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Cardiovascular Disease and Post Traumatic Stress Disorder in Adults Exposed to the Terrorist Attacks on the World Trade Center

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Running Header: CVD AND PTSD IN ADULTS EXPOSED TO TERRORIST ATTACKS

Cardiovascular Disease and Post Traumatic Stress Disorder in
adults exposed to the terrorist attacks on the World Trade Center

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May 20, 2011

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Abstract

Following events of terrorism communities and individuals are subject to the cumbersome responsibilities associated with rescue and recovery efforts. In addition to the loss of life and direct injuries sustained during the incident, long term health outcomes among the exposed population are often seen. Both physical and mental health can be affected as a result of the exposure, and some outcomes do not immediately present themselves. The population exposed to the September 11, 2001 terrorist attacks on the World Trade Center in New York City is no different, and the World Trade Center Health Registries database has been established by the New York Department of Health in order to more effectively monitor the population for long term adverse outcomes. This analysis uses the de-identified data within the World Trade Center Health Registry to examine the relationship between Post Traumatic Stress Disorder (PTSD) and cardiovascular disease as well as to identify risk factors that placed an individual at increased risk of developing PTSD. It was found that female sex, age within the range of 25-44 years, African American persons, Hispanic/Latino persons, those with lower levels of education completed, and those who are widowed, divorced or separated were at increased risk of developing PTSD. Among the exposed population those who were identified as having probable PTSD there was an increased risk of myocardial infarction, cerebrovascular accident, hypertension, heart disease and diabetes mellitus type II developing or occurring after September 11th when compared to the exposed population that did not develop probable PTSD. Mental illness, especially PTSD, is debilitating in its own right and the increased impact of the morbidity and mortality of cardiovascular disease can only act to increase the barrier to the recovery of a population following disaster. By identifying those at increased risk of developing PTSD and creating interventional programs that prevent PTSD, the adverse outcomes associated with cardiovascular disease can be avoided.

Cardiovascular Disease and Post Traumatic Stress Disorder in adults exposed to the terrorist attacks on the World Trade Center

On September 11, 2001 the United States, and more specifically New York City, was dealt a devastating blow to our national security when two hijacked airliners crashed into and destroyed the World Trade Centers. In total, almost 3,000 people perished in the terrorist events of that day with approximately 2,600 from the World Trade Centers in New York City including 343 New York Firefighters, 23 police officers, 3 EMS workers and 37 security guards and Port Authority personnel. Citizens from 115 countries lost their lives on American soil that day (Levy & Sidel, 2003). Hundreds of thousands more were directly exposed to the events that day and the mental trauma inflicted with the loss of a loved one, being in close proximity to the location of the terrorist attack or serving in the rescue and recovery efforts of the event.

“Mental health of the population is a prime target of terrorists” (Levy & Sidel, 2003, p. 66). Long term consequences and the impact on society of mental health disorders following terrorist attacks are consequently great and should continue to be the focus of public health in both research and interventions. With a terrorist attack, or any disastrous event where hundreds of thousands of people are exposed, public and private mental health resources must be targeted towards those who are most at risk for developing mental illness.

In addition, high levels of stress along with mental illness can have adverse effects on the rest of the body including the cardiovascular system. “The development of traumatic memories at the time of stress exposure represents a major vulnerability through repeated environmental triggering of the increasing dysregulation of an individual’s neurobiology. An increasing body of evidence demonstrates how the increased allostatic load associated with Post Traumatic Stress Disorder (PTSD) is associated with a significant body of physical morbidity in the form of

chronic musculoskeletal pain, hypertension, hyperlipidaemia, obesity and cardiovascular disease” (McFarlane, 2010, p. 3). Identification of those most at risk for PTSD development and therefore cardiovascular disease becomes very important and will go a long way toward the recovery of a community and potentially an entire population following disastrous events.

The long lasting health effects, psychological as well as physiologic, of those exposed to the September 11, 2001 terrorist attacks have been documented by the World Trade Center Health Registry (WTCHR) by the New York City Department of Health. The WTCHR enrolled and collected data on over 50,000 people initially in 2003 and 2004 and then again in 2006 and 2007. Demographic factors such as race, education, income, gender and marital status were collected as well as the location or role each individual played in Manhattan on September 11, 2001. In addition the data contains specific information on each person’s health at the time of the survey including mental health, respiratory diseases and cardiac conditions. Within cardiac conditions recorded, data on newly diagnosed cardiovascular disease (CVD), including myocardial infarction (MI), cerebrovascular accident (CVA), hypertension (HTN), hyperlipidemia (HLP) and diabetes as a cardiovascular risk equivalent were obtained.

Statement of Purpose

The purpose of this research is to conduct a descriptive analysis of the survey data using prevalence and incidence to provide insight into exposed persons' risks for future CV disease. Comparing these rates to those for the general population will draw attention to the unique health characteristics that this population exhibits along with potentially identifying groups in need of targeted intervention. Through specifically addressing cardiovascular disease, this study will target the diseases with the highest morbidity and mortality in the US population. By examining CVD along with PTSD in those exposed to a terrorist event and suggesting further research for

evidence based interventions, it is possible to improve the recovery and resiliency of this specific population as well as to contribute toward that of future traumatized communities.

Literature Review

“A recent meta-analysis of psychopathology in the aftermath of terrorism found that the prevalence of PTSD in directly-affected populations in the year following a terrorist incident ranges from 12-16%” (DiMaggio, Galea, & Madrid, 2007, p. 479). The attacks on the World Trade Center on September 11, 2001 are no exception to this side effect of exposure to a man made mega disaster. Nearly eight percent of Manhattan residents reported symptoms consistent with PTSD in the first month following September 11th. Much research has been done on different aspects of the aftermath of September 11th, however little conclusive evidence on the utilization of different health services has been proposed. One study done at the Veterans Hospitals in New York and New Jersey showed greater than expected mental health care service utilization. Another study looking at rates of mental health prescription drugs among a private insurance company members reported small, non-statistically significant increases.

In an effort to find more evidence of mental health services utilization within the Manhattan and surrounding New York areas, DiMaggio, Galea, and Madrid (2007) designed a study that looked specifically at the rate of selective serotonin re-uptake inhibitors (SSRI's), a common medication used in treatment of depression and anxiety disorders in Medicaid enrollees before and after September 11th. They also set out to assess the association between geographic proximity to the attacks and SSRI utilization. Results of this data analysis showed that “individuals residing within three miles of the World Trade Center site had an 18.2% increase in SSRI prescriptions compared to the previous eight month period” (DiMaggio et al., 2007, p. 479). A 9.3% increase in utilization was found for non-New York City residents, however was

statistically insignificant. A dose-response gradient was also identified, with higher rates of SSRI dispensing taking place closer to the attacks. As this analysis was conducted on the Medicaid population, the results may not be consistent across the entire population. Low socioeconomic status and unemployment are risk factors for mental health pathology and may therefore explain the SSRI utilization increase. On the other hand, the authors suggest that in the immediate aftermath of September 11th, psychiatric conditions may have been overshadowed by physical complaints. While these authors were able to identify a definitive change in one aspect of health care utilization, they do note that future research needs to look at the long term outcomes and follow up on whether this trend was sustained for longer than the initial study period (DiMaggio et al., 2007, p. 483).

Post Traumatic Stress Disorder

Post traumatic stress disorder (PTSD) is the most common mental health illness associated with exposure to mass violence and trauma (Levitt, Malta, Martin, Davis, & Cloitre, 2007, p. 1420). It is characterized by “repetitive re-experiencing of the traumatic event in the form of intrusive and unwanted memories of the trauma, nightmares and flashbacks of the trauma, difficulty modulating arousal as evidenced by insomnia, irritability, angry outbursts, hyper vigilance, difficulty concentrating and exaggerated startle response, avoidance of stimuli associated with the trauma and a general numbing of emotions with a feeling of detachment from others” (Stellman et al., 2008, p. 1248). With PTSD there are many areas of personal functioning that become impaired including interpersonal relationships, social and occupational disability, impulsive or violent behavior, family discord, sexual dysfunction, and social anxiety (Evans, Patt, Giosan, Spielman, & Difede, 2009, p. 1-2).

Some risk factors for PTSD, previously identified in the research fields of psychology and psychiatry, seem to apply to the disease resulting from any traumatic event. Other risk factors, including basic demographic characteristics, have been found to be unique to the type of trauma experienced such as those exposed to an event of terrorism or large scale disaster. For example, it was found that survivors of terrorist attacks had higher rates of PTSD than those individuals who developed the condition following survival of a Multiple Vehicle Accident (MVA). In addition, survivors of terrorism had higher levels of dissociation, PTSD, and anxiety symptoms one week following the event (Shalev & Freedman, 2005).

In identifying what makes an individual at risk for developing PTSD, it is also important to consider what makes someone resistant to mental illness, characterized as resiliency. Resilience is defined as “the ability of adults in otherwise normal circumstances who are exposed to an isolated and potentially highly disruptive event such as the death of a close relative or a violent or life threatening situation to maintain relatively stable, healthy levels of psychological and physical functioning as well as the capacity for generative experiences and positive emotions” (Bonanno, Galea, Bucciarelli, & Vlahov, 2007, p. 671). It should be noted that resilience is not simply the lack of PTSD and even resilient persons may experience some short term disturbance in their emotional and physical wellbeing following a traumatic event although it does not usually impair their ability to function.

