid for care. Deficiencies included poor sanitary conditions, a lack of formulas to feed infants, no special shelters for pregnant women or those women who had recently delivered a baby, and generally sparse information on phone accessibility or community resources. Simple steps could have decreased stress and anxiety resulting from these deficiencies, such as providing better access to telephones, etc. Obviously, much more work is needed on the interrelationship of pregnancy and catastrophes such as Hurricane Katrina, and this thesis will help contribute to this literature by comparing pregnancy outcomes in the years immediately following Hurricane Andrew. The effect of this hurricane on Louisiana alone has been selected to provide a comparison to post-Katrina outcomes.

2.6 Background Information on Pregnancy Outcomes

Before directly considering the impact of hurricanes and pregnancy outcomes, it is important to briefly consider definitions and a brief overview of causative factors associated with traditional poor birth outcomes.

Among the most common poor pregnancy outcomes discussed in the literature are Low Birthweight (LBW) and premature (preterm or short gestation) infants. LBW and premature births present serious public health problems due to a high annual occurrence, coupled with acute and long-term health complications (Agency for Healthcare Research and Quality, (AHRQ), 2002). In the United States, LBW and premature births represent two of the three main causations of infant mortality (IM), with the third being congenital anomalies.

2.6.1 Low Birthweight and Preterm Births

A Low Birthweight (LBW) delivery is defined as a birth weight below 2500 grams (5 lb. 8 oz.). Very Low Birthweight (VLBW) is defined as a weight less than 1500 grams (3 lb. 4 oz.) at delivery. A LBW can result from either a preterm birth or intrauterine growth retardation (IUGR) (AHRQ, 2002). Intrauterine growth retardation (IUGR) means that the fetus was growth-restricted and did not reach its potential size. Premature (preterm, also called short gestation) delivery is an infant whose gestational age is shorter than 37 weeks. In the United States, almost 440,000 infants are born prematurely every year, many of whom are also LBW babies (March of Dimes, 2001). Both premature births and LBW present serious health problems in

Louisiana as rates of both are higher compared to the rest of the nation (Curtis and Leitner, 2006) (Table 3).

Table 3. Percent of Live Births Less Than 2500 Grams and Less Than 37 Weeks of Gestation, Louisiana, Neighboring States, and United States, 2000 and 2003

State	**LBW, % of Live Births**		**National Ranking**	**Preterm, % of Live Births**	**National Ranking**
	2000	**2003**		**2003**	
Alabama	9.7	10	3	15.7	2
Arkansas	8.6	8.9	11	13	13
Louisiana	10.3	10.7	2	15.6	3
Mississippi	10.7	11.4	1	17.9	1
Texas	7.4	7.9	26	13.9	8
United states	7.6	7.9	-	12.3	-

Source: Morgan, K. O. and Morgan, S. (Editors) 2005. Health care State Rankings 2005 :(13h Ed.): Morgan Quitno Press, Lawrence, KS., Hoyert et al., 2006, *and* MacDorman et al., 2002.

2.6.2 Reasons to study Low Birthweight and Preterm Births

There are several important reasons to study Low Birthweight (LBW) and preterm births. A baby's birthweight is a strong determinant of survival; an infant with a lower weight has a higher risk of dying (Hoyert et al., 2006). The chance of dying is six times higher for a LBW delivery and 100 times higher for a VLBW birth (Mathews et al., 2004). In 2000, 66% of all LBW infants died in the United States (MacDorman et al, 2002). Preterm births also have higher deaths rates (Curtis and Leitner, 2006). Approximately 75% of infant mortality during the first month of life, called neonatal mortality, occurs to premature babies (March of Dimes, 2001; Goldenberg and Rouse, 1998; Johnston et al., 2001; MacDorman et al, 2002).

Another reason for studying poor pregnancy outcomes is that there is an association between LBW and a range of poor health outcomes, and developmental problems in the infant's future, such as hypertension, asthma, and a low IQ (Yiu et al., 1999; AHRQ, 2002; Curtis and Leitner, 2006). For example, preterm births are responsible for approximately 50% of all cases of neurological diseases such as cerebral palsy (McCormick, 1985; Goldenberg and Rouse, 1998).

2.6.3 Factors Influencing LBW and Preterm Births

It has been found that smoking (Shiono et al., 1986; Jaakola et al., 2001; Pollack, 2001; Moore and Zaccaro, 2000; Lorente et al*.,* 2000), drinking (Brooke et al., 1989) or substance use (Chasnoff, 1991; Shiono et al., 1995; Fergusson et al., 2002) during pregnancy also greatly increases the chance of a LBW. Factors contributing to a preterm birth include multiple births and spontaneous preterm labor (MacDorman et al, 2002). Social and behavioral factors contributing to preterm births include parental socioeconomic status (SES), prenatal care, and maternal nutrition to name just a few (Figure 3).

2.6.4 Racial Differences

There are persistent racial variations in poor pregnancy outcomes; African Americans (AA) have higher proportions of LBW and preterm infants than other racial groups (Goldenberg and Rouse, 1998; Alexander et al., 2003). For example, the incidence of premature birth is twice as high among AA as it is among Whites (Kleinman and Kessel, 1987; Creasy, 1993; Ventura et al., 1994). However, a recent study measured age-specific neonatal mortality rates (NMR) among AA, Whites, and Hispanics. The results addressed birth weight/gestational factors, encompassing most combinations of gestational ages less than 37 weeks and birth weight of less than 3500 g. This outcome indicated that AA have the lowest NMR. For the gestational ages of more than 37 weeks with birth weight of more than 3500 g, the study concluded that AA have the highest NMR, and Hispanics have the lowest (Alexander et al., 2003).

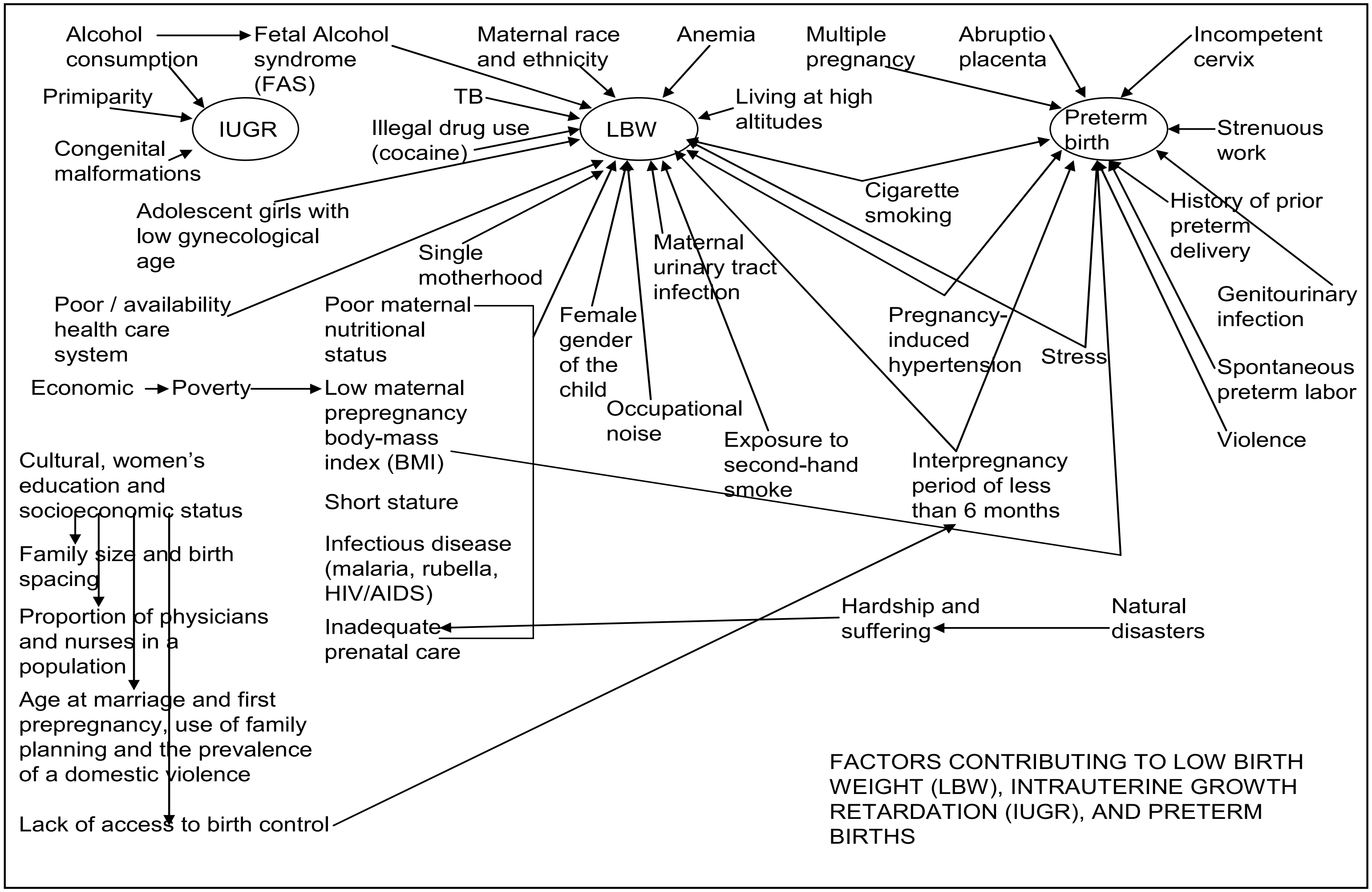

Figure 3. Factors Contributing to Low Birth Weight (LBW), Intrauterine Growth Retardation, and Preterm Deliveries.

In Louisiana, there is a large disparity in negative pregnancy outcomes between African-Americans (AA) and Whites (Curtis and Leitner, 2006). For example, for the years 1996-2002, the ratio (AA to Whites) of infant mortality rates never dropped below 2:1, and could be as high as 5:1 (Curtis and Leitner, 2006). The disparity in premature deliveries for this period ranged from about 2:1 to 3:1 (Curtis and Leitner, 2006).

2.6.5 Trends for LBW and Preterm Births

Over the last decade, rates of LBW and preterm births have increased nationally, resulting in serious economic and health implications (Guyer et al., 1999; Goldenberg and Rouse, 1998; Paneth, 1995). The percentage of preterm births increased from 10.6% in 1990 to 12.7 % in 2005 (Figure 4). The percentage of LBW was 6.7% in 1984, 7.5 in 1997, 7.6 % in 1998 and 2001 and 7.9% in 2003 (MacDorman, et al, 2002; Hoyert et al., 2006).

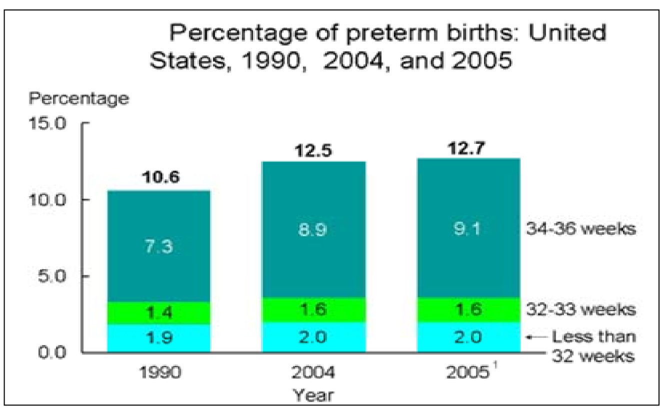

Figure 4. Preterm Births in the United States, 1990, 2004, and 2005.
[1]-based on preliminary data
Source: CDC/NCHS, National Vital Statistics System, at:
http://www.cdc.gov/nchs/products/pubs/pubd/hestats/prelimbirths05/prelimbirths05.htm

Advances in medicine now increase the likelihood of survival for an infant weighing less than 300 or 400 g (Muraskas et al., 1991; Sherer et al., 1992; Muraskas et al., 1992). Similarly, half of the infants born at 24 weeks' gestation are expected to survive (Sanders et al., 1995). However, the resulting economic costs are high. For example, the median hospital cost for a preterm labor without delivery was $2159 in 1996, and that for preterm labor with early delivery was $6593 (Nicholson et al., 2000).

Surviving preterm babies are at a higher risk for long-term morbidity, including chronic lung disease, and viral respiratory infections (McCormick, 1985; Institute of Medicine, 1985, 2003). Neurocognitive illnesses such as cerebral palsy, mental retardation (Stewart et al., 1999), deafness and language / speech / communications disorders are also frequent (AHRQ, 2002). By lowering the risk of delivering a LBW or preterm baby, both immediate hospitalization and its long-term effect can be avoided.

Birth outcomes can be improved by educating women and providing access to health care. Adequate prenatal care can improve birth outcomes in several ways. First, preexisting medical conditions may be assessed, and second, health behavior advice may be offered, for example, on healthy nutrition and smoking cessation (Huntington and Connell, 1994; Fiscella, 1995). There are many other aspects that can be considered such as improving neighborhood conditions (O'Campo et al., 1997; Fang et al., 1999; Perl et al., 2001), or maternal diet (Kennedy and Kotelchuk, 1984; Kramer et al., 1992).

2.7 Geographical Contribution to Birth Problems

Geographers studying pregnancy outcomes often link diverse social and health datasets when analyzing public health (Curtis et al., 2007a; Curtis et al., 2007b). In a relatively recent work on the reproductive health of low-income women in New York (Tempalski and McLafferty, 1997), LBW were linked to risk factors such as poverty, prenatal care, drug use and unemployment using a GIS. Similarly, other geographical studies noted a close connection between an increase in LBW births and a decrease in access to prenatal care as the economic status declined (McLafferty and Tempalski, 1995; McLafferty and Grady, 2004). Grady (2006) investigated the effect of residential segregation and racial disparities on LBW, while other studies concluded that teenage pregnancies presented a risk factor for LBW (Taylor and Chavez, 2002; and Yamada and Frederickson, 2006). Lindsay (2004) discussed social influences on pregnancy health in a study between employment and pregnancy outcomes. Spatial variations in birth problems such as congenital malformations, which are the third largest risk factor for LBW, were also examined by Lovett and Gatrell (1988).

2.8 Literature Review on Stress and Pregnancy Outcomes

Ninety years ago (1925), studies noted that the environment which "consists entirely of the conditions that relate to his mother's health and well-being" (Baker, 1925, p.162) has a considerable impact on the well-being of the baby, as early as the baby's prenatal period. Therefore, maternal health conditions can directly affect the health conditions of the baby.

Previous studies have found that pregnancy complications such as low birth weight, premature delivery, and infant mortality may be associated with life stress (Gorsuch and Key, 1974; Nuckolls et al, 1972; and McDonald, 1968; Duff and Cooper, 1994; Hoffmann and Hatch, 1996; Dole et al., 2003). Cohen et al. (1995, p.3) defined stress as a process in which "environmental demands tax or exceed the adaptive capacity of an organism, resulting in psychological and biological changes that may place persons at risk for disease". Other definitions of stress focus on an individual's perceptions and evaluations of the experienced events. For example, Hoffmann and Hatch (1996) define a) stress as the perception that an insult has taken place; b) stressors as the acute or chronic events occurring to people; and c) distress as a negative emotional response from the recognition of stress.

Many epidemiological studies have investigated the effect of psychosocial factors such as stressful life events, anxiety, and depression on a pregnancy. However, the findings are inconsistent; some studies support the hypothesis that stress can affect pregnancy (Berkowitz and Kasl, 1983; Newton and Hunt, 1984), while others do not (Omer et al., 1986; Stein et al., 1987).

Stressors have been linked to preterm delivery or growth retardation (Hoffmann and Hatch, 1996). According to Baum et al. (1982), stressors may impact physiological processes directly by means of the release of stress hormones epinephrine and norepinephrine or through altering the immune system. Physical effects of the release of these hormones include increased heart rate, elevated blood pressure and a decrease in uterine arterial blood flow (Hoffman and Hatch, 1996); and even uterine contractions (Zuspan et al., 1962). For example, animal studies revealed that rats exposed to stressors such as noise, light, heat, crowding and shock had a smaller litter and a reduced birthweight (Istvan, 1986).

When stress hormones affect immune function, susceptibility to infection including genitor-uterine infection increases, which may promote preterm labor (Cohen and Williamson, 1991; Romero and Mazor, 1988).

