Does Geography Matter? Neighborhood Effects on Post-Traumatic Stress Disorder of NYC Public School Children after 9/11

by

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Abstract

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An epidemiological study was conducted six months after 9/11 under the auspices of the NYC Board of Education, to evaluate the impact of the World Trade Center attacks on children's mental health. A large representative sample of public school students in grades 4-12 (N=8,236) was screened for eight psychiatric disorders including Post-Traumatic Stress Disorder (PTSD), as well as various types of exposures to the 9/11, health problems, family circumstances, etc.

Analyses of these data have indicated that being a student at a Ground Zero Area (GZA) school was not a significant risk factor for developing PTSD. These findings were contradictory to existing literature on PTSD. In previous PTSD studies, distance was not measured in fine scale (i.e., X miles from traumatic event), instead, arbitrary distance categories were used (i.e., was in school, was at home, etc.). For this study, Euclidian distance from the students' home zip code to their GZA schools, transportation distance and travel time have been calculated to help understand this phenomenon. Additionally, neighborhood variables (including socio-economic status (SES), residential mobility, safety, quality, and location-based physical exposure measures), as well as school environment and performance, are used to observe their potential influence.

Analyses are conducted within a geographical theoretical framework, where spatial dependence is measured and controlled for. This study will inform epidemiological, mental health and geographic literatures regarding new methodologies and will help to expand the general understanding of PTSD, the geographies of mental health, and the role and definition of physical exposure after a large-scale event, such as that of 9/11.

Preface

This dissertation is dedicated to my family, co-workers, and friends who have supported me throughout my life and believed in me. Specifically, I want to thank Judith Wicks, Thao Doan, Patricia Cohen, Ping Wu, Sa Shen, Cristiane Duarte and Fan Bin, from Columbia University – The New York State Psychiatric Institute, for all their guidance and support.

I am forever grateful for my father, Jorgito Musa, my sister, Nashla Musa, and my brother, George Michael Musa, who always encouraged me to reach for my dreams and never doubted that I would, in fact, complete my PhD. Although my mother, Angelina Koussa de Musa, is not alive today to see my success, she was always in my heart during the entire process and I know how proud she would be of me. While working in Taiwan with my “brother”, Po Huang-Chiang, I fell in love with my soul-mate, the most wonderful, supportive woman, Sally Chua, whom I married seven years ago. I would be lost without Sally, as she gave me the strength to complete this milestone in our life.

In 1995, I met two people who forever changed my life, Christina W. Hoven and Donald J. Mandell, Columbia University – The New York State Psychiatric Institute. Although I didn’t have a college degree, they saw something in me that I did not see myself. My second "mother", Christina, not only encouraged me to return to school but also helped me maintain course throughout this long chapter of my life. As with my biological mother, Donald, my second "father" has not lived to see the fruition of my educational path, but not a day goes by when I don’t think of him and know he is with me.

Finally, I would also like to dedicate this dissertation to all the children who lost a loved one or were affected by the tragic events that occurred on September 11, 2001.