One of the most interesting locations for examining resilience in the face of terrorism occurs in Israel, a small country the size of New Jersey that is made up of two diverse ethnic and religious populations: Israeli Jews and Israeli Arabs. They have long dealt with conflict in their region and terrorism has been a widely used method of inflicting damage to the Israeli people. Since 2000, terrorism has increased greatly with the Al Aqsa Intifada, the second uprising of the

Palestinian-Israeli conflict, and has subjected Israel's citizens—Arab and Jews alike—to extreme acts of violence and devastation. In examining this population, much has been learned about what makes a person have qualities of resilience. The Conservation of Resource theory was adopted by Hobfoll et al. (2008) in their analysis of the Israeli population. This theory states that psychological stress is the consequence of the threat of loss or actual loss of resources, where 'resources' denotes both material and psychosocial entities. Those who maintain supportive social relationships were found to be more resilient than those who abandoned them in the face of events of terrorism. On the other hand, those who were at risk for psychological distress within the Israeli population were those with low education levels, ethnic minority status, female gender and low income. Specifically, the Arab population experienced much higher rates of probable PTSD even though they had lower direct exposure to terrorism. As an ethnic minority, it was postulated that they had fewer resources available to them to help with recovery and also suffered from an identity issue as most consider themselves both Israeli and Palestinian (Hobfoll et al., 2008).

In a study conducted by Bonanno, Galea, Bucciarelli, and Vlahov (2007) that looked at those exposed to September 11, 2001 six months following the attacks, demographic variables that served as significant risk factors for PTSD were identified as female sex, lower socioeconomic status, ethnic minorities, higher levels of education, younger age, loss of income and the presence of chronic disease (Bonanno et al., 2007). In regards to education, it was found that people with a college degree were less likely to be resilient compared to those who had not completed high school. Females were identified as less than half as likely as men to be resilient and income and age showed only varied predictive value as to development of PTSD (Bonanno et al., 2007). Strong social support was also found to be a predictor of resilience as well as

increased age. In general, perceived social support is associated with health and wellbeing.

Although marital status wasn't specifically studied in this research, the identification of social support, something logically found within a marriage, was found to be strongly associated with resilience (Bonanno et al., 2007).

Many rescue and recovery workers were in lower Manhattan in the hours, days and months following September 11, 2001. Research has been specifically conducted on this population to help to identify workers who are at increased risk for development of PTSD and other mental illness. Among the different types of personnel at Ground Zero construction workers, engineering workers, sanitation and unaffiliated workers were at the greatest risk of mental illness (Perrin et al., 2007). In a study directly looking at utility workers, prior trauma exposure and psychiatric illness history were the most significant predictors of PTSD development, a finding that is consistent with PTSD development following any type of trauma. Close proximity to "the pile" and the feeling that workers lives were in danger also contributed to mental illness development (Evans et al., 2009). In a separate study looking at rescue and recovery workers it was found that PTSD was "significantly associated with loss of family members and friends, disruption of family, work and social life and higher rates of behavioral symptoms in the children of workers" (Stellman et al., 2008, p. 1248). Also identified as risk factors among rescue and recovery workers was long hours worked on recovery, treacherous and chaotic working conditions, fear for personal safety and handling of body parts and personal effects of victims.

Alexander and Klein (2009) in their article entitled "First Responders after Disasters: A review of Stress Reactions, At-Risk, Vulnerability and Resilience Factors" also focused on the specialized population of first responders by conducting a systematic review of the published

literature. The term ‘first responder’ encompasses many different professions and many different levels of training related to disasters. In resource-poor countries, persons who respond to and assist in disasters often have no training and get involved in the event secondary to their proximity. Regardless of their training levels, disasters subject individuals to many potentially traumatizing experiences from viewing and handling bodies and mutilated remains to coping with dying victims, interaction to those with grotesque and serious injuries and even having to deal with the distressed families of victims and communities as a whole. In addition, many will face threats to their own safety including exposure to toxic material and disease. As many of the first responders are usually found within close proximity to the disaster, they may also be victims themselves with potential loss of loved ones, friends and personal property (Alexander & Klein, 2009).

The differences in preparedness and training for first responders have been found to have varying relationships to the risk of developing adverse psychological reactions. Some reactions have been more consistent. Among the trauma related diagnoses in the psychiatric diagnostic manual, a continuum exists rather than black and white categorical definitions with “blurred lines between normal responses and pathological ones” (Alexander & Klein, 2009, p. 87). Anxiety, hyperarousal, hypervigilance, painful recollections and grief were widely noted. Some studies have found an increase in alcohol intake among trained and volunteer personnel in the immediate aftermath of disaster response, although Alexander and Klein (2009) question the association stating more evidence needs to be presented in order to make the association. Varying rates of PTSD diagnoses have been found among different groups of first responders. Following the September 11, 2001 terrorist attacks, 12% of 28,000 police officers involved reported symptoms of an anxiety disorder. After the tsunami in Southeast Asia, PTSD was identified in

approximately one quarter of Turkish Red Cross volunteers who responded (Alexander & Klein, 2009). Military personnel also commonly serve in the role of first responder, however these authors note that comparing military and civilian personnel is difficult to do as such factors as selection, training and experience widely vary between the two populations (Alexander & Klein, 2009).

The physical effects victims of disasters and first responders have been found to suffer can also greatly affect their psychological recovery. “It has been reported widely that headaches, fatigue, abdominal and skin complaints, muscular pains and cardiovascular symptoms trouble survivors after major incidents” (Alexander & Klein, 2009, p. 89). It is unclear whether any differences between the various types of first responders exist among those who respond to the same incident. Volunteer first responders were suggested to be more likely to develop post-traumatic changes in health and welfare when compared to trained responders. Conversely, some subscribe to volunteers having greater psychological protection as their work in the disaster may be more personally meaningful when it’s not seen as just another day on the job (Alexander & Klein, 2009).

It was previously noted that conducting certain tasks in the course of disaster response and recovery were more detrimental to one’s psyche than others. The handling of human remains, especially of children, has found to be one of the most traumatizing aspects of a first responder’s job and is often associated with traumatic psychological reactions. It was noted that when handling the remains of children, many first responders identify more with their parents than with the victims themselves. However, in certain groups, this job was not found to have adverse reactions. In a group of Navy divers deployed to retrieve bodies after a plane crash no signs of PTSD symptoms were identified. Canine handlers tasked with finding human remains

were also found to have high levels of resiliency in a study conducted in the months following September 11th. The question then becomes what factors—demographically speaking, training related, or individual traits—allow individuals or groups of first responders to partake in disaster recovery work and be at either increased or decreased risk of adverse psychological outcome (Alexander & Klein, 2009).

Alexander and Klein (2009) highlight factors that may exacerbate or mitigate adverse health effects and break them down into pre-disaster, peri-disaster, post-disaster and post-incident provisions. Within demographic variables prior to any disaster occurring, evidence suggested that those who are single, older, female, and have lower education levels are at higher risk for adverse outcomes. Protective mechanisms were identified as specific training in disaster work, and selection (both by self and at an organizational level) which may ensure recruitment of “hardy” personnel. During the disaster and immediate aftermath, factors related specifically to the disaster itself could prove useful in targeting those at risk. A disaster purposefully caused by man was found to have much more devastating consequences than a natural disaster. In addition, feeling unsafe in the disaster zone, an empathetic attitude toward survivors, development of an acute stress reaction, development of a dissociation reaction, feelings of helplessness in the disaster zone and intensity of exposure to traumatic stress was found to have adverse health outcomes. Protective factors peri-disaster were found to be good organization of response effort, clear definition of each individual’s duties, attention to personal physical needs, teamwork and a sense of being appreciated. It was also found that the use of black humor served in a protective role among first responders, although never when related to children (Alexander & Klein, 2009).

While there is no evidence that any single factor or coping mechanism can guarantee immunity against the adverse effects of working within a disaster zone, taking certain actions

after a disaster can help protect responders against ongoing psychological trauma. Different debriefing programs have found to decrease trauma and increase resiliency. First responders also need to take an active role in ensuring their own recovery. This task is incredibly difficult for some, as many first responders refute the need for help secondary to feeling as if they are unworthy of the status of victim following the event. Following any disaster in today's atmosphere of instant information and the media's constant coverage of the event, first responders can be placed at an increased risk of psychological sequelae secondary to its constant reiteration. Legal consequences often arise months and years later, often subjecting those involved to another re-hashing of the event. Compounding these factors, first responders are also subject to the same personal stressors, as are the rest of us, which are completely unrelated to the disaster (Alexander & Klein, 2009).

In conclusion, the given research has found that the resilience of first responders can be augmented by "selection, training, preparedness, personality factors, and good organizational and managerial practices" (Alexander & Klein, 2009, p. 92). However, long term follow up studies are still needed both to ensure that aftercare provisions for first responders meet their needs and to further identify any ill effects that these valuable personnel are faced with in the years following disaster response.