Additionally, stressors or distress may act on pregnancy outcomes indirectly by means of detrimental health behaviors such as the use of alcohol, smoking, taking in too much nutrition – all of which can be either coping mechanisms or non-compliance with medical recommendations (Istvan, 1986; Hoffman and Hatch, 1996; Curtis and Leitner, 2006). Drinking alcohol during pregnancy is associated with LBW (Passaro et al., 1996; Lundsberg et al., 1997) and preterm birth (Kesmodel et al., 2000), while smoking during pregnancy has been found to affect fetal growth leading to an average reduction of a few hundred grams (Wilcox, 1993), and tends to double the likelihood of a stillbirth (Wisborg et al., 2001). Problems may arise if the mother does not seek out adequate prenatal care because of a stress-related reaction. Inadequate prenatal care, i.e., prenatal care beginning in the second trimester or even later, has also been associated with LBW (Gortmaker, 1979; Greenberg R.S., 1983) and premature births (Alexander and Comely, 1987).

Rutter and Quine (1990), suggest a model which describes direct and indirect pathways leading lower class women (who presumably experience more stressful life events) to adverse pregnancy outcomes (Figure 5). The model shows how maternal psychological distress due to stressful life events, when combined with inadequate social support, may directly influence a poor pregnancy outcome. Conversely, an indirect influence may come through poor health behaviors for adverse pregnancy outcomes. Health beliefs, when combined with feelings of vulnerability and powerlessness, contribute to "hazardous health risks" (Hoffman and Hatch, 1996, p.383).

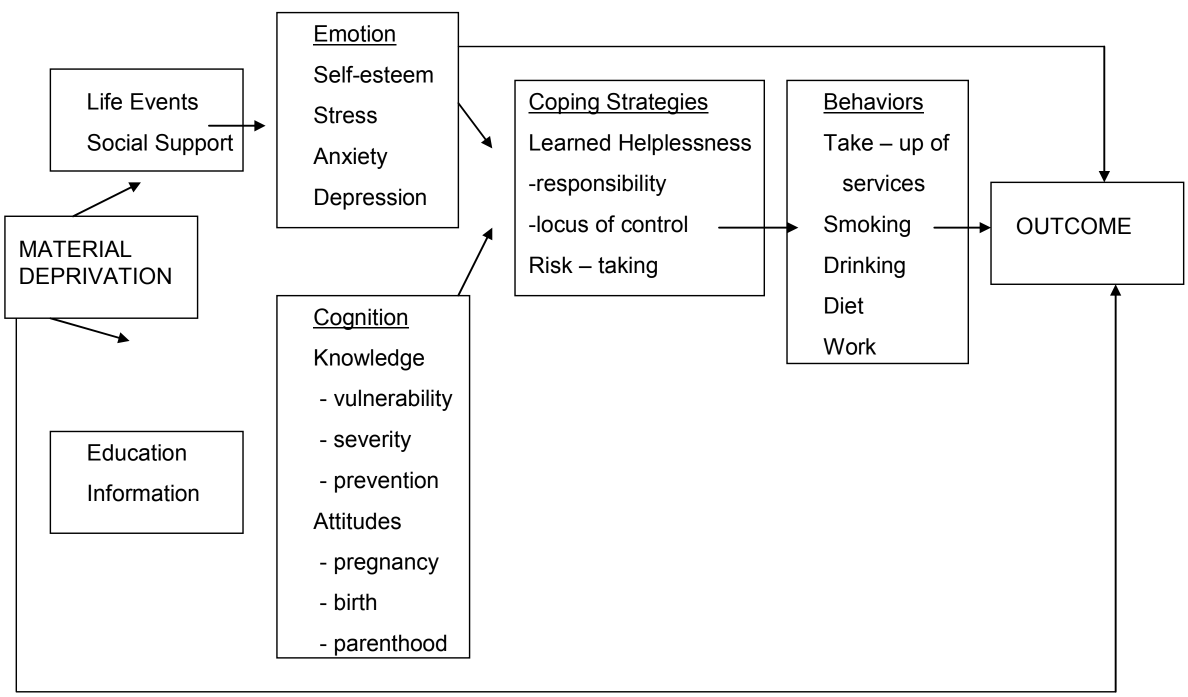

Figure 5. A model of direct and indirect ways among stressors, distress, and pregnancy outcomes.
Source: Rutter and Quine, 1990

A body of evidence suggests maternal distress may be detrimental to the fetus (Hedegaard et al., 1993; Wadhwa et al., 1993; Hoffmann and Hatch, 1996; Rini et al., 1999). In a study on relationships between life stresses and pregnancy outcomes, pregnant women who reported high life stresses before and during the pregnancy had a significant pregnancy complication rate; however, no such effects were found if the high life stress was reported for only one of the periods (Nuckolls et al., 1972). Rini et al. (1999), in a prospective study on 120 Hispanic and 110 White pregnant women, investigated the effect of prenatal stress such as pregnancy-related anxiety, personal traits such as self-esteem and optimism, and sociocultural factors such as income, ethnicity and education on birth outcomes. Women who reported higher stress appeared to have shorter gestations (Rini et al., 1999). However, it appears that the timing of exposure to stress is also important, the most vulnerable period occurs in early pregnancy. For example, Gorsuch and Key (1974) examined relationships between anxiety and life stress with pregnancy abnormalities such as preeclampsia, threatened abortion, infant distress, prematurity, LBW, etc. by interviewing 111 women-attendees of a low-income obstetrics clinic. In the study, higher levels of anxiety early in pregnancy appeared to predict abnormalities of pregnancy, while anxiety or life stress experienced before conception was not found to influence the course and outcome of pregnancy (Gorsuch and Key, 1974). This is consistent with the finding from a recent study on 40 women who experienced an earthquake during their pregnancy. Those women who were in early pregnancy during the event were found to have shorter gestations ($p < 0.05$), while women in advanced pregnancy appeared less sensitive to the effect of earthquake-related stress (Glynn et al., 2001). An association between life events and birthweight or fetal growth has also been found in other studies (Reeb et al., 1987; Pagel et al., 1990;

Wadhwa et al., 1993). Reeb et al. (1987), reported that low birthweight could be predicted by life events in a low income AA community, with a relative risk = 1.5. Wadhwa et al. (1993), in a prospective study examined the effect of a stressful life event among white middle-income women (sample size = 90) on pregnancy outcomes. They found that a one unit increase on the stress scale of life events is associated with a 55g decrease in birthweight, with the odds ratio for a low birthweight delivery being 30% higher if the mother experienced a stressful life event during her pregnancy in comparison to those who suffered no such stress ($p<0.05$) (Wadhwa et al., 1993). Mutale et al. (1991), found a positive association between a severe life event or ongoing difficulty and preterm delivery. If a mother experienced a severe life event, then the child was more than three times as likely to be born prematurely than a child whose mother was not exposed to such events (OR=3.2) (Mutale et al., 1991). Dole et al. (2003) examined psychosocial risk factors such as life stress events, depression, pregnancy-related anxiety, perceived racial and gender discrimination and neighborhood safety on preterm births. Perceptions of gender discrimination, racial discrimination and unsafe neighborhoods, as well as stress associated with these factors, were found to contribute to an increased yet imprecise, risk of premature births (Dole et al., 2003). One study found that crime as a neighborhood environmental stressor was positively associated with LBW and preterm birth among AA and White women (Messer et al., 2006). White women living in neighborhoods with a high violent crime rate showed a 40% increased chance of having a preterm birth and a 70% increased chance of having a LBW child than those living in neighborhoods with low rates of violent crime (Messer et al., 2006). Similarly, the study found an association between crime and poor birth outcomes for AA women: odds of a preterm birth were 50% higher, and for LBW deliveries 20% higher for AA women living in census block groups with a high rate of violent crime (Messer et al., 2006). An earlier study on the effect of community-level conditions on the course and outcomes of pregnancy by O'Campo et al. (1997) concluded that living in a disadvantaged neighborhood might aggravate pre-existing individual-level sociodemographic factors and health behaviors such as maternal age and education, beginning prenatal care, and health insurance status. Individual-level risk factors for LBW revealed different behaviors with regard to characteristics of the area of residence. For example, irrespective of individual poverty women benefited less from prenatal care and were at a higher risk to have LBW babies when they lived in crime-ridden, decayed areas than did women who lived in lower-risk areas (O'Campo et al., 1997).

Previous studies also examined stress effects on pregnancy outcomes when caused by community-wide disasters or the death of a spouse. A study on perinatal outcomes of women who were pregnant during or immediately after an earthquake in Taiwan found a significant correlation between spouse casualty and neonatal low birthweight (Chang et al., 2002). A Swedish study following the Chernobyl disaster also reported a shorter duration of pregnancy in women with high anxiety scores, when compared to those who were not prone to psychic anxiety (Levi et al., 1989).

CHAPTER 3. HURRICANE ANDREW, LOUISIANA

3.1 History of Hurricane Andrew

Hurricane Andrew formed as a tropical wave off the west coast of Africa on August 14, 1992, before moving towards Florida (Grimes and Stone, 1995). On August 17, due to the favorable environmental conditions, it became a tropical storm and continued gaining force (Grimes and Stone, 1995; Rappaport, 1993). It passed over the Bahamas and made its landfall along the U.S Atlantic Coast of Florida near Homestead on 24 August, 1992 as a category 5 hurricane (Grimes and Stone, 1995; Rappaport, 1993). It took Hurricane Andrew just four hours to cross the peninsula before entering the Gulf of Mexico where maximum winds measured 140 mph (Dingler et al., 1995; Grimes and Stone, 1995). The hurricane weakened and slowed down as it was moving along Louisiana's coastline (Grimes and Stone, 1995; Dingler et al., 1995).

Two days after hitting Florida, the hurricane made its second U.S. landfall on the sparsely populated south-central Louisiana coastal area near Point Chevreuil, about 20 nautical miles west-southwest of Morgan City (St. Mary Parish) as a category 3 storm at 4:30 AM EDT (Rappaport, 1993)(Figure 6). Its landfall central pressure was estimated at 956 mb and sustained winds reached 120 mph.

The strongest winds were observed ahead and to the right of the storm's motion, coinciding with the area of the greatest damage (NOAA, 1993). As it moved inland, Hurricane Andrew steadily weakened, and 24 hours after its landfall in Louisiana, it was downgraded to tropical depression status (Grimes and Stone, 1995). According to Rappaport (1993), the remnants of Hurricane Andrew merged with a cold front over the eastern United States on August 28.

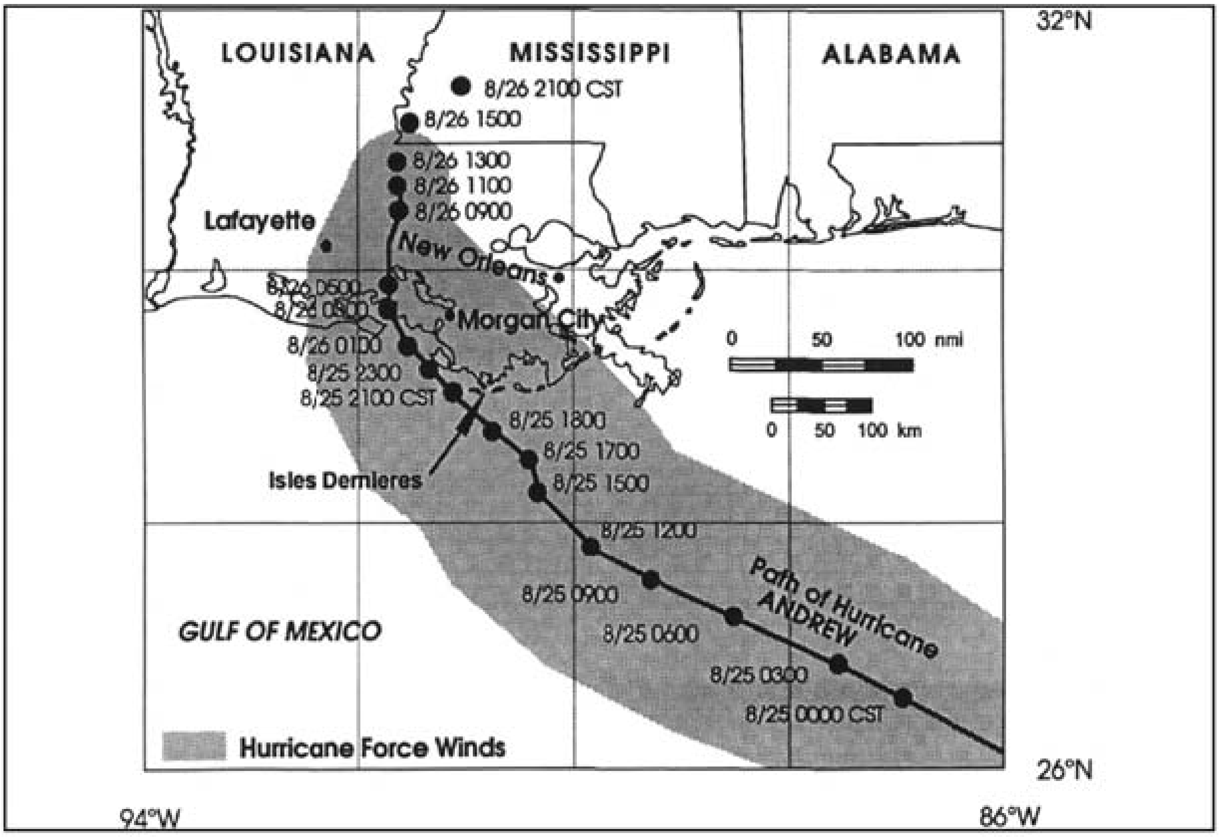

Figure 6. The Track of Hurricane Andrew in the Gulf of Mexico
Source: Penland et al., 2003. U.S.G.S. Open-File Report 03-398

Hurricane Andrew produced heavy rain observed along and to the right side of its track (Table 4), storm tides (Figure 7), and tornadoes ranging from F-0 to F-3 on the Fujita tornado intensity scale (Figure 8). Thirty-six parishes were declared disaster areas (Figure 8).

Table 4. Selected rainfall totals associated with Hurricane Andrew, August 1992.

Location	Total Rain (in)	Location	Total Rain (in)
Hammond	11.92	Butte La Rose	7.9
Robert	11.02	Ponchatoula	7.54
Amite	10.36	Mt. Herman	7.5
Morgan City	9.31	Franklin	7.03
Manchac	8.75	WSFO Slidell	5.06
Jeanerette	7.96	Jena 4WSW	4.42

Source: Rappaport (1993).