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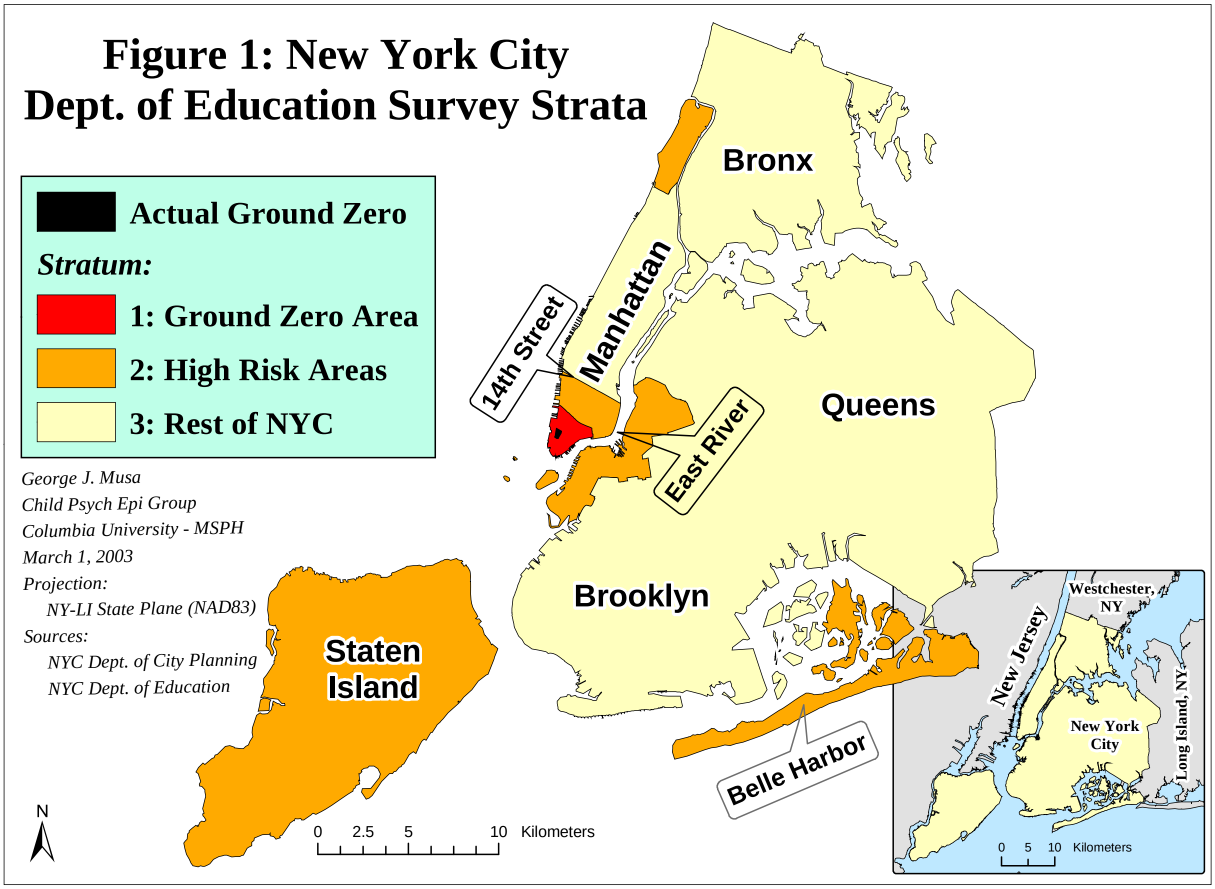
1. Introduction

The September 11, 2001 attack on the World Trade Center (WTC) affected the lives of NYC residents, especially, its children. To determine the psychological impact on children, an epidemiological study was conducted in NYC public schools six months after 9/11. A citywide clustered stratified representative sample of students in grades 4-12 (N = 8,236) was drawn from the 1.1 million public school students in NYC (Hoven, 2002). To infer impact on variously exposed groups, students from schools in both Ground Zero Area (GZA) and other areas of the city considered at high risk for exposure to the attacks, Canal to 14th Street, western shores of Brooklyn and Queens and Staten Island, were over-sampled (see Figure 1). In order to control for the potential effects of American Airlines Flight 587 that crashed in Belle Harbor NY (a highly concentrated neighborhood of first responders) on November 12, 2001, enroute to the Dominican Republic, the Belle Harbor and Washington Heights (the highest concentration of Dominicans outside of the Dominican Republic) areas, were also considered high risk and oversampled. The students were screened for Post-Traumatic Stress Disorder (PTSD) and seven other important psychiatric disorders. Demographic information, types of exposures, health problems, etc., were also collected. Though contradictory to prior PTSD literature, analyses of these data have shown that being a student in a GZA school was not a significant risk factor for developing PTSD (Hoven, 2002; Hoven, 2005; Hoven, 2004).