In a catastrophic event that is not associated with terrorism, valuable descriptive information can also be found within the population. Ranasinghe and Levy (2007) studied risk factors for PTSD and depression in displaced persons following the Sri Lankan tsunami and identified several unique variables among the population. Lower education was found to be marginally predictive for PTSD and female sex again showed higher risk of developing the disease. Those with depression were more than 7 times more likely to develop PTSD as

compared to those who were not depressed. Marital status was not found to have any significant predictive value on development of PTSD (Ranasinghe & Levy, 2007).

Cardiovascular Disease

When it comes to an evidence based approach, there still exists much controversy in the causal relationship between PTSD and cardiovascular disease. Kubzansky and Koenen (2009), in their research titled '*Is PTSD related to the development of heart disease?*' found that individuals with higher PTSD symptomology had significantly higher risk for developing coronary heart disease (CHD) after controlling for known cardiac risk factors including obesity and smoking. This group conducted their research on men who served in the military and did not have any cardiovascular disease at the beginning of the study. All cardiovascular diagnoses were confirmed by a board-certified cardiologist over the 10 year follow up period. It was found that within their given study population, for each standard deviation (SD) increase in PTSD symptom level individuals had an age adjusted relative risk of 1.26 (95% CI 1.05-1.51) for non-fatal myocardial infarctions and fatal CVD. It was also recognized that within the population diagnosed with PTSD risk factors for cardiovascular disease are particularly high, including tobacco use, alcohol use, and obesity. They were able to replicate these results by both controlling for all known coronary risk factors and when using an alternative scale for measuring PTSD (Kubzansky & Koenen, 2009).

Kubzansky and Koenen (2009) also suggested a biological pathway for the causal relationship between PTSD and CVD within their research. "PTSD reflects a dysregulation of the stress-response system, which is associated with potentially atherogenic processes" (Kubzansky & Koenen, 2009, p. 861). Furthermore, it was found that adults with the disorder have alterations in the neuro-endocrine system that are characterized by enhanced negative

feedback pathways with increased sensitivity to the stress response system. Within those who have PTSD, exaggerated catecholamine responses are present with trauma related stimuli. This increase in catecholamine production and increased total body sympathetic nervous system activity is proposed to lead to autonomic nervous system dysfunction including decreased heart rate variability, baroreflex dysfunction, and exacerbation of atherosclerosis. Skeptics to this ‘allostatic load’ theory debate what the true causal relationship actually is. They propose that the cardiovascular disease may actually contribute to the development of PTSD. The authors refute this claim, citing biomedicine’s wary attitude toward accepting that psychological stress may lead to physiological health outcomes (Kubzansky & Koenen, 2009).

“With PTSD, there is a progressive escalation of distress or a later emergence of symptoms, particularly in military and emergency service personnel” (McFarlane, 2010, p. 3). In a study of US military troops looking at the delayed effects of stress reactions in PTSD it was found that many individuals who initially coped well at the time of the trauma later became psychologically impaired with delayed onset PTSD. Veterans met DSM-IV diagnostic criteria outside of the 6 month window usually implemented for diagnosis of PTSD. The author therefore explored the evidence about the delayed effects of traumatic stress and their effects on both physiological and psychological processes. Among a random sample of 4,238 Vietnam veterans who did not have heart disease at baseline, those who met diagnostic criteria for late onset PTSD had a hazard ratio of 2.25 for developing cardiovascular disease. In addition, when the effects of depression were controlled for the degree of combat exposure was found to have little influence on rates of cardiovascular diseases. When the medical records of World War II prisoners of war were examined, those with PTSD were found to have increased rates of

cardiovascular disease including hypertension and chronic ischemic heart disease when compared to prisoners of war who did not have PTSD (McFarlane, 2010).

In his study of the long term side effects of traumatic stress, Alexander McFarlane (2010) examined the relationship between PTSD, depression and hypertension using data from the US National Comorbidity Survey. Outcomes of statistical analysis showed that PTSD is related to hypertension independent of diagnosis of major depressive disorder. McFarlane found that of all the psychiatric disorders, “PTSD is the one with the strongest relationship with somatization and particularly medically unexplained pain” (McFarlane, 2010, p. 6). The pathway proposed for causality relates to the increased sympathetic activity that results from exposure to traumatic stressors with symptomatic evidence of increased heart rate, increased blood pressure and sweaty palms. The long term implications of repeated disruption and activation of the autonomic nervous system in response to traumatic stressors could be a potential target for PTSD treatment interventions and prevention of adverse cardiovascular outcomes as well (McFarlane, 2010).

In another published work, *Terrorism, Acute Stress and Cardiovascular Health*, Holman et al. (2008) explore the specific relationship of an individual’s exposure to events of terrorism with cardiovascular disease. As much of the research in this area of medicine has been conducted on male military veterans, their study focuses primarily on the September 11, 2001 terrorist attacks and acute stress reactions suffered by the nation. This study did not just target those in New York City or surrounding areas on that day, instead noting that the mass media coverage of the attacks subjected millions to stress reactions worthy of study. They also were able to look at a population both before and after the event, with approximately 2,700 people completing a web based survey prior to 9/11 and another assessment nine to 14 days following the attack. These people were followed for three years with reports of physician diagnosed cardiovascular ailments

as the final outcome measure. Acute stress responses to 9/11 were found to be associated with 53% increased incidence of cardiovascular ailments over the study time period after adjusting for pre-terrorist attacks and mental health status, degree of exposure to the attacks, cardiovascular risk factors, total number of physical health ailments, and demographic variables. Acute stress reactions and early physiologic arousal are known risk factors for subsequent development of PTSD (Holman et al., 2008).

In New York City, there were increased rates of adverse cardiovascular events in the weeks immediately following September 11th. While immediate stress may cause immediate and potentially lethal cardiovascular events such as fatal arrhythmias, it was proposed that acute, subacute and chronic stress can gradually increase the risk of adverse cardiovascular outcomes through neurohormonal processes. Physician diagnosed cardiovascular disease increased during the three year period from 21.5% prior to 9/11 to 30.5% three years following the terrorist attacks (Holman et al., 2008). There was a two fold increase in diagnosed hypertension in those with initial high stress symptoms reported in the initial post-attack survey. As a causal theory, this research again subscribed to the allostatic load theory that combines both the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis into a neurohormonal causative model. The ongoing exposure to stress and the biological effects on the body through continuous media coverage was found to increase blood pressure, promote atherosclerosis, hypercoagulation and arrhythmias and increase the risk of myocardial infarctions. Both strengths and weaknesses were identified through this study, with the prospective and longitudinal design highlighted as one of the strongest supporting elements and the self reported nature of the health survey highlighted as the greatest weakness (Holman et al., 2008).

Focusing again on the population exposed to the World Trade Center terrorist attacks, Gerin et al. (2005) worked with the research hypothesis that blood pressure would be increased in the subjected population compared with measured blood pressure in the preceding months and in the same period during the previous year. Working from a home blood pressure monitoring study that was already in progress prior to September 11, 2001, blood pressure values from 427 patients were collected at four different sites in the US two months before and two months after the event. While these terrorist attacks occurred in New York City, the psychological and economic impact was felt by many Americans. It was found that on average, a 2mm Hg increase in systolic blood pressure existed within the studied population compared with the same time period the previous year and in the two months prior to the event. “While a 2mm Hg change in systolic blood pressure may seem small, if it is sustained and occurs throughout a population it would suggest a possible increase in stroke mortality by 6% and an increase in cardiovascular disease by 4%” (Gerin et al., 2005, p. 284). The authors recognize this finding has the potential for public health concern both in the implication for increased mortality as well as the increased financial burden (Gerin et al., 2005).

A systematic literature review of research published between 2002 and 2009 looking at the relationship between posttraumatic stress disorder, cardiovascular disease and metabolic disease was published in 2010. In total, 78 published reports were used in this analysis. “This past decade of research has provided evidence that individuals with PTSD report more health care complaints, suffer from more physician diagnosed medical conditions and exhibit higher health care utilization” (Dedert, Calhoun, Watkins, Sherwood, & Beckham, 2010, p. 61). The authors highlight a model for this causal relationship that takes into account the influences of traumatic stress, PTSD and different health behaviors that lead to the development of

cardiovascular and metabolic disease. Analyses of multiple traumatized populations, in several different nations lead to the model's use as a fitting representation. In a longitudinal study of traumatic stress resulting from prolonged exposure to war in Beirut, it was found that those with more exposure to war related trauma were at higher risk for cardiovascular mortality. Women were more significantly affected when faced with personal trauma while men reacted more strongly with property loss, displacement from their homes or from work related problems. Vietnam veterans exposed to combat with PTSD had elevated rates of CVD relative to those exposed to combat without PTSD. In Australian veterans, higher rates of hypertension are present in the population with PTSD. In US Army veterans, after controlling for demographic covariates, having a diagnosis of PTSD was associated with an adjusted odds ratio of 2.9 for type II diabetes. While many more pieces of evidence were presented, the overwhelming findings demonstrate that those with PTSD do in fact suffer from higher rates of both cardiovascular and metabolic disease and suffer higher morbidity and mortality as a result (Dedert et al., 2010).