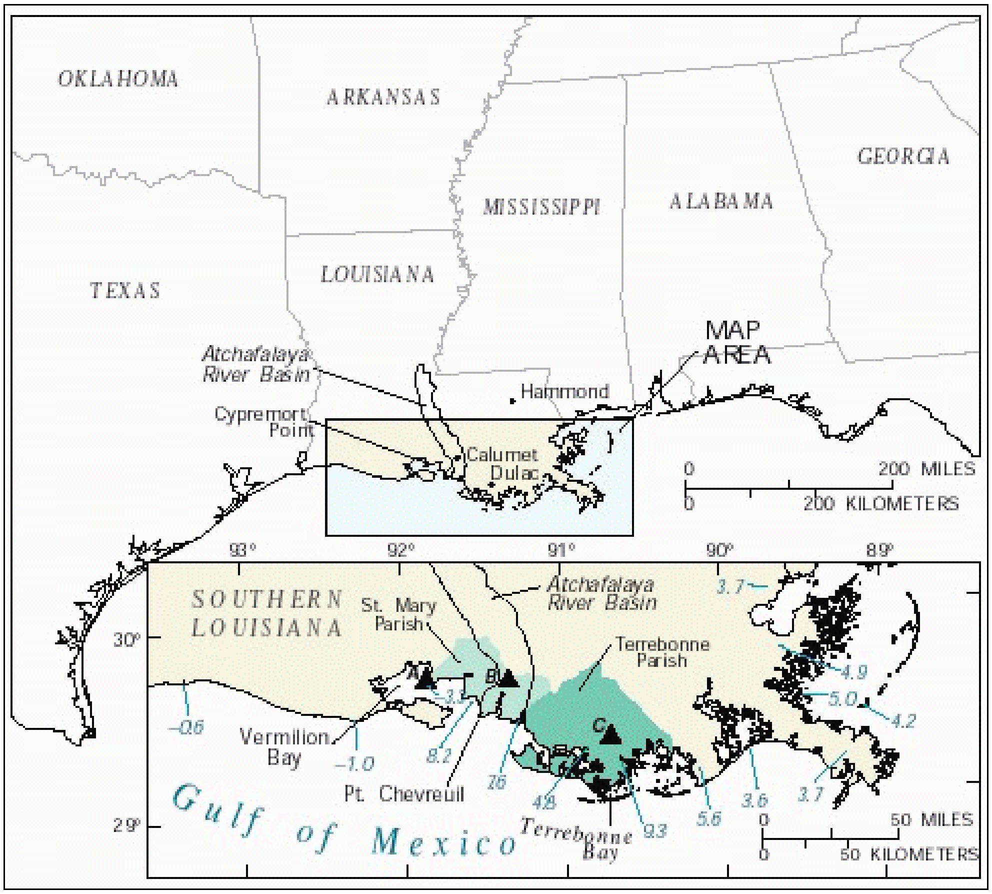

Figure 7. Storm-surge Elevations, in feet, along the Coast of Louisiana. A, Vermillion Bay, near Cypremont Point; B, Wax Lake outlet, at Coleman; C, Houma Navigation Canal, at Dulac.
Source: Lovelace and McPherson, USGS, Water Supply Paper 2425

3.2 Economic Damage

According to the damage assessment (NOAA), this hurricane was responsible for $1 billion (1992 USD) in damages to houses, agriculture, wildlife and fisheries, and the oil industry in Louisiana (Table 4). Wind, wind-blown rain, and tornados traveling to the right of the storm caused the most damage (NOAA; FEMA, 1993). Iberia Parish (New Iberia and Jeanerette) and St. Mary Parish (Cypremont Point, Morgan City, Franklin, and Patterson), received widespread wind and rain damage (FEMA, 1993). *Times-Picayune* (September 5, 1992, p.2) reported that all 26 schools in St. Mary Parish were damaged, while another 12 schools were damaged in Iberia Parish. *A Times Picayune* article by

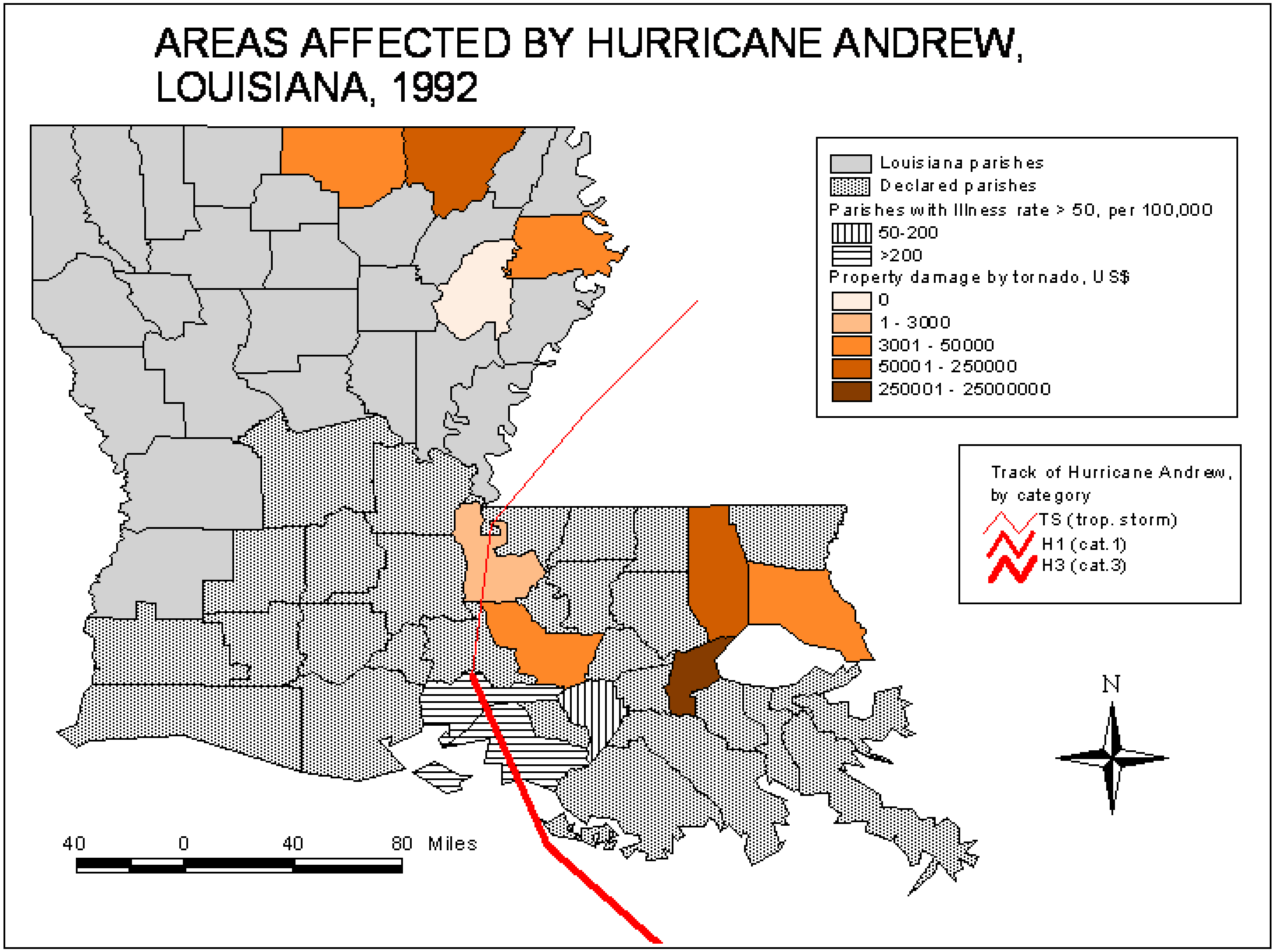

Figure 8: Affected Areas. From NOAA Storm Events Database and MMWR, 1993, 42(13)

Walsh and Ruth, from 27 August, 1992, reported that a tornado caused by the hurricane destroyed 52 houses, 14 mobile houses, and damaged another 56 houses in St. John the Baptist Parish. In addition, a tornado killed two people (one was a two-year-old girl) and injured 32 more. Much of the rest of the declared disaster area received minor-to-moderate wind damage including damage to windows and roofs.

Many Louisianans lost their houses during Hurricane Andrew. According to a Hurricane Andrew damage assessment survey in Louisiana (NOAAa), there were 3,301 homes (single, multifamily, and mobile homes combined) which were destroyed and another 18,247 homes that were damaged. However, CDC (1993b) offers another estimate: 25,000 housing units destroyed or severely damaged in Louisiana.

Table 5**.** Deaths and Damages Incurred in Association with Hurricane Andrew.

Location	**Deaths**		**Damage ($ Billion)**
	Direct	**Indirect**	
St. John the Baptist Parish	2	0	
Offshore	6	0	
Lafayette Parish	0	2	0.017
Vermillion Parish	0	0	0.001
Iberville Parish	0	1	
Terrebonne Parish	0	3	
Orleans Parish	0	1	
Plaquemines Parish	0	1	
Iberia Parish	0	1	
Louisiana:	8	9	1

Source: Rappaport (1993).

3.3 Health Consequences of Hurricane Andrew

The health consequences of the storm were also studied. According to the CDC'S MMWR (1992b, No.37), a disaster epidemiological assessment was conducted in St. Mary Parish, the worst hit area by Andrew. A sample size of 684 people had two surveys with the purpose of identifying people's health and medical needs in the hurricane-impacted areas (Table 6). Surveys were conducted on August 29, and September 3.

Hurricane Andrew left 167,000 homes and businesses in Louisiana without electricity (Hickcox, 1992), an uncomfortable and potentially stressful situation for people with special needs, such as those with medical conditions or bottle-feeding mothers. Table 6 shows that although most of the population had access to food, transportation, telephone service and running water three days after the hurricane, the majority of the area was still without electricity.

Table 6**.** Percentage of Households with Acute Needs 3-4 and 8 days Post-impact from Hurricane Andrew - St. Mary Parish, Louisiana, 1992

Household characteristic	**3 days post-impact, August 29 (n=211), %**	**8 days post-impact, September 3 (n=214), %**
Requiring medical services	19	6
Unable to obtain prescription medication	16	6
Households with injured person(s)	3	4
Inadequate food	5	NA
No running water	6	NA
No electricity	76	13
No telephone service	16	9

Statistically significant change from August 30-31survey ($p<0.05$, two-tailed test).
NA = not assessed. Source: MMWR, Vol.41, No.37, 1992.

The study noted that factors such as heat and humidity could put the population at-risk for serious heat-related illness (Greenough, 2005). At the time of the second survey, 32% were dependent on disaster-relief drinking water, while 27% of the households were dependent on disaster-relief food or food stamps (MMWR, 1992). Damage to public water supplies, sewage system, and power supplies are found to increase the risk of diarrheal diseases (Sathe et al., 1983; Noji, 1997), though no such outbreaks were reported in Louisiana (McNabb et al., 1995). In total, there were 462 Hurricane Andrew-related health events in Louisiana with 445 (96%) of these having non-fatal outcomes (McNabb et al., 1995). Out of the 17 deaths related to Andrew, eight were direct (including two deaths caused by the tornado) and nine indirect deaths (Table 4). Indirect deaths are defined as those “caused by hurricane-related events, such as evacuation, clean-up, inability to obtain medication, loss of electricity, or stress-induced cardiovascular events" (MMWR, 1992, No.35). According to Rappaport (1993), many indirect deaths took place during the "recovery phase", for example one death occurred during the evacuation in a motor-vehicle crash (McNabb et al., 1995). According to McNabb et al., (1995), 445 nonfatal events consisted of 383 injuries (86%) and 62 (14%) illnesses. Among all the parishes, St. Mary, St. John, and Iberia had the highest hurricane-related injury or illness rate (in excess of 200 per 100,000), and Iberville and Assumption ranked second highest (with a rate of 50 to 200 per 100,000) (Figure 8). The most frequent injuries reported were cuts, lacerations, and puncture wounds (McNabb et al., 1995).

3.4 Stress and Displaced Population

Massive evacuations were ordered in Louisiana, due to the threat of Hurricane Andrew. According to NOAA (1993), the following parishes were ordered to evacuate: Orleans (West Bank), Plaquemines (South Half), Lafourche (South Half), Terrebonne (South Half), St. Martin (Lower Half), Iberia, and Cameron. Recommendations to evacuate were given to Orleans (East Bank), Jefferson (West Bank), St. Tammany, Plaquemines (North Half), Lafourche (North Half), Terrebonne (North Half), St. Charles, St. James, Assumption, Vermillion, Calcasieu, and Lafayette.

It is estimated that about 1,250,000 people evacuated from parishes in south-central and southeastern Louisiana during hurricane Andrew in 1992 (Rappaport, 1993). A displaced population generally suffers numerous stresses (Madrid et al., 2006; Curtis et al., 2007), resulting from the evacuation itself, long stays in evacuation shelters and the eventual return and struggle through the initial recovery process (Curtis et al, 2007). However, the biggest health concern is the inability of the displaced population to manage their chronic and other diseases (Greenough, 2005). People with immediate health care needs, like tuberculosis treatment, heart disease or those managing diabetes with a drug regime increase their risk of a potentially fatal outcome.

3.4.1 Shelters

Generally, the most vulnerable in a displaced population are those who are forced to stay in shelters because they do "not have the resources to evacuate, the network of friends and family elsewhere, or the health care they needed for such chronic conditions as hypertension, diabetes, mental illness, and addiction"(Rathbun and Cranmer, 2006, p.773). According to a FEMA hazard mitigation report (1993), there were 258 shelters opened and operated by the American Red Cross (ARC), caring for about 53,000 people.

Table 7. Shelter Status Report as of August 26, 1992, 2 a.m.

Parish	Open	Sheltered	Parish	Open	Sheltered
Evangeline	7	390	West Baton Rouge	1	230
Lafayette	6	3015	Assumption	4	1000
St. Landry	17	957	Jefferson	12	1224
St. Martin	6	1750	Lafourche	5	1080
Vermillion	2	210	Orleans	9	21,590
Acadia	18	1745	Plaquemines	2	550
Rapides	2	1920	St. Charles	2	700
Calcasieu	1	127	St. John	3	1800
Ascension	4	1120	St. Mary		
East Baton Rouge	3	1400	Tangipahoa	1	115
Iberville	1	900	Terrebonne	10	3479
Livingston	1	90	**Total**		**44,132**

Source: LA Office of Emergency Preparedness (OEP) Communications

A *Morning Advocate* article from August 26, 1992, by Steve Wheeler and Frank Main described the evacuees' stressful experiences as they took shelter in the Centroplex and LSU Field House in Baton Rouge. One of the evacuees was an unnamed eight-month pregnant woman from New Orleans, who said that she had exactly one hour to pack her bags before evacuation. Disaster shelters often do not have enough potable (or any) water and other supplies, and are often crowded and unclean (Greenough, 2005). Scarcity of resources tends to generate stress. Disaster shelters that housed people during Andrew were no exception. There was no food for the evacuees in the municipal auditorium sheltering 770 Morgan City residents, who had received orders from the police to come to the auditorium (Borenstein et al., *Sun Sentinel*, August 26, 1992). A lack of supplies was observed in the LSU Field House at Baton Rouge: a Red Cross volunteer stated that the supplies of cots and blankets were completely gone. Stress can also be generated by fear (Briggs, 2000). Articles reported that more than 3,500 evacuees who stayed in two shelters in Iberia and one shelter in St. Mary Parish were frightened, with "kids crying, people screaming, running everywhere" as winds blew off the roofs; two people had heart attacks while witnessing the roof of a shelter ripped, causing leakage at Jeanerette High School (Steve Culpepper and Keith Lawrence, *The Advocate*, August 27, 1992, p.8A; Calvin Lear, *The Advocate,* August 27, 1992, p.13A).

3.5 Hurricane Andrew and Pregnant Women

One aspect of disaster-related health and vulnerability that has received little attention is the impact of pregnant populations. However, this is not to say pregnancy-related stories are not found in the mass media surrounding such events.

Newspaper articles provide an insight into the stress hurricane Andrew generated. For example, an article reported that as many as 1,500 pregnant women, mostly in their last trimester of pregnancy, were hospitalized in South Florida for fear of starting an early labor due to the approach of the hurricane; indeed, many of these women did deliver early (Ray Lynch, *Sun-Sentinel*, August 25, 1992). An article by Bob Anderson, (*The Advocate*, August 27, 1992, p.10A) in a report on Livingston Parish, Louisiana, stated that a woman staying in A Denham Springs shelter went into labor, and had to be transported to a hospital. Another article reported two pregnant women in St. Landry

Parish, Louisiana, who also went into labor during the hurricane and had to be transferred to the hospital (Culpepper and Lawrence, *The Advocate*, August 27, p.8A). A photograph by Tim Mueller (*The Advocate*, August 27, 1992, p.13A) pictured a pregnant woman in her last trimester at Bayou Vista, Louisiana. This woman had to seek shelter in Opelousas, Louisiana, after a mandatory order to evacuate by St. Mary's officials. Unfortunately, Hurricane Andrew completely destroyed her house. Looking at what little was left from her house and possessions, she appears tired and stressed. According to Dingman (1995), any loss whether of a loved one, or even of property, can be a very stressful and intense experience A photograph by Brad Bigley (*The Advocate*, August 29, 1992, p.3B) pictured a young woman crying in frustration after she despaired on getting food and could wait no longer, saying she had a sick, premature baby at home who needed medicine. Steve Wheeler described the distress and confusion experienced by many people who were seeking food stamps to replace supplies spoiled by the hurricane. These storm victims waited for a long time outside the food stamp office in debilitating heat, many of them with children (*The Advocate*, September 2, 1992, p.1A). A seven-month pregnant woman became ill, suffering heat exhaustion after standing a long time in line, and had to be taken inside the building, and then transported to a hospital. Paramedics also had to treat a nine-month old boy, who became dehydrated.

3.5.1 Property Loss and Pregnancies

Although an overwhelming majority of evacuated people returned home, people whose houses were destroyed or badly damaged did not come back; at least, for some time. If a pregnant woman lived in such household, then her usual routine would be disrupted, leaving her to experience the double stress of coping with both a disaster and its aftermath. Curtis et al. (2007) state that stress, associated with the inability to return home, can contribute to a poor birth outcome. Financial problems and widespread property damage in a community were found to contribute to psychological effects (Norris et al., 2002). On the other hand, stress could affect pregnancy indirectly resulting in behavior such as delayed prenatal visits, substance use, smoking, non-compliance with medical recommendations, etc., which could also negatively affect pregnancy (Hoffmann and Hatch,1996).