Source: Musa, et al., 2003

1.1. Statement of the Problem

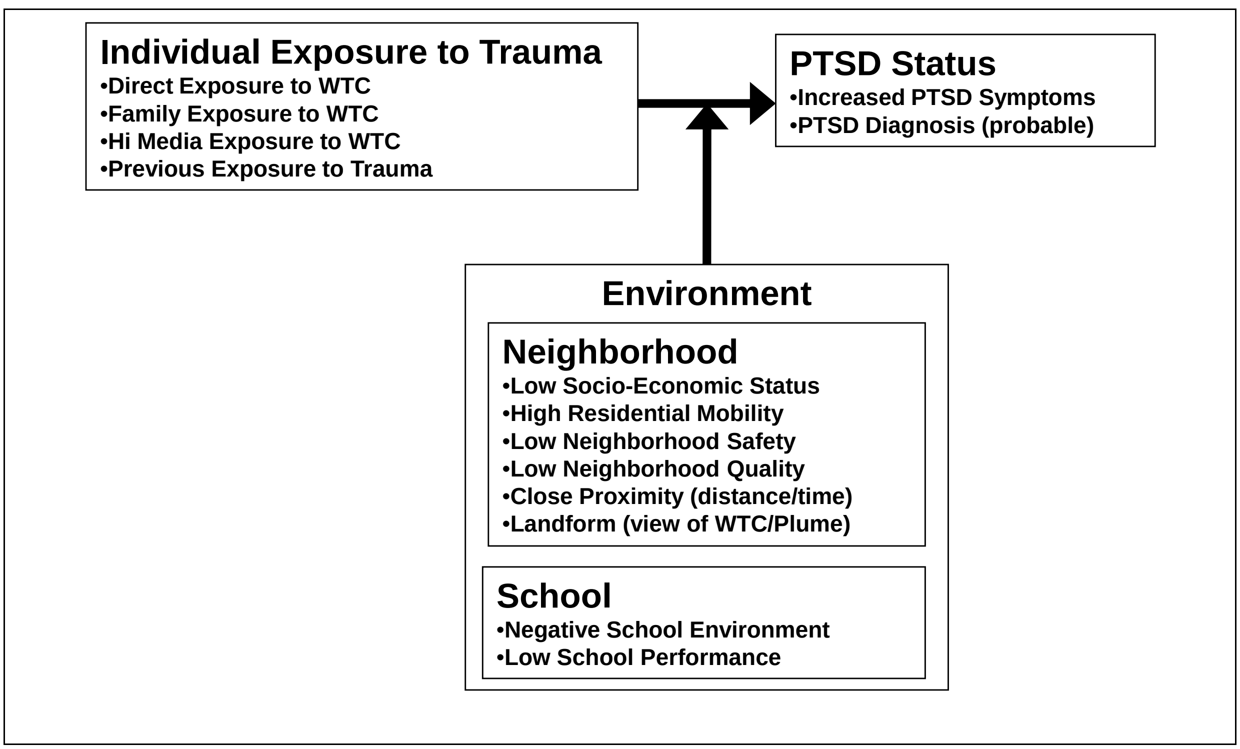
Previous analyses have indicated that the rates of probable post-traumatic stress disorder (PTSD) among students from public schools located at Ground Zero were quite similar to those located throughout the rest of the city (Hoven et al., 2002; Hoven et al. 2005; Musa et al., 2003). To further evaluate the potential effect of distance from the attack on probable PTSD in finer gradations, participating schools were geocoded and their distance to Ground Zero calculated to determine distance decay of rates – it was hypothesized that the further a school was located from Ground Zero, the lower the risk for developing PTSD. Buffers were created for use as categorical variables in the original analytical models to examine the effect of location on personal physical exposure, the most significant risk factor for PTSD (American Psychiatric Association, 1994). Thus far, all analyses done have shown that distance from the WTC Center to either the student's school or their home zip code is not a factor for probable PTSD in this data.