The identification of biological markers within those suffering from PTSD that indicates cardiovascular disease or metabolic disease is occurring was also a priority within this systematic review. Although to date no longitudinal studies exist looking specifically at biomarkers of CVD and type 2 diabetes risks in individuals with PTSD, Dedert, Calhoun, Watkins, Sherwood, & Beckham (2010) proposed several areas where physiologic markers should be analyzed. They first utilized the theory of autonomic dysregulation where either the sympathetic or parasympathetic nervous systems are disrupted, or some interplay between the two. Going through different physiological factors contributing to cardiovascular disease, evidence is given for each one demonstrating how PTSD has made an impact. Those with PTSD have a more pronounced increase in heart rate in response to traumatic cues and have a higher resting heart

rate overall. In a meta analysis of both women and men with PTSD, an increase in basal heart rate and blood pressure were found when compared to trauma and non-trauma exposed individuals without PTSD. A retrospective review of female veterans found similar findings, with no group differences in blood pressure or body mass index, but an increased resting heart rate in those with PTSD (Dedert et al., 2010).

Blood pressure findings were not as consistent as heart rate findings, although evidence of a meta-analysis still suggests trends toward higher basal rates in systolic blood pressure. A study of police officers with PTSD showed exaggerated BP increases in response to traumatic scripts or prompts when compared to traumatized officers without PTSD. Endothelial dysfunction is one of the greatest contributors to cardiovascular disease as the initial step in the physiological process of atherosclerosis. This biomarker offers a potential piece of evidence for pre-clinically evident cardiovascular disease in those diagnosed with PTSD. Using both flow mediated dilation (FMD) and ultrasound of carotid arteries as indicators of endothelial dysfunction, it was found that police officers with higher standard deviations of PTSD symptomology had $\frac{1}{2}$ the brachial reactivity found on FMD as compared to their peers. No significant differences in carotid artery thickness were found (Dedert et al., 2010).

Hyperlipidemia is also a long known contributing factor to adverse cardiac outcomes. While it is well established that Major Depressive Disorder (MDD) is associated with increased serum lipid levels, evidence suggests that individuals with PTSD are also at risk. When compared to MDD, those with PTSD experienced higher cholesterol, LDL and triglyceride levels as well as lower levels of HDL. In a large medical record review of combat veterans, individuals with PTSD, PTSD and comorbid MDD, MDD alone and no mental health diagnosis were compared. Among patients with both depression and PTSD, patients were 56% more likely to

have cholesterol >135 mg/dL and 38% more likely to have LDL>110 mg/DL. This population of patients was also found to have higher BMI and higher weight than the no mental health diagnosis group (Dedert et al., 2010).

Other theories of the relationship between PTSD and cardiovascular disease were explored in the systematic review put forth by Dedert et al. (2010). The allostatic load model evidence highlights the process of adaptation to stressors and achieving physiologic stability through change. In other words, the body fails to shut off physiological responses after the traumatic stressor is removed. Blood pressure is increased, heart rate is increased, more inflammatory cytokines are released and the body is subjected to a sustained exposure of glucocorticoids (Dedert et al., 2010).

Another group of thought suggests that behavioral and hostility influences the development of PTSD, with research identifying an association between hostility and adverse health outcomes including coronary artery disease, peripheral artery disease, hypertension, all cause premature mortality, hypertension and hyperlipidemia. These results were identified indifferent of gender (Dedert et al., 2010).

Within health behaviors that place an individual at risk for cardiovascular disease, many are found within individuals who suffer with PTSD. Increased alcohol use, elevated BMI, tobacco use and poor health habits including decreased exercise, lack of self care and increased caloric intake were found to be highly prevalent with the PTSD population. Specifically within substance abusers, those with PTSD had significantly higher incidences of cardiovascular disease independent of gender and ethnicity. While some of these theories have less evidence supporting them, the documented health behaviors that are highly prevalent within the PTSD population are

known risk factors for cardiovascular disease and therefore likely part of the etiology (Dedert et al. 2010).

As a result of their systematic review, Dedert et al. (2010) also highlighted areas within this area of research that are lacking. One of the foremost such areas within PTSD research is related to gender. Very little evidence exists on the differences of gender in adverse cardiovascular physiology of PTSD. Most studies looking at the relationship between cardiovascular disease and PTSD focus on male veterans exposed to combat and few look at female victims diagnosed with PTSD. In order to become an accepted psychologic-physiologic relationship, more epidemiologic studies of PTSD and physical illness must establish evidence over different demographic groups (Dedert et al., 2010).

More evidence into the health behavioral aspects of PTSD and cardiovascular disease is also needed, especially designed in a longitudinal fashion. None the less, clinical implications of the present body of research have the opportunity to greatly impact those exposed to traumatic events that go on to develop PTSD. By implementing preventative measures and earlier interventions both the physical and mental health of individuals with PTSD can be significantly improved (Dedert et al., 2010).

“Sundnews and Birhbaum report that between 1951 and 2000 there had been 7,312 disasters resulting in more than nine million deaths, costing \$961,895,000” (Alexander & Klein, 2009, p. 87). These statistics highlight the grave impact that disasters have inflicted upon our nation in our history and they are not inclusive of two of the most expensive and devastating disasters of the last decade with the terrorist attacks on the World Trade Centers and Hurricane Katrina. The long term effects that disasters have on a population are also significant and would

greatly increase both the financial burden and the morbidity and mortality of a population (Alexander & Klein, 2009).

Specifically, the literature evidence presented have demonstrated that those exposed to traumatic events are at an increased risk of developing long lasting adverse mental health effects in the form of Post Traumatic Stress Disorder. There is also adequate proof to illustrate a relationship between a diagnosis of PTSD and cardiovascular disease, a category of illness with the highest morbidity and mortality in the United States. While prevention of traumatic events such as events of terrorism would have the greatest impact on adverse health outcomes, the recovery and resilience of a population can only be improved with early interventions targeted at those at the highest risk for morbidity and mortality.

Methods

The World Trade Center Health Registry created a database of those exposed to both the physical and mental health effects of the September 11, 2001 terrorist attacks in New York City. The registry is planned and operated by the New York Department of Public Health and Hygiene in partnership with the federal Agency for Toxic Substances and Disease Registry (ATSDR). Participants were broken into four groups based upon exposure: (1) rescue and recovery workers (2) residents south of Canal Street, (3) students and staff in schools (pre-K through 12th grade) south of Canal Street, and (4) building occupants and people passing by in lower Manhattan (Murphy et al., 2007). Approximately 28% overlap between the categories was present, with the greatest occurring with rescue and recovery workers who lived in lower Manhattan. Initial data collection for the first wave of the study began September 5, 2003 and continued through November 20, 2004. Total eligibility for the registry is estimated at approximately 410,000 people, but only 71,000, or 17%, have chosen to become part of the study. Each enrollee

completed a phone interview that obtained demographic information as well as what they were exposed to on September 11, 2001 and their health before and after the terrorist attack. The goal of the project is to follow up for 10 years with these enrollees and to determine to that extent certain health conditions have persisted and whether any new symptoms or conditions have emerged (World Trade Center Health Registry, n.d.).

De-identified data was downloaded directly from the New York Department of Health and Hygiene website and converted from SPSS to Excel format. Once those under the age of 18 were removed from the 2003-2004 collection data, the de-identified data for 61,186 enrollees was published in the database materials. Within this information, demographic variables including gender, age, marital status, highest level education achieved, status as rescue or recovery worker, whether or not the individual was evacuated from a building and whether or not they were residents south of Canal Street were utilized. Gender was described as either male or female. Age categories were broken down by the following ranges: 18-24 years old, 25-44 years old, 45-65 years old and greater than 65 years old. Marital status was categorized as either married, not married but living with a partner, widowed, divorced, separated, or never married. Education level was stratified with the following: Some high school, high school graduate/GED, 1-3 years of college, and four or more years of college. Race was broken down as either white/Caucasian, black/African American, Hispanic/Latino, Asian, Other, and don't know/missing/refused. The other demographic information was categorized as yes/no for the variables of rescue/recovery worker, evacuated from building, residence south of Canal Street.

Among the health variables in the first data collection wave, probable PTSD was measured by using the PTSD screening tool PTSD-Civillian Version (PTSD-CV), which is a 17 item self reported symptom scale that corresponds to the American Psychiatric Association's

DSM-IV criteria (Perrin et al., 2007). Enrollees answered questions about their emotional state in the four weeks prior to the interview and a score of at least 44 out of a possible 85 points on the PTSD-CV screening tool gave them the label of ‘probable PTSD’ (World Trade Center Health Registry, n.d.). Cardiovascular health was self-reported and was posed as ‘have you ever been told by a doctor that you have “x” condition’. The survey then goes on to distinguish whether the diagnosis was given before or after September 11th, 2001.

Microsoft Excel was utilized for analysis of data. Data points identified as having an age of less than 18 years old were eliminated from this analysis. Initially, the frequencies of each demographic variable, mental health outcome and cardiovascular outcome were calculated and reported in both numerical and percent format. In addition, response rates for each variable were obtained. For the data analysis, the incidence of probable PTSD within the demographic variables as well as the incidence of adverse cardiovascular outcomes within the probable PTSD population were calculated. Relative risk was then used to compare those incidences to the entire exposed population. Relative risk and 95% confidence intervals were calculated using the EpiMax 2 x 2 calculator (<http://www.healthstrategy.com/epiperl/epiperl.htm>).