CHAPTER 4. AN ANALYSIS OF PREGNANCY OUTCOMES IN THE AREA AFFECTED BY HURRICANE ANDREW

4.1 Introduction

This study analyzes existing birth databases containing pregnancy outcomes in Louisiana for the years 1990 – 1995 to determine the impact of Hurricane Andrew on reproductive health indicators such as LBW and preterm births.

4.2 Materials and Methods

Pregnancy data by zipcode were analyzed for the period 1990-1995. These data contain information on the date, month and year of the birth, birthweight, number of visits to see a doctor, month initiating prenatal care, gestational age at delivery, as well as parental characteristics such as race, age, education, address among other variables.

Storm track data for the Atlantic basin was downloaded from the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center web site: http://maps.csc.noaa.gov/hurricanes/download.html. The GIS shapefile contains information for all the hurricanes between 1851 and 2006. These data provide information on the hurricanes as to the name, year, month, day, and time, latitude, and longitude. Hurricane characteristics such as wind force, pressure, category of the storm, and the basin are also included in the available information. Track data of Hurricane Andrew was extracted from this shapefile and added as a layer in the GIS.

4.3 Buffering Procedure

According to Williams and Duedall (1997, p.42), Hurricane Andrew was considered a relatively small compact system. That is why a buffer of 20 miles radius around the track of Hurricane Andrew was drawn. This buffer was chosen as a proxy for the area which experienced the greatest hurricane-related stress, since the hurricane-force winds, the greatest damage, and an elevated hurricane-related illness rate were observed there. ArcView 3.2 GIS was used to create a buffer zone around Hurricane Andrew's track. The resulting layer was added to the project and used for subsequent procedures.

4.4 Data Problems and Manipulation

Shapefiles of Louisiana parishes, zip code tabulation areas (ZCTA) were obtained from Census (web address: http://www.census.gov/geo/www/cob/z52000.html) and ESRI (web address: http://arcdata.esri.com/data/tiger2000/tiger_county.cfm?sfips=22) and entered into the GIS. Birth data were aggregated to zip code areas; however, the boundary shape files were for ZCTA which were reported problematic elsewhere as raw ZCTAs can also include water areas (HH codes) and sparsely populated areas (XX codes), and often are spatially discontinuous (Grubesic and Matisziw, 2006). To make these spatial units compatible and to avoid errors in future procedures, the following manipulation was performed. All the ZCTAs with HH and XX codes were removed from the original ZCTA file. In addition, several polygonal separate areas had the same ZCTA name; so to avoid double representation of the data assigned to the ZCTA due to the frequent spatial discontinuity, all five-digit ZCTAs consisting of multiple polygonal areas were dissolved, using ZCTA as a common attribute (Grubesic and Matisziw, 2006).

4.5 Study Area – Zip Codes Falling within Buffer Area

To extract zip codes falling within a 20-miles buffer for future analysis, two themes were clipped using the GeoProcessing wizard in ArcView. The output became a new theme used for all subsequent analyses (Figure 9). Tables in .dbf format from the original database containing birth information for the years 1990 – 1995 were added to the project. The query was performed to extract the information on the births that occurred within zip code areas inside the 20-mile buffer. The resulting outputs- tables were added to the GIS.

4.6 Analysis of Pregnancy Outcomes in the Area Affected by Hurricane Andrew, a Short-Term Impact.

To view the impact of Hurricane Andrew on pregnancy outcomes, this study used a consistent timeframe for the intervals under investigation with September always being the first month and July the last (as Hurricane Andrew struck Louisiana at the end of August, for the sake of the investigation, this month was removed from all analyses). This temporal sequence was chosen to eliminate any seasonality bias in the births. The study was designed to capture women who were pregnant a) during, b) immediately after, or c) during the months following the hurricane. The first comparison occurred for the period before (September 1991-July1992) and immediately after (September 1992-July 1993) the hurricane.

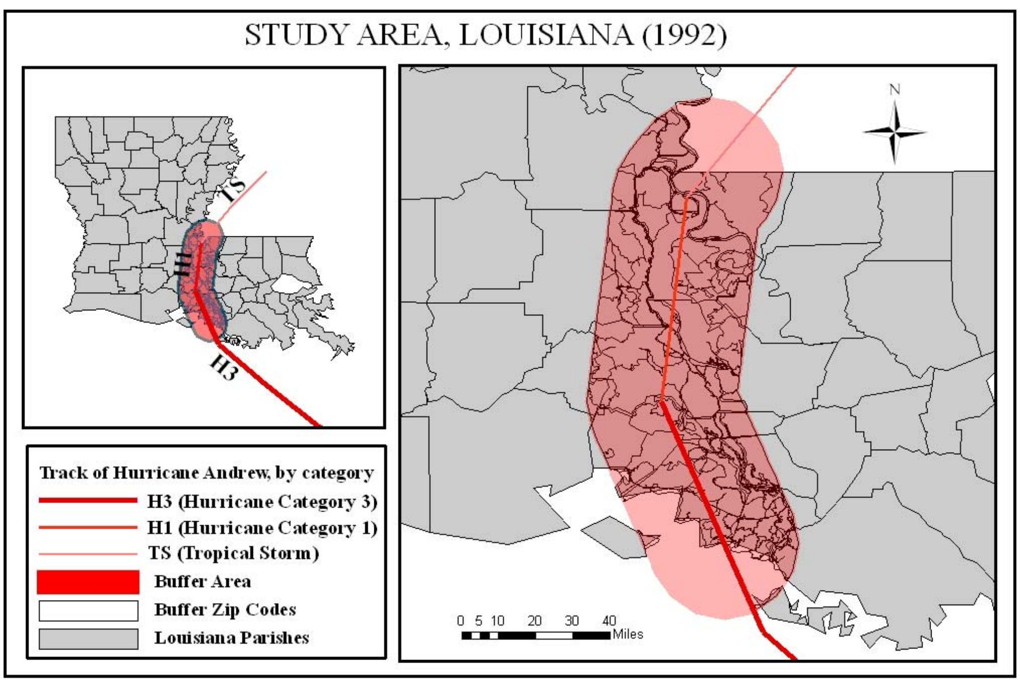

Figure 9. The 20-miles Buffer Area which Comprised the Study Area

Birth data from the tables produced earlier for the years 1990 – 1995, were again queried using ArcView 3.2 to suit the chosen period of September – July. The outputs from these queries were combined using Excel. The resulting table for September 1991–July 1992 was added to the GIS.

The steps above were repeated to extract all births that occurred September 1992–July 1993.

4.7 Statistical Analysis and Hypotheses to Test

The specific purpose of this thesis is to test the following hypotheses:

Hypothesis $_{01}$: there is no impact of Hurricane Andrew on premature deliveries (there is no difference between pre- and post-disaster level of premature deliveries infants) in the affected areas.

Hypothesis $_{02}$: there is no impact of the hurricane on LBW (there is no difference between pre- and post-disaster level of LBW infants) in the affected areas.

Hypothesis $_{03}$: there is no difference between the pre- and post-disaster level of adverse pregnancy outcomes between affected and non-affected zipcodes.

The level of significance chosen to test all these hypotheses was 95%.

A Chi-squared test was applied to see if adverse pregnancy outcomes were significantly different before and after the hurricane. According to Agresti (1996), the Pearson X^2 statistics can be used to test independence in I × J tables:

$X^2 = \sum (n_{ij} - \mu_{ij})^2 / \mu_{ij}$,

where n_{ij} is the observed data, μ_{ij} is the expected value of n_{ij} and estimated $\mu_{ij} = n_{i+}n_{+j} / n_{..}$. The null hypothesis was that stress due to hurricane Andrew had no statistical effect on pregnancy outcomes. According to Agresti (1996), a test statistic and its p-value can present evidence against the Ho.

A two-way contingency table was constructed with the binary response variable being a number of adverse pregnancy outcomes (yes/no: infants born prematurely and normal pregnancy outcomes), and with the independent dichotomous variable being a period before hurricane and after hurricane. To find whether the number of adverse pregnancy outcomes has changed significantly, a Chi-squared test of significance using X^2 statistic (SAS: PROC GENMOD and SAS- PROC FREQ with MEASURES option) was applied. The latter procedure also calculated the odds ratio (OR) for the infants to be born prematurely, as well as a 95% confidence interval for the odds ratio. OR is the ratio of the "success" probabilities for the two periods – before and after the hurricane.

SAS software was utilized to perform all statistical analyses.

4.7.1 Race Effect

Due to the number of studies investigating pregnancy outcomes between races, it was decided to also analyze these data for this effect. As AA and the Whites represent the largest racial groups in Louisiana, (33.1% and 64.1%, respectively) (Louisiana QuickFacts, 2005) only the birth records for these subpopulations were used in the analysis. The study considered premature deliveries first. Prematurely born infants were extracted from the original birth database for each race (Whites and Blacks). A 2x2x2 contingency table was constructed with the binary response (counts of whether the infant was born prematurely and or within term) for each of the racial groups for the period September 1991– July 1992 and September 1992– July 1993. The proportion of preterm births for both AA and Whites were compared between pre- and post-disaster levels using the Cochran-Mantel-Haenszel statistic (CMH).

According to Agresti (1996, p.61) Cochran-Mantel-Haenszel statistic (CMH) is a more powerful test, compared to significance tests performed separately for each of the partial tables. CMH summarizes information from two partial tables and follows the Chi-squared distribution with 1 Degree of Freedom (DF).

The statistic has a Pearson X^2 form:

$CMH = [\sum_k(n_{11k} - \mu_{11k})]^2 / \sum_k Var(n_{11k})$,

where $\mu_{11k} = n_{1+k} n_{+1k} / n_{++k}$ is the mean and expected frequencies of the premature deliveries,

$Var(n_{11k}) = n_{1+k} n_{2+k} n_{+1k} n_{+2k} / n^2_{++k} (n_{++k} - 1)$ is the variance,

$\{ n_{1+k} n_{2+k} \}$are the row totals in partial tables,

and $\{ n_{+1k} n_{+2k} \}$ are the column totals (Agresti, 1996, p.61).

One can also estimate the strength of an association (effect of stress due to the hurricane on premature births for both races) using a Mantel-Haenszel estimator of common odds ratio θ_{MH} as well as a 95% confidence interval for the common odds ratio (CI) (Agresti, 1996, p.62). θ_{MH} has a form:

$\theta_{MH} = \sum_k (n_{11k} n_{22k} / n_{++k}) / \sum_k (n_{12k} n_{21k} / n_{++k})$, (Agresti, 1996, p.62).

Then, the hypothesis will be tested as to whether stress due to the hurricane has a similar effect on premature deliveries for both races. This is a homogeneous association test (Agresti, 1996, p.63). A Breslow-Day statistic is applied. According to Agresti (1996, p.63), the Breslow-Day statistic has an approximate Chi-squared distribution and it has a Pearson form:

$\sum (n_{ijk} - \text{estimated } \mu_{ijk})^2 / \text{estimated } \mu_{ijk}$,

where n_{ijk} are the observed values for premature deliveries.

SAS software reports Breslow-Day statistic using PROC FREQ.

Similar methodology was used for another adverse pregnancy outcome: the number of children born at a Low Birth Weight. First, all races were used to compare pre- and post-disaster levels of LBW, then, controlling for race, counts of LBW and those with normal weight, were compared for the periods before and after the hurricane, for AA and Whites.

4.8 Longer-Term Impact

To determine the impact of the hurricane over a longer period, different time intervals were used. However, to maintain the same rationale as previously, the beginning and end points of the timeframe were still the same – September to July. The following four time intervals were investigated:

Table 8. Time intervals for the long-term.

"Before" the hurricane period	"After "the hurricane
September 1990-July1991	September 1993-July 1994
September 1991-July 1992	September 1994-July 1995

The first two periods were assigned to be the period "before" the hurricane, and the other two periods as "after" the hurricane. For this analysis, the period of September 1991 – July 1992 was chosen as the baseline for comparison (period of September 1992-July 1993 was excluded from the analysis). The combined data of these two time intervals preceding Hurricane Andrew ("before" period) were also compared to the combined data of the time intervals following Hurricane Andrew ("after" period).

4.9 Statistical Analyses for the Longer Impact

For this analysis, data were first tabulated into a two-by-two contingency table for all races. Second, to control for the race effect, data were tabulated into a two-by-two-by-two table for AA and Whites. The tables were analyzed using the same techniques as described in the previous section.

4.10 Analysis of Pregnancy Outcomes in the Non-affected Area

To establish a control for this study, an area was selected within Louisiana that was not affected by the hurricane. This area had to be outside of the hurricane's track, and had to sustain little or no damage; further, there had to be no mandatory evacuation order. The purpose of this control was to establish whether any revealed variations in birth outcomes were due to the hurricane, or indicative of larger trends in pregnancy outcomes.

Zip code areas were chosen mostly from the parishes of Sabine, Vernon, and De Soto, and a few from Red River, Natchitoches, Caddo, Rapides, Beauregard, and Allen. These parishes were chosen as a non-affected area control because the parishes were located outside the area of hurricane-force winds. Neither hurricane-related tornadoes were reported in the area, nor was the area damaged by the storm, nor were these areas declared disaster parishes. Since Hurricane Andrew hit mostly rural parishes such as St. Mary, Terrebonne, and Iberia; the chosen parishes are similar in this regard, they being mostly rural. According to U.S. Census 1990, racial make-up of the affected and non-affected areas is quite similar, too (Table 9).

Table 9: Racial Composition in the Affected and Non-affected Areas.

Race	Affected	Non-affected
White, %	67.2	70.7
Black, %	31.4	25.5

4.10.1 Problems and Data Manipulation

To select appropriate zip code areas falling within the aforementioned parishes, the original ZCTA file had to be cleaned, due to having discontinuous areas sharing the same ZCTA name. These areas were dissolved and a new layer was added to the project (Figure 10).

Birth data for the years 1990 – 1995 for the 41 zip code areas falling within these parishes were extracted from the database and manipulated to suit the chosen timeframe.

The same rationale was applied to the non-affected area as for the affected area: the cases of LBW and preterm births were compared between two periods for the short-term impact: before the hurricane, September 1991 – July 1992, and after, September 1992 – July 1993. Pre- and post – hurricane birth data in the area unaffected by the hurricane were compared, using the same statistical techniques as discussed in the previous subsection. To investigate the longer-term impact, two years following the hurricane were considered. These were September 1993 – July 1994 and September 1994 – July1995. Analogous statistical procedures were performed to compare pre- and post-disaster levels of preterm and LBW births as compared for the affected area.

Results were compared to those for the affected area.

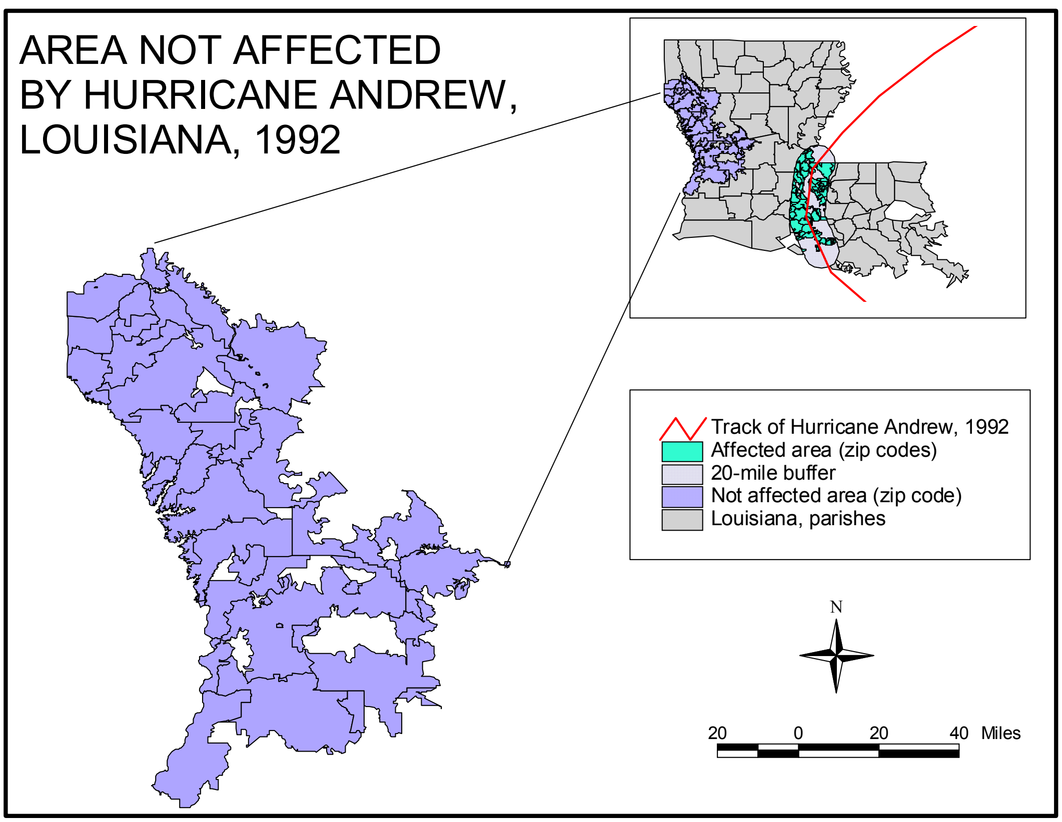

Figure 10. Area Not Affected by Hurricane Andrew.