1.2. Purpose of the Study

The overall purpose of this study is to examine what neighborhood and school level factors are associated with probable PTSD. Euclidian distance from the students' home zip code to GZA schools is calculated, and a transportation model is applied to measure both travel distance and time. Neighborhood variables (socio-economic status (SES), residential mobility, neighborhood safety, neighborhood quality, and location-based physical exposure measures) are studied to observe their possible influence. School environmental variables (school environment and school performance), individual and family level variables (child demographics, physical, family, prior, and TV exposure, maternal educational attainment, etc.) are examined. These new measures are studied with traditional statistical techniques, including Hierarchical Linear Modeling (HLM), and spatial analysis techniques (Spatial Regression and Geographically Weighted Regression). Based on these analyses, this study identifies how neighborhood, school and individual factors influence PTSD in children.

Figure 2 represents the conceptual model tested in this research. Prior analyses on these data has demonstrated that the students' WTC exposure (direct, family and TV exposure) and their previous exposure to a traumatic event, as well as being female and young, are the strongest risk factors for endorsing PTSD Symptoms and developing the (probable) Disorder. In this research, environmental factors (neighborhood and school) are tested to determine their impact on levels of PTSD (symptoms and probable diagnosis) related to WTC exposures. It is postulated here that residing in a neighborhood with low socio-economic status (SES), low neighborhood safety, low neighborhood quality and high residential mobility are risk factors for PTSD symptoms and (probable) disorder and, in fact, indirectly influence the students' PTSD Status. Proximity to the WTC (distance and time) and having a direct view of the WTC and/or the plume of smoke from one's neighborhood are also considered risk factors affecting PTSD in children. In addition to these negative neighborhood environmental factors, attending a school with a negative school environment and low school achievement indirectly affects PTSD Status of students.

Figure 2. Conceptual Model



1.3. Significance of the Study

Although distance effects on PTSD have been studied, for the most part, distance measures have been arbitrary or anecdotal. Objective measures of distance need to be tested in order to understand its true effect. Neighborhood factors have been used in studies of anti-social behavior, substance use, major depression and anxiety but not in relationship to PTSD. Several epidemiological studies have applied statistical models when analyzing multi-level data, but few, if any, have measured how neighborhood, school and individual factors are associated with PTSD. The effect of spatial autocorrelation has not been considered, tested for, or controlled for in previous studies – an important consideration when analyzing data which has a spatial component as spatial aggregation of data can influence statistical models. This study not only includes individual and school level data but also Census population data and location-based physical exposure measures derived using GIScience methodologies. Analysis is conducted with a geographical theoretical framework, where the effects of spatial dependence is measured (and controlled for, if needed). This study informs the epidemiological, mental health and geographic literature concerning new methodologies and will help to expand the overall understanding of PTSD, the geographies of mental health, and the role and definition of physical exposure after a large-scale event, such as that of 9/11.

2. Literature Review

The relationship between geography and physical health has long been studied (Barrett, 2000; Gilbert, 1958; May, 1950; Haggett, 1992; Meade, 1977; Corburn, Osleeb, and Porter, 2006; Jackson, Richardson & Best, 2008; Duncan, Jones & Moon, 1993). In similar fashion, researchers have been studying variations of psychopathology across different cultures, communities and geographies, in an effort to determine why these variations occur (Weissman, 1978, Faris and Dunham, 1939; Eaton, 1974; Silver, Mulvey and Swanson, 2002; Galea et al., 2005; Galea et al., 2007; DiMaggio et al., 2010; Hoven et al., 2004). For example, Faris and Dunham (1939) described how schizophrenia and substance abuse rates differed among urban cores, suburbs and rural areas (higher concentrations surrounding the urban core) in Chicago. The social stress model that specifies that “stressful life events and chronic life difficulties cause psychological stress and that psychological stress contributes to mental health problems” was developed using this framework (Silver, Mulvey and Swanson, 2002, pg., 1457). Other theories have evolved that considered deficiencies of socio-cultural areas that were found to provide physical security that lead to higher rates of psychopathology (Leighton, 1965). These socio-cultural areas would result in high concentrations of single parent homes, weak social organizations, few recreational opportunities, and high crime. Others argue that “these patterns, in turn, often follow a recent history of disaster, widespread ill health, extensive poverty, cultural confusion, widespread secularization, extensive migration and rapid and widespread social change” (Cohen, Slomkowski and Robins,1999, pg. 3). However, few, if any, have measured the relationships of these socio-cultural factors on mental health of children.