Results

In total, data was obtained and analyzed for 68,186 people enrolled in the World Trade Center Health Registry. Those who were under 18 years of age or who did not have an age listed were excluded from this analysis. The demographic breakdown of the survey population’s gender, age, race, education, marital status, position as a rescue or recovery worker, position as a worker on the World Trade Center “pile”, residence on September 11, 2001, and whether or not the person was evacuated from a building south of Canal Street is presented in Table 1 as both frequency and percent. The frequency and percent of adverse cardiovascular health outcomes,

including probable PTSD, new onset hypertension, new myocardial infarction, new onset heart disease, new cerebrovascular accident, new onset diabetes mellitus type II and new onset of non-specified heart problem in addition to smoking status are listed in Table 2.

For the WTCHR survey, response rates to the individual categorical questions varied, however, for the variables used in this analysis they were found to be >95% with one notable exceptions. Specifically, those who worked on the WTC “pile” had a response rate of 43.23% when considering the entire survey population. Although no definitive evidence could be found within the code book, it is highly probable that only those who were documented as rescue and recovery workers were given that question as a follow up. When this is taken into consideration, the response rate is found to be 96.54%. These results are summarized in table 3.

Risk Factors for Post Traumatic Stress Disorder

The World Trade Center Health Registry survey sought to collect information on both demographic descriptive variables in addition to the new occurrence of many different health outcomes. As such, the incidence of PTSD within each demographic and descriptive variable was obtained. The overall incidence of PTSD within the surveyed population is 16.35% and the incidence within each demographic or descriptive variable is given in table 4. Relative risk with 95% confidence intervals are also listed in table 4. Females were found to have a 48% increased risk of developing PTSD when compared to the males documented in the survey population (RR: 1.482, 95% CI: 1.432-1.535). Within the different age groups only those in the 45-64 age range are found to more at risk for PTSD development, with a 17% increased chance (RR: 1.68, 95% CI: 1.127-1.211). Those in the 18-24 and the >65 age range were less likely to develop PTSD with 24% and 34% decreased risk respectively (RR: 0.763, 95% CI 0.703-0.828 and RR: 0.658,

95% CI 0.586-0.738). Within the 25-44 year old age range, there was no statistically significant result found (RR: 0.969, 95% CI 0.936-1.004).

The relative risk for probable PTSD development within different racial demographics demonstrated that Caucasian and Asian individuals have a decreased risk of 51% (RR: 0.491, 95% CI 0.475-0.509) and 14% (RR: 0.858, 95% CI 0.796-0.924) respectively while African Americans, Hispanic/Latinos, and those who categorized themselves as “other” had an increased risk of 64% (RR: 1.644, 95% CI 1.574-1.717), 115% (RR: 2.150, 95% CI 2.069-2.233), and 45% (RR: 1.447, 95% CI 1.300-1.605) respectively. Not completing high school, obtaining a high school diploma or GED and completing some college were all found to place an individual at increased risk of developing PTSD with anywhere from a 20% increased risk (some college) to an 88% increased risk (grades less than high school). Having a minimum of a college degree was found to be protective with a 42% decreased risk of developing PTSD when compared to the remaining survey population (RR: 0.581, 95% CI: 0.560-0.603). Marital status also proved insightful, with a married person having the only protective demographic variable with a 32% decreased risk of PTSD development (RR: 0.679, 95% CI 0.656-0.704). Those who are not married but are living with a partner along with those who are widowed, divorced, and separated were all at increased risk of developing PTSD. Those who were separated had the highest risk at a 120% increase (RR: 2.202, 95% CI: 2.065-2.345) while those who have never been married had no statistically significant findings (RR: 1.019, 95% CI 0.977-1.064).

Within the descriptive variables, Rescue and Recovery Workers are found to have a decreased risk of developing PTSD when compared to the rest of the exposed population. Those who were rescue and recovery workers had a 20% lower risk of developing PTSD whereas those who were not had a 25% higher risk of PTSD (RR: 0.800, 95% CI 0.772-0.829, RR: 1.250 95%

CI 1.206-1.295). Among Rescue and Recovery workers, those who worked on the pile had a 6% increased risk of PTSD development (RR: 1.060 95% CI 1.001-1.123). Those who lived in closer proximity to the World Trade Center site, defined as south of Canal Street, had a 9% decreased risk of PTSD development (RR: 0.906, 95% CI 0.864-0.949). Finally, those who were evacuated from a building south of Canal Street had no increased risk of developing PTSD following 9/11/01 (RR: 0.989, 95% CI 0.946-1.035).

The prevalence of smoking within the PTSD population as well as the relative risk of smoking serving as risk factor for PTSD development were calculated and results are listed in table 5. Never smoking and history of smoking with no current use are both found to be protective against PTSD with both having a 16% decreased risk (RR: 0.838, 95% CI 0.809-0.867 and RR 0.844, 95% CI 0.809-0.880). A current smoking history demonstrated a 62% increased risk of PTSD development when compared to the remaining exposed population (RR: 1.618, 95% CI 1.555-1.684).

Risk Factors for Cardiovascular Disease

Among the adverse cardiovascular outcomes accounted for within the WTCHR, the differentiation was made between long standing cases and those of new onset. The incidences are recorded in Table 6 along with the incidence of each adverse outcome within the PTSD population. While the incidence ranged from 0.61% to 6.93%, the relative risk that PTSD served as a risk factor for each outcome's development proved to be widely statistically significant. Within those who were found to have probable PTSD, there was an increased risk of developing hypertension of 67% above the entire exposed population (RR: 1.665, 95% CI 1.536-1.804). The PTSD population also has a 115% increased risk of having a myocardial infarction (RR: 2.146, 95% CI 1.628-2.826). Those with PTSD have a 90% increased risk of developing new onset

heart disease (RR: 1.897, 95% CI 1.512-2.378) and a 145% increased risk of having a CVA (RR: 2.449, 95% CI 1.634-2.201). There is also an increased risk of development of new onset Diabetes Mellitus as well as a new onset non-specified heart problem at 90% and 60% respectively (RR: 1.897, 95% CI 1.634-2.201 and RR: 1.599, 95% CI 1.268-1.868).

Discussion

Disasters of any kind—and especially events of terrorism—continue to affect communities in the days, weeks, months and even years following the actual event. Rescue efforts take place most immediately followed by the struggle to rebuild and the recovery of those affected. Evidence already presented suggests that the recovery of the community is influenced by the varying exposures that each individual experienced. The loss of loved ones was definitively highlighted as one of the most influential factors effecting recovery, although physical injury to self was also quite predictive. The financial burden of rebuilding following disaster continues to effect individuals and governments alike. Structural damage to buildings, infrastructure and homes alike greatly impedes the path to recovery. Immediately resulting physical and mental illness following disasters creates great impairment as well. Interventions targeting each of these influencing factors can be implemented in hopes of quickening the process of recovering.

Post Traumatic Stress Disorder

Long term detrimental outcomes, which may not be addressed or even considered immediately following disaster, can continue to burden communities long after physical infrastructure has been repaired or replaced. Post Traumatic Stress Disorder alone can prolong recovery, with the financial costs involved in treatment as well as the decreased functioning of individuals with the condition and theoretically lower contribution to society secondary to the

debilitating effects of the disease. Identifying those at risk for developing a sustained psychological trauma and designing interventions accordingly has the potential to decrease the impairment that PTSD creates for both individuals and communities.

The results of this analysis did show that certain demographic or descriptive variables increased the risk of a person developing probable PTSD following an event of terrorism. Females were found to be more at risk than men as well as those individuals in the 45-64 age range. Male sex and the age ranges of 18-24 and >65 years of age were found to be protective demographic characteristics. Those who were 25-44 years of age showed no statistically significant differences in risk. A person's race was also indicative of whether they were at risk for psychological traumatic injury. Hispanic/Latino and African Americans had a much higher risk of developing PTSD when compared to Caucasian and Asian persons. Ethnic minorities were identified by Bonanno et al. (2007) as placing an individual at risk for PTSD development when exposed to the September 11th terrorist events.

While marriage status wasn't specifically studied in Bonanno et al.'s (2007) analysis, social support was strongly identified as a predictor of resilience. Within marriage, it would suggest that strong social ties exist allowing a person to have a level of protection against psychological trauma. In the WTCHR analysis, those who were married were the only demographic group who had a decreased risk of PTSD development, strengthening the theory of marriage as a source of social support. However, those who were not married but living with a partner, a social situation that would seem to be perceived as having much of the support which would be present in a marriage, had an increased risk even over those who never married. Divorced and widowed persons both had statistically significant increased risks of PTSD development. Further exploring the differences between marriage and those who cohabit with

a partner could potentially highlight what specifically about marriage is protective in events about terrorism. Confounding factors to be considered which could be utilized in future analyses include length of relationship, financial status of each couple and degree of familial ties outside of the relationship.