CHAPTER 5. RESULTS

5.1 Pregnancy Outcomes before and after Hurricane Andrew

5.1.1 Short Impact: Preterm Births, All Races

Simple descriptive statistics show that a number of premature infants born during September 1992-July 1993 (“after” period) were greater than during September 1990-July1991 (“before” period), given that the total number of births was approximately the same for both periods (Table 10).

Table 10. Summary of Preterm Births, All Races, Short-term

Period	Preterm, Counts	Normal, Counts	Total, counts
After	589	5625	6214
Before	477	5784	6261

Visual examination of the distribution of the number of monthly premature births which occurred in the affected area shows a dramatic increase during the period immediately following the hurricane, and especially during April 1993, and September 1992 (Figure 11).

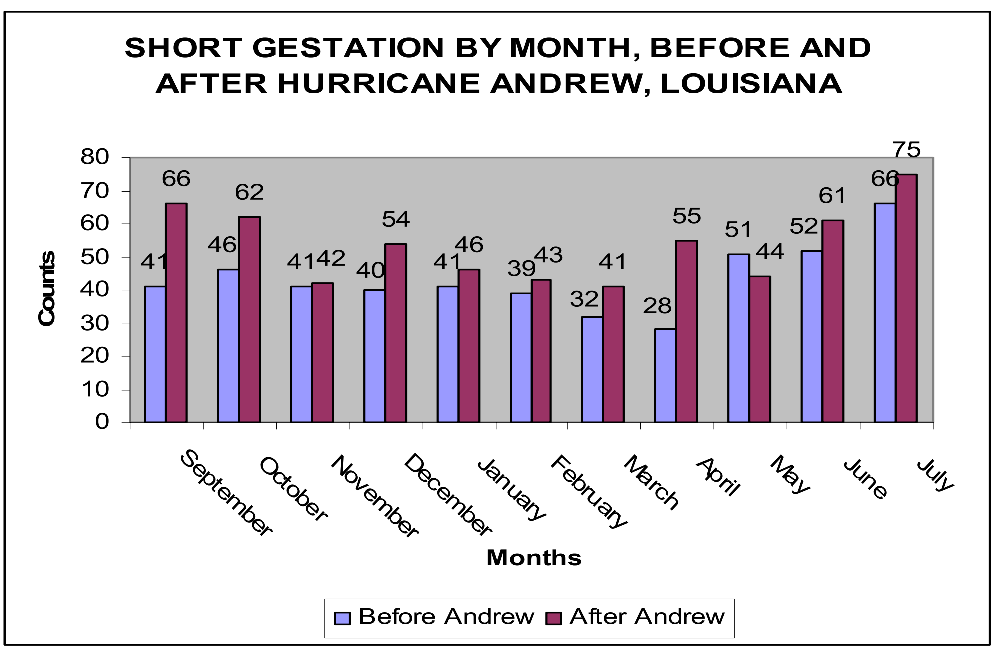

Figure 11: Preterm Births for Periods September 1991-July 1992 and September 1992 – July 1993, by Month.

With regard to all races combined, the analysis shows that there was a significant increase in the number of preterm births for the period immediately following the hurricane (p=0.0002). Results from the analysis lead to a rejection of the null hypothesis, which stated that there was no significant difference in the number of adverse pregnancy outcomes (in this case, premature deliveries) before and after the storm. Odds ratio (OR) analysis shows that the odds for a child to be born prematurely in the area affected by the hurricane increased 27% after the storm, with in the worst case, this increase being as high as 44%.

5.1.2 Short Impact: LBW Births, All Races

Somewhat surprisingly, the number of LBW deliveries was slightly greater before the hurricane than after.

Table 11. Summary of LBW Births, All Races, Short-term

Period	LBW, Counts	Normal, Counts	Total, count
“After”	581	5633	6214
“Before”	601	5660	6261

However, there was no significant increase between the two periods (p=0.635) (Figure 12).

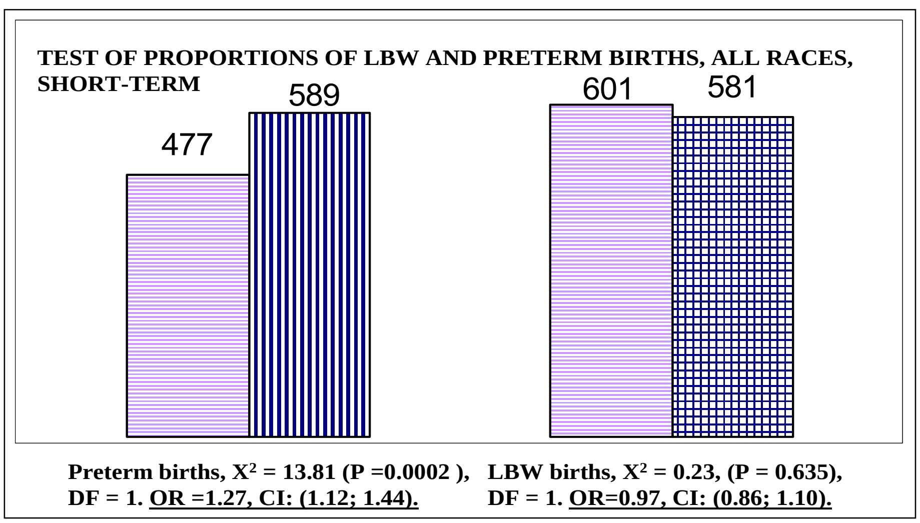

Figure 12. Pregnancy Outcomes for Periods September 1991-July 1992 and September 1992 – July 1993

5.1.3 Short Impact: Preterm Births, by Race

To see whether Whites and African Americans (AA) were differently impacted by the storm, pregnancy outcomes were also analyzed separately for each race (Table 12).

Table 12. Summary of Preterm Births, by Race, Short-term

Race	Period	Preterm, counts	Normal, Counts	Total
White	After	235	3263	3498
	Before	185	3417	3602
Black	After	352	2297	2649
	Before	288	2312	2600

Results are consistent with the earlier analysis without considering race effect: that is, after controlling for race, there is still a significant difference in the number of premature births between the two periods of before and after Hurricane Andrew, with CMH equal to 13.6 (p=.0002) (Figure 13). The Mantel-Haenszel common odds ratio estimator θ_{MH} is equal to 1.27, that is, there was a 27 % increase in the odds for an infant to be born prematurely for either race. The Breslow-Day statistic is equal to 0.35 (p = 0.55), i.e., this evidence does not contradict the hypothesis that stress due to the hurricane had the same effect on premature births for either race (Table 13).

Table 13. Test Statistics, Individual and Global, for Preterm Births Controlling for Race, Short-term.

Race	Period	Preterm, counts	Normal, counts	Total	X^2	p-value
White	After	235	3263	3498	7.98	<0.05
	Before	185	3417	3602		
Black	After	352	2297	2649	5.99	<0.05
	Before	288	2312	2600		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**	
13.62	.0002	1.27	(1.12; 1.44)	0.35	0.5539	

5.1.4. Short impact: LBW Births, by race

From the descriptive statistics table (Table 14), it can be seen that the incidence of LBW deliveries does not vary much before and after the hurricane for each race.

Table 14. Summary of LBW Births, by Race, Short-term

Race	Period	LBW, counts	Normal, counts	Total
White	After	228	3270	3498
	Before	228	3374	3602
Black	After	350	2299	2649
	Before	371	2229	2600

In the analysis that takes race into account, the results are again consistent with the earlier finding: there is no significant difference in the number of LBW births between the two periods for either race, with CMH equal to 0.423 (p = 0.516). The Mantel-Haenszel common odds ratio estimator θ_{MH} equal to 0.96 and a 95 % confidence interval (0.85; 1.08) suggests that there was no change in the odds for an infant to be born with a LBW for either race. The Breslow-Day statistic is equal to 0.9186 (p = 0.34), i.e., this evidence does not contradict the hypothesis that hurricane-related stress had the same effect on LBW births for either race. Table 15 shows test statistics for the short-term impact analyses of significance and homogeneous association between hurricane-related stress and LBW births, controlling for race.

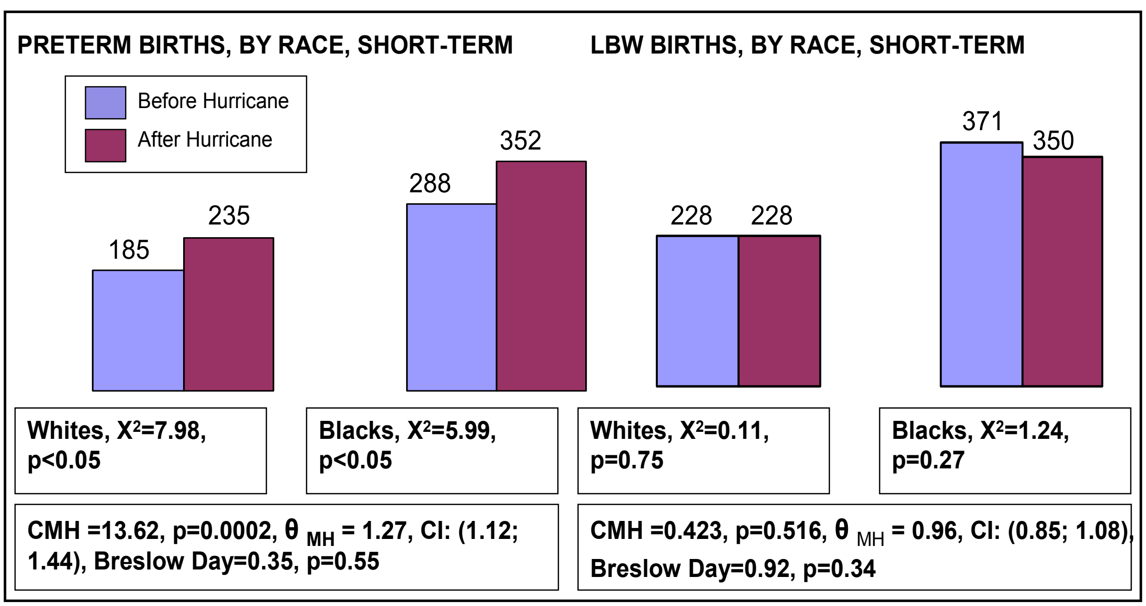

Figure 13. Pregnancy Outcomes, by Type, Short-term, by race

Table 15. Test Statistics, Individual and Global, for LBW Births by Race, Short-term.

Race	Period	LBW	Normal, counts	Total	X^2	p-value
White	After	228	3270	3498	0.105	0.7464
	Before	228	3374	3602		
Black	After	350	2299	2649	1.237	0.266
	Before	371	2229	2600		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**	
0.423	0.516	0.96	(0.85; 1.08)	0.9186	0.3378	

5.1.5. Long-term Impact: Preterm Births, All Races

Over a longer temporal period, there was a general increase in premature delivery births (Table 16).

Table 16. Summary of Preterm Births, All Races, Long-term

Period	Preterm, count	Normal, count
September 1993-July 1994	568	5338
September 1991-July 1992	477	5784
September 1994-July 1995	630	5357
September 1991-July 1992	477	5784
Sep93Jul94&Sep94Jul95	1198	10695
Sep90Jul91&Sep91Jul92	901	11497

An analysis of preterm births over the longer period for all races shows that there was a significant increase in the number of infants born prematurely for the periods following the hurricane, during both September 1993-July 1994 versus September 1991-July 1992 and September 1994-July 1995 versus September 1991-July 1992, as well as September 1993-July 1994 & September 1994-July 1995 versus September 1990-July 1991 & September 1991-July 1992 (Figure 14 and Table 17).

Table 17. Test Statistics, Individual and Global, for Preterm Births Controlling for Race, Long-term.

Period	Preterm, count	Normal, count	X^2	p-value
September 1993-July 1994	568	5338	15.46	<.0001
September 1991-July 1992	477	5784		
September 1994-July 1995	630	5357	31.4	<.0001
September 1991-July 1992	477	5784		
Sep93Jul94&Sep94Jul95	1198	10695	60.54	<.0001
Sep90Jul91&Sep91Jul92	901	11497		

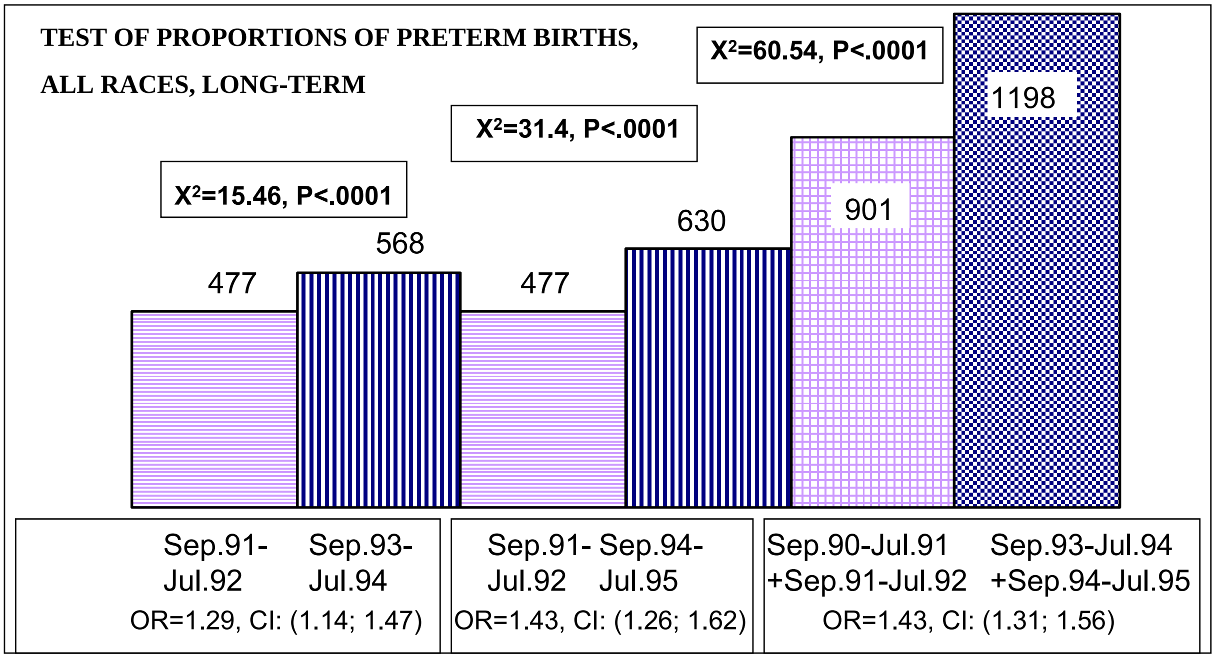

Figure 14: Preterm Births, Long-term, All Races

5.1.6. Long-term Impact: LBW, All Races

Birth data for the longer time period comparison is similar to that for the short term regarding little variation in the comparative number of LBW infants (Table 18).

Table 18. Summary of LBW Births, All Races, Long-term

Period	LBW, count	Normal, count
September 1993-July 1994	571	5335
September 1991-July 1992	601	5660
September 1994-July 1995	568	5419
September 1991-July 1992	601	5660
Sep 93Jul94&Sep 94Jul95	1139	10754
Sep 90Jul91&Sep 91Jul92	1210	11188

Statistical analysis of LBW births has similarly shown that there was no significant change in the number of infants born with a LBW during the periods following the hurricane, during both September 1993-July 1994 versus September 1991-July 1992 and September 1994-July 1995 versus September 1991-July 1992, as well as September 1993-July 1994 & September 1994-July 1995 versus September 1990-July 1991 & September 1991-July 1992 (Figure 15 and Table 19).