Results from the analysis of the WTCHR differed from what Bonanno et al. (2007) found in their study when the level of education a person obtained was considered. Relative risk for those who obtained at least a four year college degree demonstrated a protective value, whereas anything less than a college degree placed a person at risk. However, Bonanno et al. (2007) found that “people with a college degree were less likely to be resilient as compared to those who had not completed high school” (p. 673). The differing findings could be related to several things. The sample size used in Calhoun, P. S., Watkins, L. L., Sherwood, A., & Beckham et al.’s (2007) analysis was much smaller than the data base of the WTCHR. They also conducted their analysis six months after the September 11th terrorist attacks, whereas the WTCHR data collection occurred in 2003-2004. This delay would allow for recovery from more acute psychological trauma and only the development of the more chronic mental illnesses would be recorded. Otherwise, it could be seen that the September 11th attacks on the World Trade Center—one of the most notable symbols of finance and capitalism found within the New York skyline—placed those with higher education at an increased risk of direct harm to themselves or a loved one. While people of all different backgrounds perished on September 11th, striking at such symbolism in many ways targeted the American dream—one that involves working your way to the elite status in a given field, which usually requires extensive training and education.

Rescue and Recovery workers that responded to the attack on the World Trade Centers were actually found to have a decreased risk of PTSD in 2003-2004 when compared to the rest

of the September 11th population. Among rescue and recovery workers, those who worked on the pile had a slightly increased risk of developing PTSD, however statistical significance is questionable (RR: 1.060, 95% CI 1.001-1.123). Evans, Patt, Giosan, Spielman, and Difede (2009) discussed how the type of rescue and recovery worker, the extent of their training prior to the event, the volunteer vs. paid employee status of each individual as well as the degree of exposure each person faced as a contributing factor to the development of adverse psychological outcomes. Stellman et al. (2008) added that classifying the degree of environmental hazards, the number of hours worked, the handling of body parts and the presence of fear for personal safety also provided unique conditions which contributed to the development of PTSD. The lack of this information collected in the rescue and recovery workers within the WTCHR database makes any descriptive conclusions about what this specific population impossible.

PTSD was found in the surveyed population at 16.35%, or over 10,500 individuals likely suffering with the disorder two to three years following the terrorist attacks. While a more in depth look at these individuals, the level of impairment faced and the impact it has had on their lives would help to further recovery efforts, just acknowledging the high incidence within the population and helping to foster opportunities for treatment would significantly contribute to the recovery of the entire exposed population and the New York City community. Identifying persons who are at increased risk because of a demographic variable or descriptive factor can theoretically target those who are in need of intervention and make sure that these people have access to care and the treatment they would need for their personal recovery.

Cardiovascular Disease

In the United States, cardiovascular disease is responsible for more deaths than any other illness or disease since 1900. Mortality data shows that CVD is responsible for 1 out of every 2.7

deaths in the US. Many different factors have contributed to CVD's emergence into this position, mostly attributable to the American lifestyle and related choices that are made over the course of one's life. Smoking is largely responsible as well as obesity caused by a high fat diet with poor exercise habits. In the United States, 65 million people meet the definition of hypertensive while over 13 million suffer from coronary artery disease. The prevalence of heart attacks is approximately 7.2 million and strokes are prevalent in 5.5 million. With increasing age, incidence of all forms of cardiovascular disease also increases. The direct and indirect financial cost of all CVD in the US is estimated to be greater than \$400 billion. Genetic risk factors do exist which contribute to these statistics, however medical and public health interventions targeted at lifestyle has made the greatest impact toward reducing morbidity and mortality. In conclusion, CVD has great impact on the population with high morbidity and mortality directly related. Prevention remains the best treatment option available to decrease this impact (Thom et al., 2006).

Much evidence has been presented discussing the relationship between PTSD and cardiovascular disease. While the exact mechanism of this relationship hasn't been established and is more likely to be multi-factorial in nature, there is conclusive evidence to support the contributory causal relationship between the two diseases. Therefore, when disasters occur that contribute to higher rates of PTSD within the exposed population it can be said that increased incidences of cardiovascular disease will also occur. Therefore identifying those persons who are at increased risk of developing PTSD can help to decrease long term morbidity and mortality due to CVD. Secondly, those identified as having PTSD can be targeted for closer monitoring of cardiovascular status with special attention paid to educating those with the disease on steps toward creating a healthier cardiovascular system. Earlier interventions could also be

implemented, perhaps starting an aspirin regimen at an earlier point than would otherwise be done or more closely monitoring blood pressure levels with appropriate treatment interventions.

The results of this study highlighted the relationship between PTSD and cardiovascular disease. Among those with a diagnosis of probable PTSD it was found that an increased risk of development all of the adverse cardiovascular conditions accounted for exists when compared to the entire exposed population. Myocardial Infarction and Cerebrovascular Accidents had the highest relative risk at 2.146 (95% CI 1.628-2.826) and 2.449 (95% CI 1.808-3.313) respectively. These two conditions have the highest initial mortality of all the outcomes recorded and also create significant disability if one survives the initial onset. Heart disease and hypertension also have significant morbidity and mortality and definitively contribute to the development of MI and CVA as listed above, however the progression to mortality is generally spread out over a longer time course. The relative risks that demonstrated increased cardiovascular outcomes among those exposed to the terrorist attacks were much higher than predicted prior to analysis and ranged from increases of 59% to 144%. As the vascular system is interconnected throughout the body and adverse pathological development isn't usually restricted to one specific area, having similar risk among all outcomes is not surprising. For example, hypertension contributes not only to CVA's through destruction of the vasculature within the brain parenchyma but also increases strain on the heart muscle and contributes to the development heart disease.

Co-morbid conditions as well as life style risk factors greatly contribute to the development of cardiovascular disease and can be seen as a confounding factor in establishing a causal relationship between PTSD and cardiac disease. Tobacco use is one of the most identified and cited sources of increasing risk for adverse cardiac conditions and smoking status was

accounted for in the WTCHR database. Among those with PTSD, the prevalence of current and former smokers totaled greater than 46%. Those who are current smokers were found to be at an increased risk for developing PTSD, with a 61.8% higher risk when compared to former smokers and those who have never smoked. Substance abuse of all types is highly prevalent among those with PTSD and cause significant impairment in its own right. The question then becomes, did the tobacco use result in the development of cardiovascular disease or is PTSD to blame. In order to fully explore this relationship, it would be necessary to obtain more information related to when smoking began, the duration and the pack year history of each individual. While smoking most definitely contributes to the development of cardiovascular disease, it has been found in several different literature sources that the causal relationship of PTSD and adverse cardiovascular disease does exist independently of tobacco use. Expanding upon the substance abuse information within the WTCHR survey, specifically information regarding cigarette smoking would further strengthen the published evidence.

Limitations

One of the greatest limiting factors found within this analysis relates to the release of collected data. In addition to the 2003-2004 data collection cycle, two additional data collections have been completed—one in 2006-2007 and one in 2008-2009. The later just focused on children, however the 2006-2007 survey focused on adults and served as a follow up to the original 2003-2004 survey. Unfortunately the data remains inaccessible to the public and repeated inquiries to the New York City Department of Health were unable to reveal when this might be made available. As cardiovascular disease is the cause of many physiologic changes over the course of time, having the second set of data would have allowed for capturing trends as the cardiovascular disease would theoretically progress. It would also have allowed for

comparing the population's mental health outcomes at two different points in time. It would have been impossible to make a direct comparison between the 2003-2004 and 2006-2007 survey populations, as the data that was publically accessible is de-identified and therefore could not be utilized for anything other than showing trends within the population. Obtaining access to both sets of data with identifiers could show a direct relationship between PTSD and increased incidences of cardiovascular disease along with descriptive characteristics of those individuals therefore strengthening the evidence for a causal relationship.

Another limitation of this analysis involves the lack of detail within the survey itself. As such a large data collection would already be time intensive and costly, a more thorough investigation into more specific information on each person enrolled was probably not feasible. However having more information regarding both health statistics and rescue and recovery workers would have greatly contributed to the validity of this study. Confounding factors previously mentioned within health variables include obesity, activity level, chronic conditions before September 11th, alcohol use, family history of mental illness or cardiovascular disease, access to health care and previous history of mental illness. Obtaining information on enrollees related to the confounding factors could help to illustrate a more definitive relationship between disasters, PTSD, and cardiovascular disease. More information on rescue and recovery workers would also have been useful. Elaborating on how many hours each individual worked, what their exposures were, what training experiences each worker had participated in prior to the event, and where each individual came from to work during/following September 11th would provide a better descriptive analysis of the risk that rescue and recovery workers had as well as making a comparison to the available literature more meaningful.

Looking Forward

Public health implications for this analysis are multi-tired. Primarily, this contributes to the body of knowledge regarding a population exposed to disaster, more specifically to events of terrorism, and what risks this population has over those who were not exposed. Large scale disasters where hundreds of thousands of people are exposed to hazardous conditions, traumatic experiences and the death of their neighbors, friends and relatives can greatly impact the functionality of society. Aside from the initial rescue and recovery period, recognizing that these populations have faced a unique exposure and screening and treating them appropriately—whether for biological, physiological or psychological conditions—is a key part of the public health sector’s role at the local, state and federal levels. This often involves assisting a population to rebuild and recover as well as prevent long term adverse outcomes to the best of the available knowledge regarding risk. Having the ability to recognize those at even higher risk based upon a descriptive or demographic variable will help in the screening and evaluation process. Highlighting the characteristics could also aid in designing interventional opportunities. For example, if it was found that pregnant women were at an increased risk of developing psychological trauma following an event of terrorism, screening and intervention could be targeted both at Obstetrics offices within a community and also with pediatricians with specific instructions for the mothers of infants of an age range that would include women pregnant during the event of terrorism.

Specifically related to this analysis, PTSD and cardiovascular disease have significant impairment, morbidity and mortality in their own right. Establishing and further exploring the relationship between the two can improve the health of the population. If certain demographic and descriptive factors have placed individuals at higher risk for developing PTSD and those

with PTSD are at higher risk of developing adverse cardiovascular outcomes, then creating interventions designed at prevention of PTSD has the potential to reduce the risk of adverse cardiovascular outcomes. When such a large population is affected by an event, such as was the case with the September 11th attacks on the World Trade Center, it can become a slow and tedious process for recognizing and treating the adverse outcomes that will inevitably result. As with many conditions, prevention is the best option for both PTSD and cardiovascular disease. Having validated information regarding which people are at increased risk can greatly aid in the design of information dissemination as well as intervention design. Screening information can be given to primary care offices, specialists and public health officials along with information for the individual regarding treatment options and resources available. It can also be turned into public service announcements and specific interventions can be designed such as support groups or specialized clinics within public health. In New York City, three such specialized monitoring and treatment centers exist: The World Trade Center Environmental Health Center at Bellevue Hospital Center, The Fire Department of New York World Trade Center Medical Monitoring and Treatment Program and the Mount Sinai Consortium World Trade Center Medical Monitoring and Treatment Program.

This analysis also has value in its ability to highlight the limitations of the WTCHR database regarding outcome determination and identifying unrecorded potential confounding factors. Ideally, future work would focus on designing a disaster database-database, where surveys/studies could be designed quickly following a man made or natural disaster. Certain types of disasters would determine what type of questions would need to be utilized in order to thoroughly examine the population and outcomes they may face. For example, those exposed to a terrorist attack that involves fire, explosion and environmental air quality would be asked

questions related to respiratory health outcomes, prior conditions and risk factors whereas someone exposed to a hurricane or flood would be subjected to questions regarding property damage or loss, sanitary conditions and water hazard exposures. For future analysis of adverse cardiovascular outcomes related to PTSD, not only is long term follow up of those exposed necessary but more information regarding other risk factors and potentially confounding variables would need to be included in any population analysis. Physical characteristics of the individual such as BMI would be important as well as family history, cholesterol status, medication use past and present, and an activity/lifestyle analysis. As “increased alcohol use, elevated BMI, tobacco use, and poor health habits including decreased exercise, lack of self care and increased caloric intake were found to be highly prevalent within the PTSD population” (Dedert et al., 2010, p. 70-71), further expounding on the degree with health status of each individual with PTSD would help to account for confounding factors for cardiovascular disease. Regarding mental health, prior exposures to disasters, events of terrorism or traumatic events should be documented as well as any prior mental health diagnoses. The literature also provided evidence that the level of PTSD symptomology provided a predictive indicator for development of adverse cardiovascular outcomes. Measuring the level of impairment within the population exposed to September 11th would help to confirm or refute this association.

Most of the research conducted and published in the literature has targeted veterans with combat experience as the exposed populations, which is a population largely exposed of males within specific age groups. However, combat exposure is very different than the manmade and natural disasters that are faced within our nation’s borders and information gleaned from the veteran population may not necessarily coincide with what the general public might face. Utilizing the September 11th population not only provides a large number of data points available

for analysis, but also expands the variability among people exposed to include women, those of all different age groups and backgrounds, as well as different ethnic and cultural backgrounds. Designing long term follow up studies based on this population for adverse cardiovascular disease and PTSD would expand the evidence for both PTSD individually and the causal relationship between the two. Very little research has been done specifically related to cardiovascular disease and those exposed to events of terrorism or natural disaster, therefore utilizing this population would serve to fill an identified gap within current the current knowledge base.

Having access to care is also key to the recovery of a person for any condition, PTSD and cardiovascular disease notwithstanding. If we recognize that increased risk exists, but that with the aforementioned conditions the majority of persons have no insurance and do not qualify for Medicare/Medicaid then demonstrating that they are at an increased risk is a mute point. Collecting information regarding access to health care, insurance coverage, employment status, income and resource availability (i.e. are there any shortages or circumstantial experience that occur secondarily to the disaster itself) would help to create an initial understanding of a populations ability to recover regardless of the disaster specific circumstances and risk of adverse outcomes. When special treatment and monitoring centers have been established following disaster, creating a registry can serve as a mechanism for distributing information about such available services as well as contacting individuals about population monitoring findings.

Creating registries quickly following a disaster also opens the door for follow up of the exposed populations. If much dissemination or relocation of the population occurs following the event, if little to no tracking or recording of this information occurs, creating databases at a later

time becomes nearly impossible. Hurricane Katrina is a perfect example of what problem exists when trying to analyze disaster outcomes after the event has long passed. So many people were permanently relocated in the days and weeks after the Hurricane struck and parts of Mississippi and Louisiana flooded to such disastrous levels. Little is known about where these people ended up and very few research projects related to this population exist as identifying and contacting this group has become impossible. While rescue efforts and life saving interventions should be the most important initial steps to occur directly following disaster, data collection is also an important part of developing this system within our nation. If a disaster registry database existed and information gathering could be started more quickly—even if it's just initially obtaining contact information for exposed or affected individuals—the potential for positive research outcomes greatly improves. While IRB and other ethical considerations would likely need to be conducted before research on human subjects can be conducted, without this initial information gathering identifying the exposed population could prove impossible.

Another interesting avenue of research that could potentially result from this analysis relates to the resiliency versus mental illness following a traumatic event. Much work has been done regarding what places a person at higher risk for mental illness, however, not nearly as much exists regarding what makes a person resilient. Analyzing the well population following an event of terrorism not only for descriptive and demographic information but for lifestyle choices and other potential avenues that serve in a protective nature for an individual could contribute to the field of preparedness. If we know certain people are higher risk for adverse mental health outcomes, than potentially public health programs could be designed at preparing them for better outcomes. For example, if elderly widows with few social outlets are at increased risk for mental trauma following disaster perhaps public health along with social services and senior centers

could work to get that specific group of people within a community together to help strengthen social ties and create a support network for those individuals. While this may be seen as expensive and non-essential part of preparedness at this time for our country, it can be said that these are the measures that would see the most benefit in the future. The United States is not subject to nearly as many events of terrorism and manmade destruction as other nations, the potential exists that this could be part of our day-to-day to experience. In this instance, prevention is the best option for maintaining a community with these types of preparedness interventions serving in that role. In a country that faces these challenges much more frequently, such as Israel, preparedness tasks such as training, drills, and social interventions are a key part of their ability to respond and recover when an event does occur.

Within the rescue and recovery worker sub-population much opportunity for further analysis exists. There is a lot of literature about what contributes to a rescue or recovery workers ability to conduct their job and remain protected from developing traumatic psychological outcome. With so many rescue and recovery workers registered within the WTCHR, collecting more information on this population could provide a significant contribution to the available evidence. The rescue and recovery workers for September 11th were made up of a large variety of people with different backgrounds and training experiences. Some were volunteers with the national medical response teams; some were employees of the New York City first responder organizations that lost hundreds of close friends and co-workers. Regardless, the purposeful destruction of the World Trade Centers and the large loss of life that resulted was an event of a magnitude that very few had ever been previously exposed to. As it was found within the data analysis that serving in this capacity served in a protective role, identifying what contributed to this resiliency could serve to enhance training for first responders to future disasters. Improving

preparedness measures, including increasing the coping abilities of our first responders, can only serve to improve rescue efforts and further facilitate recovery of a community.

Finally, having access to the 2006-2007 second wave of data collection for the WTCHR survey data and conducting a similar analysis to that done with the data from the 2003-2004 database would allow for demonstrating any changing trends within the population. Especially as cardiovascular disease is the result of an ongoing disease process and PTSD is generally a chronic condition with significant impairment, conducting data analysis of the second and future waves of data collection among adults registered in the WTCHR could serve to highlight any special needs or unique outcomes that this population is faced with. The WTCHR conducted by the New York City Department of health is a longitudinal population survey with data collections planned for every other year, therefore much opportunity for future research exists.

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Access Date: January 23, 2011.