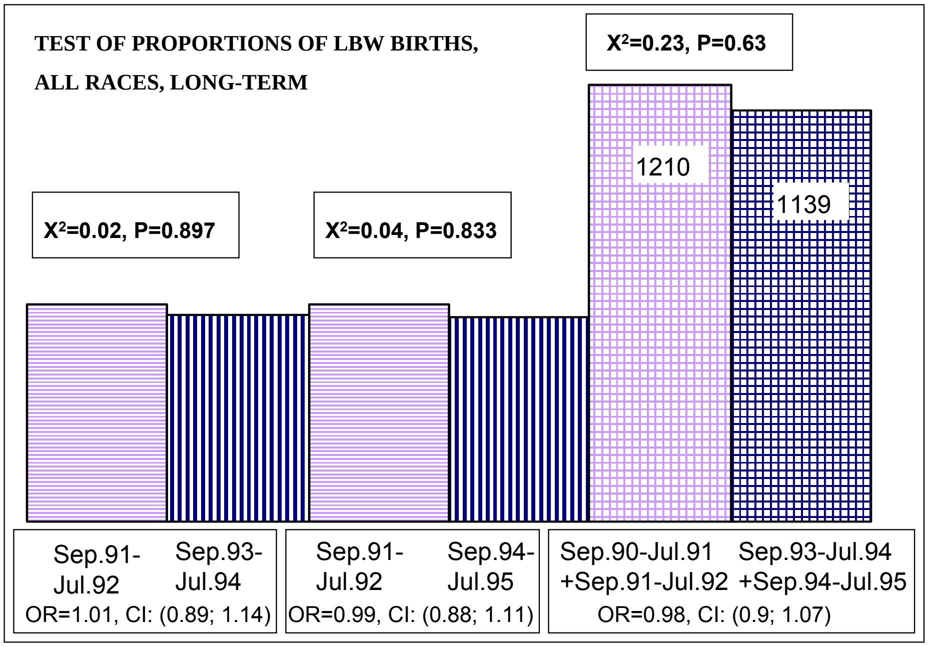

Figure 15. LBW, Long-term, All Races.

Table 19. Test Statistics for LBW Births for All Races, Long-term.

Period	LBW, count	Normal, count	X^2	p-value
September 1993-July 1994	571	5335	0.02	0.897
September 1991-July 1992	601	5660		
September 1994-July 1995	568	5419	0.04	0.833
September 1991-July 1992	601	5660		
Sep 93Jul94&Sep 94Jul95	1139	10754	0.23	0.63
Sep 90Jul91&Sep 91Jul92	1210	11188		

5.1.7. Long-term Impact: Preterm Births, by Race

Table 20. Summary of Preterm Births, by Race, Long-term

Race	Period	Preterm, count	Preterm, count	Total
White	September 1993-July 1994	205	3062	3267
	September 1991-July 1992	185	3417	3602
Black	September 1993-July 1994	357	2224	2581
	September 1991-July 1992	288	2312	2600
White	September 1994-July 1995	232	3136	3368
	September 1991-July 1992	185	3417	3602
Black	September 1994-July 1995	391	2143	2534
	September 1991-July 1992	288	2312	2600
White	Sep.94-Jul.95&Sep.93-Jul.94	437	6198	6635
	Sep.91-Jul.92&Sep.90-Jul.91	342	6785	7127
Black	Sep.94-Jul.95& Sep.93-Jul.94	748	4367	5115
	Sep.91-Jul.92&Sep.90-Jul.91	550	4608	5158

An examination of the birth data reveals that despite a slight decline in the total number of births following the hurricane, there is an increase in the number of infants born prematurely for both Whites and AA (Table 20).

An analysis of a longer-term effect of hurricane-related stress on premature births in the affected area, controlling for race, displays a consistently significant difference in the number of premature births in the periods before and after Hurricane Andrew (Figure 16 and Table 21). The Mantel-Haenszel common odds ratio estimators (θ_{MH}) are between 1.27 and 1.43, i.e., there was a 30-40 % increase in the odds for a premature infant birth for either race. Small Breslow-Day statistics show that the evidence does not contradict the hypothesis that hurricane-related stress had the same effect on premature births for either race.

Table 21. Test Statistics, Individual and Global, for Preterm Births Controlling for Race, Long-term.

Race	Period	Preterm	Normal	X^2	p-value
White	September 1993-July 1994	205	3062	4.15	<0.05
	September 1991-July 1992	185	3417		
Black	September 1993-July 1994	357	2224	9.02	<0.05
	September 1991-July 1992	288	2312		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
13.08	0.0003	1.27	(1.11; 1.44)	0.09	0.76
White	September 1994-July 1995	232	3136	9.5	<0.05
	September 1991-July 1992	185	3417		
Black	September 1994-July 1995	391	2143	21.19	<.0001
	September 1991-July 1992	288	2312		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
30.42	<.0001	1.43	(1.26; 1.62)	0.28	0.6
White	Sep.94-Jul.95& Sep.93-Jul.94	437	6198	20.56	<.0001
	Sep.91-Jul.92&Sep.90-Jul.91	342	6785		
Black	Sep.94-Jul.95& Sep.93-Jul.94	748	4367	36.5	<.0001
	Sep.91-Jul.92&Sep.90-Jul.91	550	4608		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
56.99	<.0001	1.42	(1.30; 1.56)	0.1718	0.7887

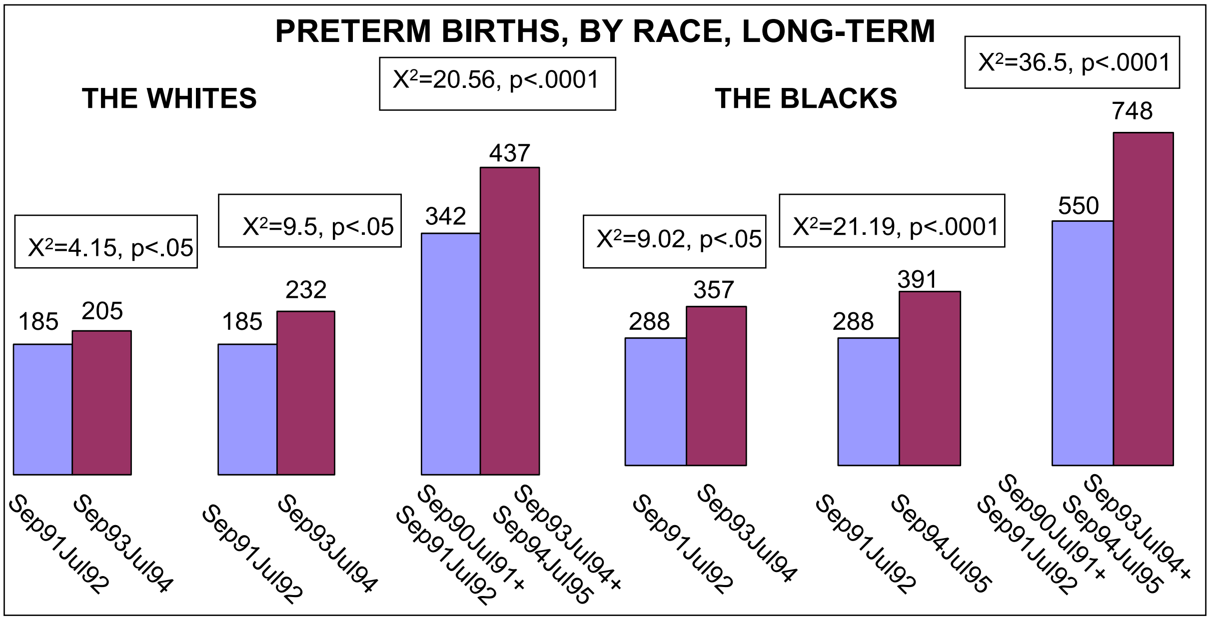

Figure 16. Preterm Births, Long-term, by Race

5.1.8. Long-term Impact: LBW Births, by Race

Descriptive statistics (Table 22) show that the incidence of LBW cases does not vary much before and after the hurricane for each race for the longer time period.

Table 22. Summary of LBW Births, by Race, Long-term

Race	Period	LBW, count	Normal, count	Total
White	September 1993-July 1994	192	3075	3267
	September 1991-July 1992	228	3374	3602
Black	September 1993-July 1994	372	2209	2581
	September 1991-July 1992	371	2229	2600
White	September 1994-July 1995	213	3155	3368
	September 1991-July 1992	228	3374	3602
Black	September 1994-July 1995	350	2184	2534
	September 1991-July 1992	371	2229	2600
White	Sep.94-Jul.95+ Sep.93-Jul.94	405	6230	6635
	Sep.91-Jul.92+Sep.90-Jul.91	452	6675	7127
Black	Sep.94-Jul.95+ Sep.93-Jul.94	722	4393	5115
	Sep.91-Jul.92+Sep.90-Jul.91	749	4409	5158

Statistical analysis of a longer-term effect of hurricane-related stress on LBW births controlling for race shows that there is consistently no significant difference in the number of LBW births between the two periods of before and after Hurricane Andrew (Figure 17) (see Table 23 for individual X^2 and global CMH test statistics). The Mantel-Haenszel common odds ratio estimators (θ_{MH}) are about 1, which suggests that there is no change in the odds for an infant to be born with LBW for either race. The small Breslow-Day statistic provides evidence that does not contradict the hypothesis stating that stress due to the hurricane had the same effect on LBW births for either race. Table 23 shows test statistics, individual and global, for the longer-term impact analyses of significance and homogeneous association between hurricane-related stress and LBW births, controlling for race in the area affected by Hurricane Andrew.

Table 23. Test Statistics, Individual and Global, for LBW Births Controlling for Race, Long-term.

Race	Period	LBW	Normal, count	X^2	p-value
White	September 1993-July 1994	192	3075	0.612	0.434
	September 1991-July 1992	228	3374		
Black	September 1993-July 1994	372	2209	0.0218	0.8826
	September 1991-July 1992	371	2229		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
0.135	0.713	0.98	(0.86; 1.1)	0.4993	0.4798
White	September 1994-July 1995	213	3155	0.0001	0.9924
	September 1991-July 1992	228	3374		
Black	September 1994-July 1995	350	2184	0.2221	0.6374
	September 1991-July 1992	371	2229		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
0.1378	0.7105	0.98	(0.86; 1.1)	0.0844	0.7714
White	Sep.94-Jul.95+ Sep.93-Jul.94	405	6230	0.3335	0.564
	Sep.91-Jul.92+Sep.90-Jul.91	452	6675		
Black	Sep.94-Jul.95+ Sep.93-Jul.94	722	4393	0.3447	0.5571
	Sep.91-Jul.92+Sep.90-Jul.91	749	4409		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
0.6709	0.4127	0.97	(0.88; 1.05)	0.0073	0.9319

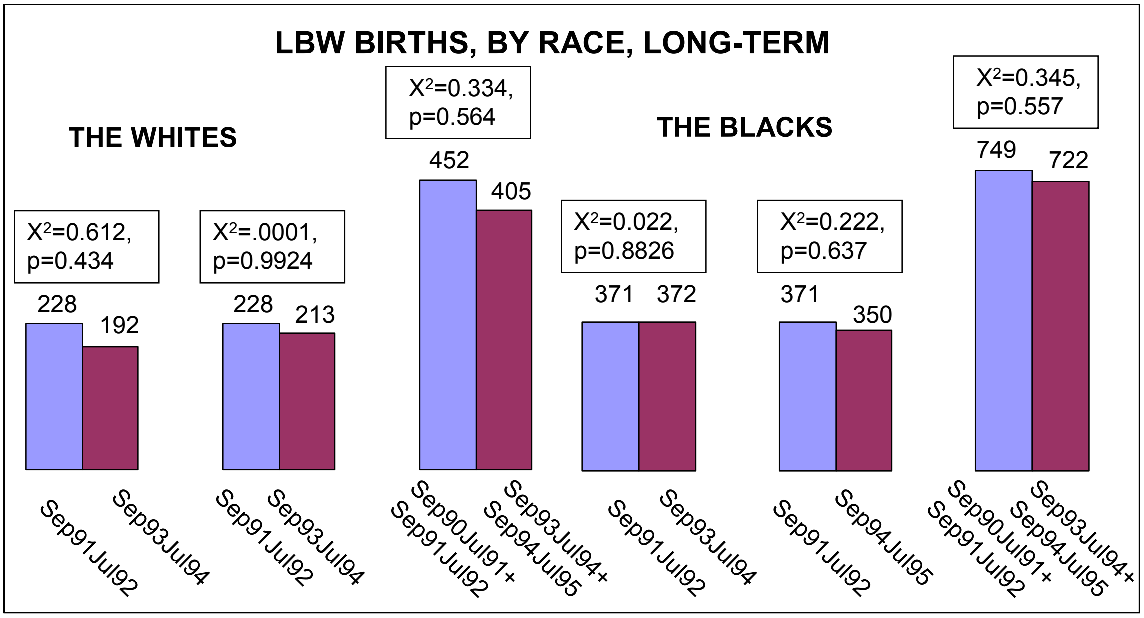

Figure 17. LBW, Long-term, by Race

5.2 Pregnancy Outcomes before and after Hurricane Andrew in Non-affected Areas

5.2.1. Short Impact: Preterm Births, All Races

To recap, the purpose of this analysis was to provide a comparison for a non-hurricane impacted area. This was to determine whether any difference in birth outcomes were hurricane related, or merely reflective of larger systematic changes. From the Table 24, it can be seen that despite the decline in births for all races after the hurricane, cases of preterm births actually increased during September 1992-July 1993 ("After" period) compared to September 1991-July 1992 ("Before" period), a significant increase (p=0.02), not controlling for race effect (Table 25).

Table 24. Summary of Preterm Births, All Races, Short-term, Non-affected Area

Period	Preterm, Count	Normal, Count	Total
After	304	2732	3036
Before	291	3200	3491

Table 25. Test Statistics for Preterm Births, All Races, Short-term, Non-affected Area

Period	Preterm, Count	Normal, Count	X^2	p-value	OR	CI
After	304	2732	5.52	0.02	1.22	(1.03;1.45)
Before	291	3200				

5.2.2 Short Impact: LBW Births, All Races

Descriptive statistics do not suggest a significant variation in LBW babies born during September 1992-July 1993 ("After" period) compared to September 1991-July 1992 ("Before" period) in the area not affected by the hurricane (Table 26).

Table 26. Summary of LBW Births, All Races, Short-term, Non-affected Area

Period	LBW, Count	Normal, Count	Total
"After"	254	2782	3036
"Before"	276	3215	3491

Similarly to the affected area, there was no significant increase in LBW infants in the area not affected by the hurricane (p=0.497) (Table 27 and Figure 18).

Table 27. Test Statistics for LBW Births, All Races, Short-term, Non-affected Area

Period	LBW, Count	Normal, Count	X^2	p-value	OR	CI
"After"	254	2782	0.46	0.497	1.06	(0.89;1.27)
"Before"	276	3215				

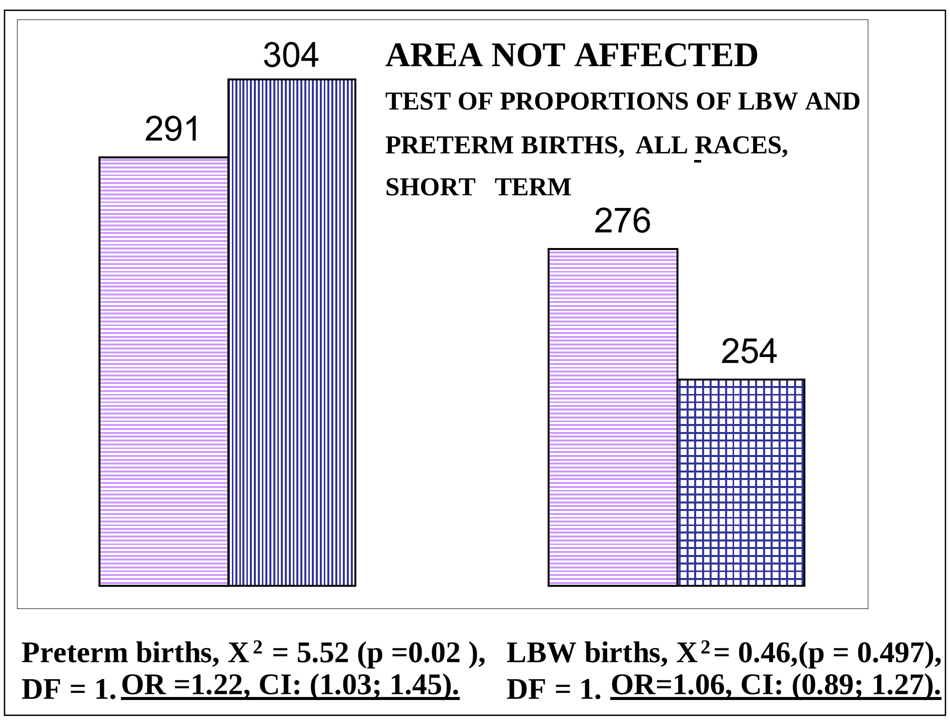

Figure 18. Pregnancy Outcomes for Periods September 1991-July 1992 and September 1992 – July 1993

5.2.3 Short Impact: Preterm Births, by Race

Considering preterm deliveries within each race, descriptive statistics reveal that although whites experienced declines in all births and preterm births, this was not seen for AA, who given a total decline in births, suffered an increase in the number of preterm infants (Table 28).