Appendix 1: Data Tables

Table 1: Demographic and Descriptive Characteristics of WTCR 2003-2004 Survey Population

		Frequency	Percent (%)
Gender	Male	41186	60.40
	Female	26998	39.60
Age	<18	0	0
	18-24	4392	6.48
	25-44	37021	54.58
	45-64	23799	35.09
	>65	2618	3.86
Race	White/Caucasian	43440	63.71
	Black/African American	8204	12.03
	Hispanic/Latino	8936	13.11
	Asian	4759	6.98
	Other	1266	1.86
	Missing/Don't Know/Refused	1581	2.32
Education	Grades< High School	3503	5.23
	High School/GED	12902	19.25
	Some College	16434	24.52
	College+	34180	51.00
Marital Status	Married	38218	57.11
	Not married, live with partner	4575	6.84
	Widowed	1607	2.40
	Divorced	5854	8.75
	Separated	2136	3.19
	Never Married	14529	21.71
Rescue/Recovery Worker	Yes	30535	44.88
	No	37651	55.22
Worked on World Trade Center "Pile"	Yes	12501	42.41
	No	16976	57.59
Residency 9/11/01	South of Canal Street	12282	18.01
	North of Canal Street	55904	81.99
Evacuated From Building on 9/11/01 South of Canal Street	Yes	29304	71.57
	No	11636	28.43

Table 2: PTSD and Cardiovascular Risk Factors/Outcomes in WTCHR W1 Survey Population			
	Smoking Status	Frequency	Percent
	Never Smoked	38420	57.15
	Former Smoker	18010	26.79
	Current Smoker	10791	16.05
	Probable PTSD		
	Yes	10697	16.35
	No	54740	83.65
	New Onset Hypertension		
	Yes	3125	4.63
	No	64436	95.37
	New Myocardial Infarction		
	Yes	262	0.39
	No	67532	99.61
	New Onset Heart Disease		
	Yes	406	0.60
	No	67262	99.40
	New Cerebrovascular Accident		
	Yes	207	0.30
	No	67621	99.70
	New Onset Diabetes Mellitus Type II		
	Yes	910	1.34
	No	66834	98.66
	New Onset Heart Problem (Other)		
	Yes	913	1.35
	No	66753	98.65

Table 3: Response Rates within the WTCHR Survey Data

Variable	Response Rate (%)
Gender	100
Age	99.48
Race	100
Education	98.30
Marital Status	98.14
Rescue/Recovery Worker	100
Worked on WTC "Pile"	43.23 **
Residency 9/11/01	100
Evacuated from Building on 9/11/01 South of Canal Street	60.04
Smoking Status	98.58
Probable PTSD	95.97
New Onset Hypertension	99.08
New Myocardial Infarction	99.43
New Onset Heart Disease	99.24
New Cerebrovascular Disease	99.48
New Onset Diabetes Mellitus Type II	99.35
New Onset Heart Problem	99.24
**96.54% with consideration of just those who identified themselves as Rescue and Recovery Workers	

Table 4: Incidence of PTSD and Relative Risk with 95% Confidence Intervals for Demographic Variables

		Incidence (%)	Relative Risk	95% Confidence Interval
Gender	Male	13.17	0.675	0.651-0.698
	Female	19.53	1.482	1.432-1.535
Age	18-24	12.16	0.763	0.703-0.828
	25-44	15.46	0.969	0.936-1.004
	45-64	17.31	1.168	1.127-1.211
	>65	10.47	0.658	0.586-0.738
Race	White/Caucasian	11.40	0.491	0.475-0.509
	Black/African American	23.94	1.644	1.574-1.717
	Hispanic/Latino	29.31	2.150	2.069-2.233
	Asian	13.60	0.858	0.796-0.924
	Other	22.51	1.447	1.300-1.605
	Missing/Don't Know/Refused	14.42	0.917	0.810-1.037
Education	Grades< High School	28.23	1.881	1.777-1.989
	High School/GED	21.21	1.473	1.417-1.532
	Some College	17.97	1.201	1.155-1.248
	College+	11.54	0.581	0.560-0.603
Marital Status	Married	12.99	0.679	0.656-0.704
	Not married, live with partner	20.33	1.324	1.245-1.406
	Widowed	20.78	1.335	1.209-1.472
	Divorced	23.95	1.606	1.528-1.687
	Separated	33.10	2.202	2.065-2.345
	Never Married	15.93	1.019	0.977-1.064
Rescue/Recovery Workers	Yes	13.79	0.800	0.772-0.829
	No	17.23	1.250	1.206-1.295
Worked on World Trade Center "Pile"	Yes	14.45	1.060	1.001-1.123
	No	13.63	0.943	0.890-0.999
Residency on 9/11/01	South of Canal Street	14.45	0.906	0.864-0.949
	North of Canal Street	15.96	1.104	1.053-1.158
Evacuated from Building on 9/11/01 South of Canal Street	Yes	18.58	0.989	0.946-1.035
	No	18.78	1.011	0.966-1.057

Table 5: Smoking Prevalence within the Probable PTSD Population and as a Risk Factor for probable PTSD with 95% Confidence Intervals

	Prevalence within probable PTSD (%)	Relative Risk	95% Confidence Interval
Never Smoked	52.50	0.838	0.809-0.867
Former Smoker	23.47	0.844	0.809-0.880
Current Smoker	23.51	1.618	1.555-1.684

Table 6: Incidence of Cardiovascular outcomes within the Survey Population and within those with Probable PTSD

	Incidence within WTCHR (%)	Incidence within PTSD Population (%)
New Onset Hypertension	4.63	6.93
New Myocardial Infarction	0.39	0.70
New Onset Heart Disease	0.60	0.99
New Cerebrovascular Accident	0.30	0.61
New Onset Diabetes Mellitus Type II	1.34	2.22
New Onset Heart Problem (Other)	1.35	1.96

Table 7: PTSD as a Risk Factor for Adverse Cardiovascular Outcomes Reported as Relative Risk with 95% Confidence Interval

	Relative Risk	95% Confidence Interval
New Onset Hypertension	1.665	1.536-1.804
New Myocardial Infarction	2.146	1.628-2.826
New Onset Heart Disease	1.897	1.512-2.378
New Cerebrovascular Accident	2.449	1.808-3.313
New Onset Diabetes Mellitus Type II	1.897	1.634-2.201
New Onset Other Heart Problem	1.599	1.368-1.868


Appendix 2: IRB Approval



Office of Research and Sponsored Programs
201J University Hall
3640 Col. Glenn Hwy.
Dayton, OH 45435-0001
(937) 775-2425
(937) 775-3781 (FAX)
e-mail: rsp@wright.edu

DATE: November 2, 2010

TO: Katie Imhof, MD/MPH Candidate
Community Health - Center for Global Health
Sabrina Neeley, Ph.D., Fac. Adv.
Community Health

FROM: B. Laurel Elder, Chair 
WSU Institutional Review Board

SUBJECT: SC# 4278

'Cardiovascular Disease and PTSD in those exposed to the terrorist events of 9/11'

At the recommendation of the IRB Chair, your study referenced above has been recommended for exemption. Please note that any change in the protocol must be approved by the IRB; otherwise approval is terminated.

This action will be referred to the Full Institutional Review Board for ratification at their next scheduled meeting.

NOTE: This approval will automatically terminate two (2) years after the above date unless you submit a "continuing review" request (see http://www.wright.edu/rsp/IRB/CR_sc.doc) to RSP. You will not receive a notice from the IRB Office.

If you have any questions or require additional information, please call Robyn Wilks, IRB Coordinator at 775-4462.

Thank you!

Enclosure

RESEARCH INVOLVING HUMAN SUBJECTS

SC# 4278ACTION OF THE WRIGHT STATE UNIVERSITY
EXPEDITED REVIEW

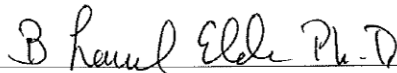
Assurance Number: FWA00002427

Title: 'Cardiovascular Disease and PTSD in those exposed to the terrorist events of 9/11'

Principal Investigator: Katie Imhof, MD/MPH Candidate
Community Health - Center for Global Health
Sabrina Neeley, Ph.D., Fac. Adv.
Community Health

The Institutional Review Board Chair has approved an exemption with regard to the use of human subjects on this proposed project.

REMINDER: Federal regulations require prompt reporting to the IRB of any changes in research activity [changes in approved research during the approval period may not be initiated without IRB review (submission of an amendment), except where necessary to eliminate apparent immediate hazards to subjects] and prompt reporting of any serious or on-going problems, including unanticipated adverse reactions to biologicals, drugs, radioisotope labeled drugs or medical devices.



Signed _____ Chair, WSU-IRB

Approval Date: November 02, 2010

IRB Mtg. Date: November 15, 2010

Appendix 3: Public Health Core Competencies Met

Analytical

1. Defines a Problem
2. Selects and defines variables relevant to defined public health problems
3. Identifies relevant and appropriate data and information sources
4. Applies ethical principles to the collection, maintenance, use, and dissemination of data and information
5. Makes relevant inferences from quantitative and qualitative data
6. Obtains and interprets information regarding risks and benefits to the community
7. Recognizes how the data illuminates ethical, political, scientific, economic, and overall public health issues

Policy Development/Program Planning Skills

1. Collects, summarizes, and interprets information relevant to an issue
2. Utilizes current techniques in decision analysis and health planning
3. Decides on the appropriate course of action

Communication Skills

1. Communicates effectively both in writing and orally, or in other ways
2. Solicits input from individuals and organizations

Cultural Competency Skills

1. Identifies the role of cultural, social, and behavioral factors in determining the delivery of public health services
2. Understands the dynamic forces contributing to cultural diversity

Basic Public Health Sciences Skills

1. Identifies the individual's and organization's responsibilities within the context of the Essential Public Health Services and core functions
2. Defines, assesses, and understands the health status of populations, determinants of health and illness, factors contributing to health promotion and disease prevention, and factors influencing the use of health services
3. Identifies and applies basic research methods used in public health
4. Applies the basic public health sciences including behavioral and social sciences, biostatistics, epidemiology, environmental public health, and prevention of chronic and infectious diseases and injuries
5. Identifies and retrieves current relevant scientific evidence
6. Identifies the limitations of research and the importance of observations and interrelationships