Table 28. Summary of Preterm Births, by Race, Short-term, Non-affected Area

Race	Period	Preterm, count	Normal, count	Total
White	After	134	1809	1943
	Before	154	2104	2258
Black	After	166	865	1031
	Before	129	1029	1158

Statistical analysis controlling for race gave different results from the earlier statistical analysis that ignored this effect: there is no difference in the number of premature births for whites (p=0.922), but there is a significant difference for AA (p=0.0007), for the period following the hurricane. The Breslow-Day statistic is equal to 5.56 (p = 0.0184), indicating that this evidence contradicts the hypothesis that hurricane-related stress had the same effect on premature births for either race. In fact, the two races experienced a different effect. Table 29 shows test statistics for the analysis of significance and homogeneous association between hurricane-related stress and premature births, controlling for race over a short term.

Table 29. Test Statistics for Preterm Births, by Race, Short-term

Race	Period	Preterm	Normal, count	Total	X^2	p-value
White	After	134	1809	1943	0.0095	0.9222
	Before	154	2104	2258		
Black	After	166	865	1031	11.5119	0.0007
	Before	129	1029	1158		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**	
5.95	**0.0147**	**0.81**	**(0.68;0.96)**	**5.56**	**0.0184**	

5.2.4 Short Impact: LBW, by Race

Descriptive statistics show only a slight variation in LBW for each race in the area not affected by the hurricane over the short term (September 1992-July 1993 versus September 1991-July 1992) (Table 30).

Table 30. Summary of LBW Births, by Race, Short-term

Race	Period	LBW, count	Normal, count	Total
White	After	109	1834	1943
	Before	130	2128	2258
Black	After	140	891	1031
	Before	140	1018	1158

Statistical analysis controlling for race shows that neither Whites nor African-Americans experienced a significant increase in LBW deliveries in the non-affected area (p-values are equal to 0.837 and 0.298, respectively) (Table 31 and Figure 19). The Mantel-Haenszel common odds ratio estimators (θ_{MH}) equal to 0.95 and 95% CI for odds ratio (0.78; 1.13) (Table 31) suggest that there is no change in the odds for Low Birth Weight deliveries for either race during the period immediately following Hurricane Andrew (September 1992 – July 1993). The Small Breslow-Day statistic (0.75) and its p-value (0.385) do not contradict the hypothesis stating that hurricane-related stress had the same effect on LBW births for either race, Whites or African-Americans.

Table 31. Test statistics for LBW Births, by Race, Short-term, Non-affected Area

Race	Period	LBW	Normal, count	Total	X^2	p-value
White	After	109	1834	1943	0.0423	0.837
	Before	130	2128	2258		
Black	After	140	891	1031	1.08	0.298
	Before	140	1018	1158		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**	
0.37	0.54	0.95	(0.78; 1.13)	0.75	0.385	

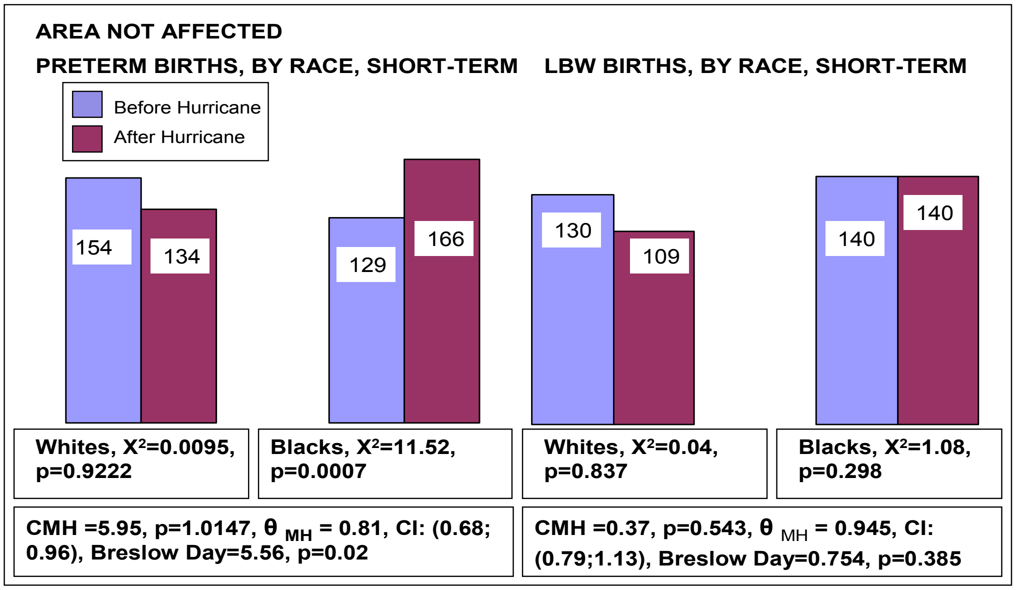

Figure 19. Pregnancy Outcomes, by Type, Short-term, by Race, Non-affected Area.

5.2.5 Long Impact: Preterm Births, All Races

Descriptive statistics show that all races combined, during all periods except for September 1993-July 1994, experienced an increase in premature deliveries in the area not affected by the hurricane (Table 32).

Table 32. Summary of Preterm Births, All Races, Long-term, Non-affected Area

Period	Preterm, count	Normal, count
September 1993-July 1994	278	2724
September 1991-July 1992	291	3200
September 1994-July 1995	319	2519
September 1991-July 1992	291	3200
Sep93Jul94&Sep94Jul95	597	5243
Sep90Jul91&Sep91Jul92	576	6392

Accordingly, statistical analysis without consideration of a race effect shows that in the area not affected by the hurricane, there is no significant difference in preterm births for September 1993-July 1994 relative to September 1991-July 1992 ($p=0.19$). However, there was a significant difference in preterm births for September 1994-July 1995 ($p<0.0001$), and September 1993 – July 1994&September 1994 – July 1995 (p=0.0001), in comparison to baseline periods. Table 33 and Figure 20 show the test statistics for preterm deliveries for all races combined, over a longer-term, in the non-affected area.

Table 33. Test Statistics for Preterm Births, All Races, Long-term, Non-affected Area

Period	Preterm	Normal	RR	95% CI:	X^2	p-value
September 1993-July 1994	278	2724	1.12	(0.95; 1.33)	1.726	0.1889
September 1991-July 1992	291	3200				
September 1994-July 1995	319	2519	1.39	(1.18; 1.65)	15.16	<.0001
September 1991-July 1992	291	3200				
Sep 93Jul94&Sep 94Jul95	597	5243	1.26	(1.12; 1.42)	14.62	.0001
Sep 90Jul91&Sep 91Jul92	576	6392				

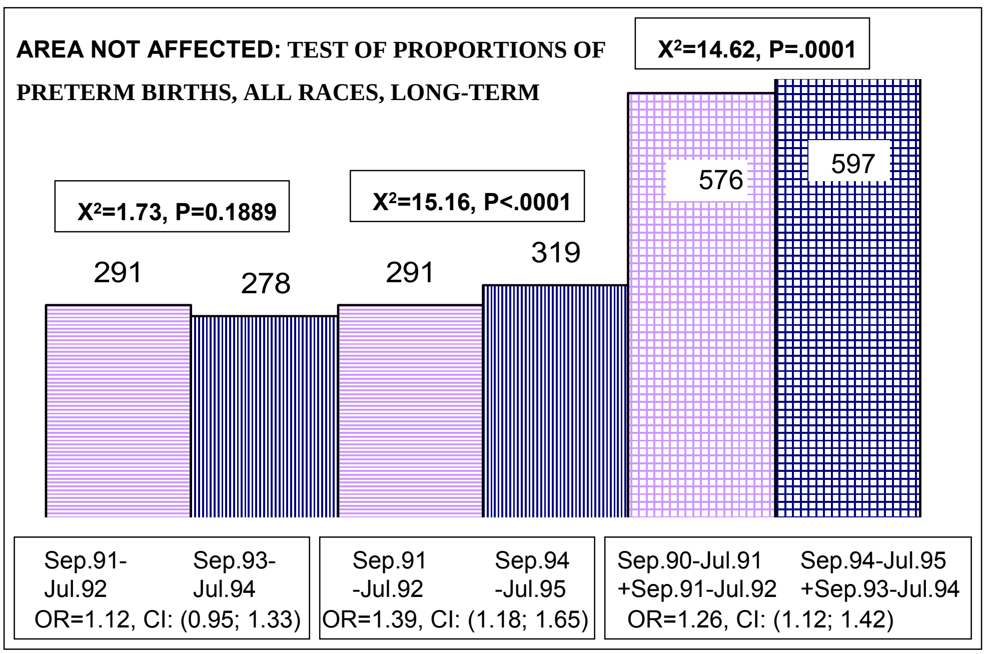

Figure 20. Preterm Births, Long-term, All Races, Non-affected Area

5.2.6 Long Impact: LBW, All Races

Descriptive statistics show that without considering race, during all periods there was actually a slight decline in the number of LBW deliveries in the area not affected by the hurricane (Table 34). Results of the statistical analysis without considering a race effect, for the longer-term were consistent with those for the short term for the non-hurricane impacted area.

Table 34. Summary of LBW Births, All Races, Long-term, Non-affected Area

Period	LBW, count	Normal, count
September 1993-July 1994	245	2757
September 1991-July 1992	276	3215
September 1994-July 1995	267	2571
September 1991-July 1992	276	3215
Sep 93Jul94&Sep 94Jul95	512	5328
Sep 90Jul91&Sep 91Jul92	565	6403

There was no statistically significant increase in the number of LBW infants born after the hurricane, p-values being equal to 0.89, 0.83, and 0.63 for September 1993-July 1994, September 1994-July 1995, and September 1993 – July 1994& September 1994 – July 1995, respectively (Table 35 and Figure 21).

Table 35. Test Statistics for LBW Births for All Races, Long-term, Non-affected Area

Period	LBW	Normal	RR	95% CI:	X^2	p-value
September 1993-July 1994	245	2757	1.03	(0.87; 1.24)	0.02	0.897
September 1991-July 1992	276	3215				
September 1994-July 1995	267	2571	1.21	(1.01; 1.44)	0.04	0.833
September 1991-July 1992	276	3215				
Sep 93Jul94&Sep 94Jul95	512	5328	1.09	(0.96; 1.23)	0.23	0.63
Sep 90Jul91&Sep 91Jul92	565	6403				

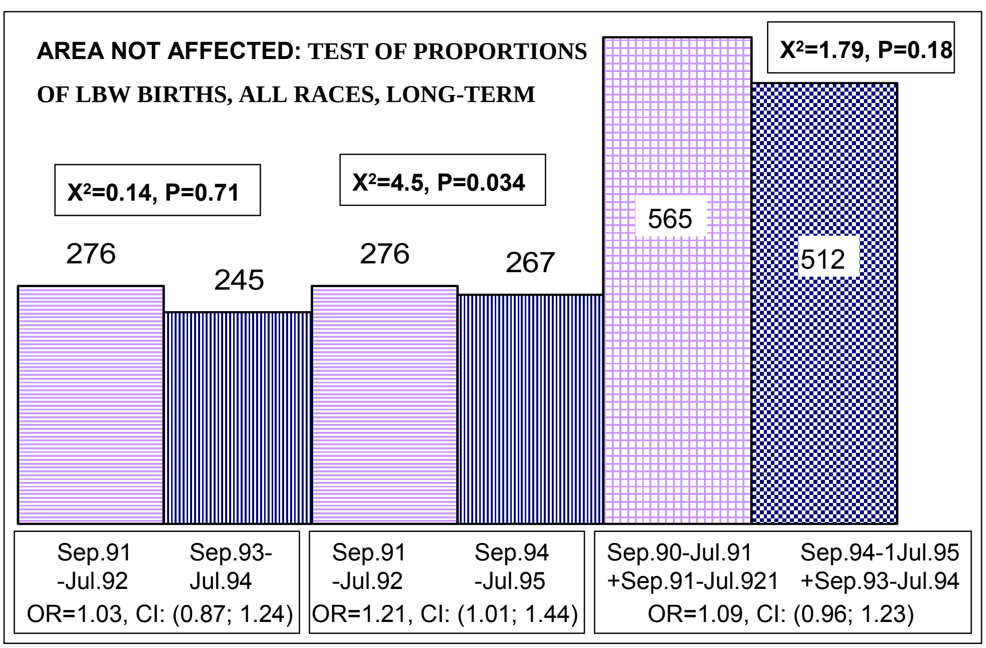

Figure 21. LBW, Long-term, All Races, Non-affected Area.

5.2.7 Long Impact: Preterm Births, by Race

In terms of race, whites experienced a dramatic decline in births for all periods, but particularly for September 1993 – July 1994& September 1994 – July 1995, relative to September1991 – July 1992& September 1990 – July 1991, although the absolute number of preterm births stayed approximately the same (Table 36).

Table 36. Summary of Preterm Births, by Race, Long-term, Non-affected Area

Race	Period	Preterm, count	Normal, count	Total
White	September 1993-July 1994	136	1799	1935
	September 1991-July 1992	154	2104	2258
Black	September 1993-July 1994	140	863	1003
	September 1991-July 1992	129	1029	1158
White	September 1994-July 1995	154	1677	1831
	September 1991-July 1992	154	2104	2258
Black	September 1994-July 1995	165	782	947
	September 1991-July 1992	129	1029	1158
White	Sep.94-Jul.95& Sep.93-Jul.94	290	3476	3766
	Sep.91-Jul.92&Sep.90-Jul.91	294	4215	4509
Black	Sep.94-Jul.95& Sep.93-Jul.94	305	1645	1950
	Sep.91-Jul.92&Sep.90-Jul.91	268	2036	2304

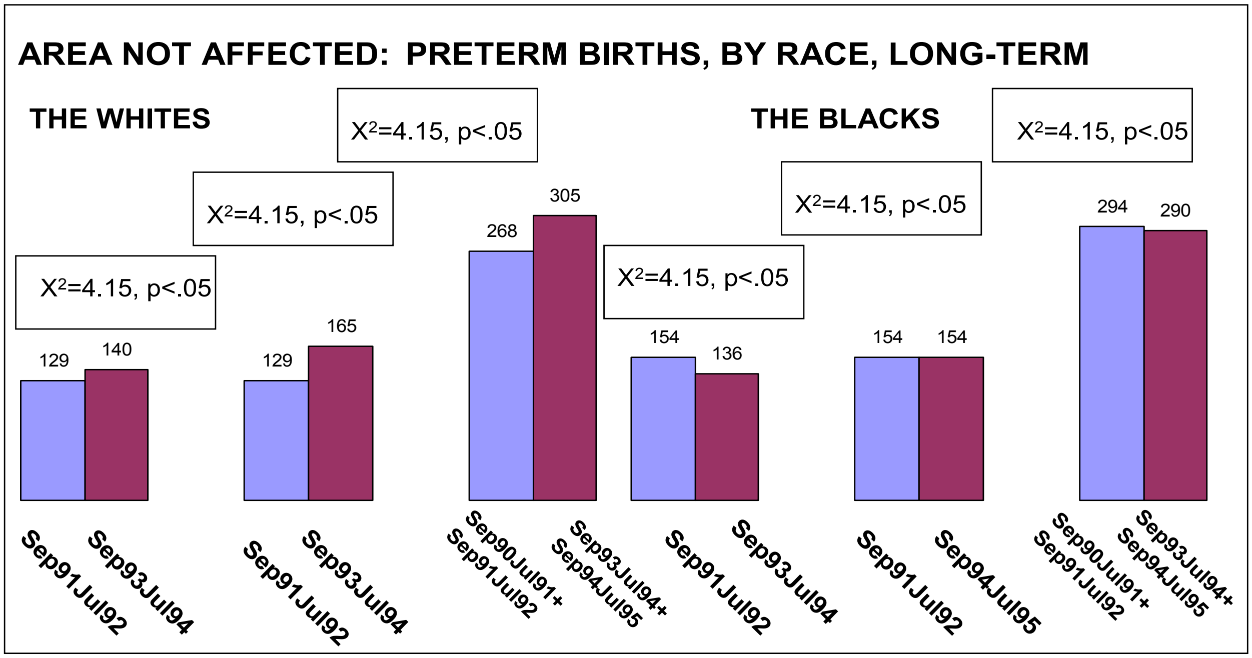

Figure 22. Preterm Births, Long-term, by Race, Non-affected Area.

Statistical analysis indicates that in the area not affected by the hurricane, there was no statistically significant increase in the number of preterm deliveries for Whites during September 1993 – July 1994. However, there was a significant increase in the number of preterm infants during the following year (September 1993 – July 1994) and September 1993 – July 1994& September 1994 – July 1995, when compared to baseline periods (p=0.04) (Table 36 and Figure 22). For African-Americans living in the non-affected area, there was a statistically significant increase in the number of preterm babies for all periods following Hurricane Andrew (Table 37).

Table 37. Test Statistics, Individual and Global, for Preterm Births Controlling for Race, Long-term, Non-affected Area.

Race	**Period**	**Preterm, count**	**Normal, count**	**X^2**	**p-value**
White	Sep. 1993-July 1994	136	1799	0.07	0.7911
	Sep. 1991-July 1992	154	2104		
Black	Sep. 1993-July 1994	140	863	3.92	0.05
	Sep. 1991-July 1992	129	1029		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
2.39	0.12	1.15	(0.96; 1.37)	1.59	0.21
White	Sep. 1994-July 1995	154	1677	3.67	0.06
	Sep. 1991-July 1992	154	2104		
Black	Sep.1994-July 1995	165	782	17.12	<0.0001
	Sep. 1991-July 1992	129	1029		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
17.91	<0.0001	1.44	(1.21; 1.31)	2.87	0.09
White	Sep.94-Jul.95& Sep.93-Jul.94	290	3476	4.36	0.04
	Sep.91-Jul.92&Sep.90-Jul.91	294	4215		
Black	Sep.94-Jul.95&Sep.93-Jul.94	305	1645	14.56	<0.0001
	Sep.91-Jul.92&Sep.90-Jul.91	268	2036		
CMH	**p-value**	**θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
17.19	<0.0001	1.29	(1.14; 1.46)	1.72	0.18

5.2.8 Long Impact: LBW, by Race

Similar to preterm births, the absolute number of LBW births stayed approximately the same for whites despite the decline in births for all periods, while African-Americans do not appear to have a dramatic change in LBW for either period (Table 38).

Table 38. Summary of LBW Births, by Race, Long-term, Non-affected Area

Race	Period	LBW, count	Normal, count	Total
White	September 1993-July 1994	122	1813	1935
	September 1991-July 1992	130	2128	2258
Black	September 1993-July 1994	121	882	1003
	September 1991-July 1992	140	1018	1158
White	September 1994-July 1995	129	1702	1831
	September 1991-July 1992	130	2128	2258
Black	September 1994-July 1995	136	811	947
	September 1991-July 1992	140	1018	1158
White	Sep.94-Jul.95& Sep.93-Jul.94	251	3515	3766
	Sep.91-Jul.92&Sep.90-Jul.91	258	4251	4509
Black	Sep.94-Jul.95&Sep.93-Jul.94	257	1693	1950
	Sep.91-Jul.92&Sep.90-Jul.91	296	2008	2304

Statistical analysis showed that neither Whites nor African-Americans have a statistically significant increase in the number of LBW births for either period over a longer-term in the area not affected by Hurricane Andrew (Table 39). Therefore, one fails to reject the null hypothesis stating that there was no difference in the number of LBW deliveries for a longer term (that is, during September 1993 – July 1994 versus September 1991 – July 1992 and September 1994 – July 1995 versus September 1991 – July 1992), for either race.

The small Breslow-Day statistics and its corresponding p-values do not contradict the hypothesis stating that hurricane-related stress had the same effect on Low Birth Weight deliveries for either race, Whites or African-Americans (Table 39).

Table 39. Test Statistics, Individual and Global, for LBW Births Controlling for Race, Long-term, Non-affected Area.

Race	Period	LBW	Normal	X^2	p-value
White	September 1993-July 1994	122	1813	0.5532	0.46
	September 1991-July 1992	130	2128		
Black	September 1993-July 1994	121	882	0.0003	0.985
	September 1991-July 1992	140	1018		
CMH	**p-value**	**Θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
0.267	0.61	1.05	(0.87; 1.26)	0.29	0.593
White	September 1994-July 1995	129	1702	2.83	0.093
	September 1991-July 1992	130	2128		
Black	September 1994-July 1995	80	521	2.36	0.125
	September 1991-July 1992	140	1018		
CMH	**p-value**	**Θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
5.18	0.023	1.23	(1.03; 1.47)	0.009	0.9243
White	Sep.94-Jul.95& Sep.93-Jul.94	251	3515	3.16	0.08
	Sep.91-Jul.92&Sep.90-Jul.91	258	4251		
Black	Sep.94-Jul.95&Sep.93-Jul.94	257	1693	0.1	0.748
	Sep.91-Jul.92&Sep.90-Jul.91	296	2008		
CMH	**p-value**	**Θ_{MH}**	**CI**	**Breslow-Day**	**p-value**
2.2	0.14	1.1	(0.97; 1.25)	1.06	0.3

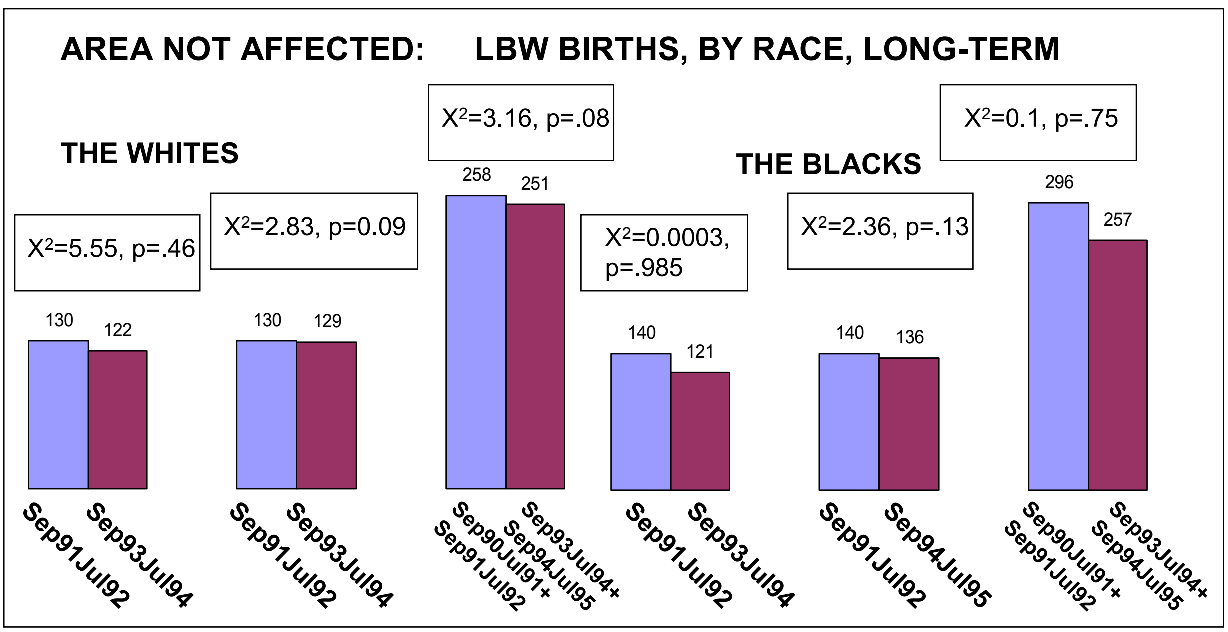

Figure 23. LBW, Long-term, by Race, Non-affected Area.

To summarize all results, it may be said that there was consistently a significant difference in the number of the preterm deliveries for women who lived in the hurricane-affected area. Both analyzed groups, all races combined, and when stratified for race effect, showed a significant increase in the number of premature births for the periods following Hurricane Andrew.

However, no such difference was found for LBW deliveries. Neither all races combined, nor Whites and AA considered separately, experienced a significant difference in LBW births for any period that was investigated in comparison with the baseline.

Only AA women were found to have a significant difference in the number of the preterm deliveries in the area not affected by the hurricane. The White women living in the area not impacted by the hurricane, did not have a significant increase in the number of premature births for the periods following Hurricane Andrew.

No significant difference was found for LBW deliveries for all races combined, nor taking into account race effect in the non-affected area.

CHAPTER 6. DISCUSSION AND CONCLUSION

The field of public health continues to contribute to the understanding of causes and consequences of illness in society (McKinlay and Marceau, 2000). The field addresses a range of problems, for example the spread of infectious disease, increases in infant mortality, and decreases in life expectancy. Within the United States, public health objectives can include the prevention of diseases and injuries, protection against environmental hazards, promotion of healthy behaviors, response to an increase in social inequalities in health and more recently, preparation for health effects associated with a terrorist strike or a natural disaster (Lederberg, 1996; Lee and Paxman, 1997; Noji, 1997).

Previous studies have found that disaster-related short- and long-term health outcomes are either exposure-related or stress-related (mental and physical) (Bertazzi, 1989). The research of this thesis was based on the general premise that stresses related to Hurricane Andrew adversely influenced pregnancy outcomes.

On August 26, 1992, Hurricane Andrew made landfall as a category 3 storm on Louisiana's coast. Research suggests that the stress caused by the storm negatively impacted pregnant women who resided in the afflicted area. In particular, this study focuses on whether the storm resulted in pregnancy complications, such as LBW and preterm births, among women who were pregnant before or after the storm, and who were residents in the hurricane-affected area. Samples of birth data taken in Louisiana from before and after Hurricane Andrew were analyzed with and without taking the effect of race into account. A categorical data analysis difference in proportions test was applied to birth data to find the impact of hurricane-related stress on poor birth outcomes, i.e., LBW and preterm deliveries over short and long terms.

Previous studies found that the timing of the stress is important, because women who are in their early pregnancy seem to be more vulnerable to the effect of stress; yet women tend to become increasingly more resilient as the pregnancy advances (Gorsuch and Key, 1974; Glynn et al., 2001). For example, pregnant women who experienced earthquake-related stress while being in the first trimester had significantly shorter gestations than women in advanced stages of pregnancy (Glynn et al., 2001). However, in this study not only women who were in their early pregnancy, but also those who were in the last trimester seemed to deliver their babies earlier as there was a dramatic increase in the number of preterm babies born during September and October in 1992 and in April 1993 compared to September, October, and April of the preceding year.

Generally, results of the analysis appear to be consistent with findings by Rini et al., (1999) and Mutale et al., (1991) who found that pregnant women exposed to stress experienced shorter gestations. Within births of all races, preterm births were found to be significantly higher during periods following the disaster over both a short (September 1992-July 1993 versus September 1991-July 1992) and longer terms (September 1993-July 1994 & September 1994-July 1995 versus September 1991-July 1992). Controlling for race, this still holds true over both short and longer terms, separately for Whites and African Americans.

Previous studies also found an association between stressful life events and a baby's birth weight (Reeb et al., 1987; Wadwha et al., 1993). However, no such difference was found for LBW infants whose mothers were impacted by Hurricane Andrew, not only for all races combined, but also when considered separately for each race. A conclusion may be made that Hurricane Andrew had different impacts on different negative pregnancy outcomes. The traumatic event did not seem to impact LBW deliveries. On the other hand, the opposite effect was observed for premature births.

With regard to the control area not affected by the hurricane, results tended to be somewhat inconsistent. All races combined, for example, experienced a significant increase in the number of prematurely born babies during the period following the hurricane. However, after the birth data were considered separately for each race –- interesting trends became apparent. For example, Whites did not experience a change in proportion of preterm deliveries either during the period immediately following the hurricane (September 1992-July 1993), or during the following year (September 1993-July 1994). However, there was a significant increase in the number of preterm deliveries during September 1994-July 1995 versus the baseline (September 1991-July 1992), which may be indicative of some other process.

African Americans conversely suffered a significant increase in the number of preterm babies born during all analyzed time intervals, relative to a baseline period. However, African-Americans do not seem to have a linear trend between life-event stress and preterm deliveries (Berkowitz and Kasl, 1983*)*. Because of the inconsistent results, that is, due to the absence of association between life events and the risk of a preterm delivery for the African-American populations, the African-Americans should not be used as a reference for association between stressful events and premature births (Berkowitz and Kasl, 1983). Therefore, considering Whites only, it can be said that white pregnant women living in the area affected by the hurricane, experienced a consistent significant increase in the number of preterm babies during all three periods following the hurricane (September 1992-July 1993, September 1993-July 1994, and September 1994-July 1995) compared to a baseline period (September 1991-July 1992), while Whites living in the area not affected by the hurricane did not suffer such consequences, at least not during the period immediately following the hurricane (September 1992-July 1993) nor during September 1993-July 1994. This finding is in agreement with that of Berkowitz and Kasl (1983), who found a significant linear association between life-event stress and preterm delivery for white women.

Certainly, more research is needed. According to Hobel and Culhane (2003, p. 1714S), “The risk of preterm birth and poor fetal growth is multifactorial and the maternal stress response appears to be influenced by other conditions such as work strain and poor nutrition”. Similarly, because of a bad diet caused by Hurricane Gilbert women delivered significantly more babies with neural tube defects (Duff et al., 1994). This important issue also must be addressed, because previous studies indicate that disasters may cause similar nutrition deficiencies (Noji, 1997, p.15).

A common belief is that the Gulf Coast may be entering a period of increasing frequency and severity of extreme weather events such as hurricanes (e.g., Hurricanes Katrina and Rita), -- while the United States as whole is now, arguably, more likely to experience other human-induced disasters (for example, because of terrorism). These events, in turn, may lead to “greater numbers of pregnant women facing stressful events that are outside of their control and that will result in foetuses experiencing increasing levels of prenatal maternal stress” (King and Laplante, 2005, p.43). Previous studies have found a clear association between stressful life events and the onset of numerous diseases (Kune, 1993). However, the effect of these disasters on pregnancy outcomes is still poorly understood (Buekens, 2000; Curtis and Leitner, 2006; Curtis et al., 2007). Natural disasters such as hurricanes are not preventable, but their negative health impact on the lives of people can and should be lessened (Silverman, 1995). It is therefore vitally important that high quality standardized data are collected after any such event allowing for the analysis and understanding of the resulting complex health legacy.

In conclusion, it may be said that disaster stressors are “visibly distressing and unambiguous” in comparison with other stressors (Haines et al., 1996). Disaster stressors often involve “certain or already present loss or harm” to the whole communities (Dunkel-Schetter and Skokan, 1990, p.440). Old wives’ tales about the possible impact of a pregnant woman’s mental health on her unborn fetus may be found true after all. Previous epidemiological studies showed a clear relationship between maternal stress and preterm births (Hobel and Culhane, 2003, p. 1711S). However, exposure to stress was assessed only at the individual level (Hobel and Culhane, 2003, p. 1711S). The post-hurricane landscapes of Andrew, and more recently Katrina and Rita, now require us to consider mass associations between neighborhood level stress and poor birth outcomes.

The limitation of this study is that it had a retrospective design. There is an obvious need for studies to prospectively assess the effects of stressful events such as a hurricane upon pregnant women. A holistic approach, including a social context (neighborhood characteristics, family structure, economic levels, pre-disaster health outcomes and post-disaster service provision to name just a few important variables), should also be included in the analysis.

Future research can be based on a smaller community, for example Morgan City, which was badly damaged by the hurricane and residents of which were given a mandatory order to evacuate. The finer scale will allow for a better analysis and understanding of how the impact of a hurricane can affect pregnancy outcomes.

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