2.1. Neighborhood Effects

Several studies have shown that socio-economic status is inversely correlated with psychopathology including major depression, substance abuse and anxiety disorders (Dohrenwend, et al., 1992, Gorman-Smith & Tolan, 1998; Galea et al., 2005; Galea et al., 2007; DiMaggio et al., 2010). Researchers have also shown that although neighborhood SES and an individual's SES are highly correlated, "neighborhood characteristics made an independent contribution to the prevalence of mental disorders" (Silver et al., 2002; pg. 1458). Disadvantaged neighborhoods (high poverty and high rates of single-mother households) with high residential mobility (percent of residents not living in the same neighborhood in the past five years), have been identified to predict higher rates of depression and anxiety (Ross, 2000). A modified version of the social stress model (Silver et al., 2002) has been used to analyze schizophrenia, major depression and substance abuse in communities (New Haven, CT, Baltimore, MD, Durham, NC and Los Angeles, CA), using the National Institute of Mental Health's Epidemiological Catchment Area (ECA) – a community probability study of adults conducted between 1981 and 1983 (N=11,686 after excluding St. Louis, originally included in the ECA) – individual level data, as well as neighborhood level data from the 1980 Census tracts (N=261) where the participants resided. Since multicollinearity exists among the Census level variables, a principal components analysis (PCA) (with Varimax rotation) was performed to create two indices ("neighborhood disadvantage" and "neighborhood residential mobility") from the thirty-six Census variables. Percent: households with public assistance, families that are "husband-wife", persons living below poverty, adult unemployment, families with children in female-headed households, and annual income above $30,000, loaded into the "neighborhood disadvantage" component. And, percent of persons (over five years old) who resided in the same household for the past five years and percent of rental housing units loaded into the "neighborhood residential mobility" component. Their main findings included that the neighborhood disadvantage and the neighborhood residential mobility indices were statistically significantly associated with all three measures of psychopathology (schizophrenia, major depression and substance abuse), even after controlling for individual SES such as household income, education attainment and living with spouse/significant other. Similar to Major Depression, Schizophrenia and Substance Abuse, community level variations of SES, residential mobility, and ethnic heterogeneity have been found to be correlated with crime (Sampson, 1985, 1988; Byrne & Sampson, 1986), delinquent and violent behavior and anti-social personalities (Gorman-Smith, et al., 1996; Dohrenwend, et al., 1992). Although these studies shed light into neighborhood effects on several mental health disorders in adults and adolescents, none have included the potential impact of the school's environment on children and adolescents. Furthermore, none have considered neighborhood safety, a possible proxy for previous exposure to traumatic events.

2.2. PTSD

Post Traumatic Stress Disorder (PTSD), an anxiety disorder which develops after an individual is directly or indirectly exposed to a traumatic event, was first included in the *Diagnostic and Statistical Manual of Mental Disorders, Version III* (DSM-III) by the American Psychiatric Association for adults in 1980 and for children and adolescents in the DSM-III-R in 1987. PTSD has been widely studied in relation to natural and technical disasters, as well as a consequence of war and violence (Davis & Siegel, 2000). According to the DSM-IV, to develop

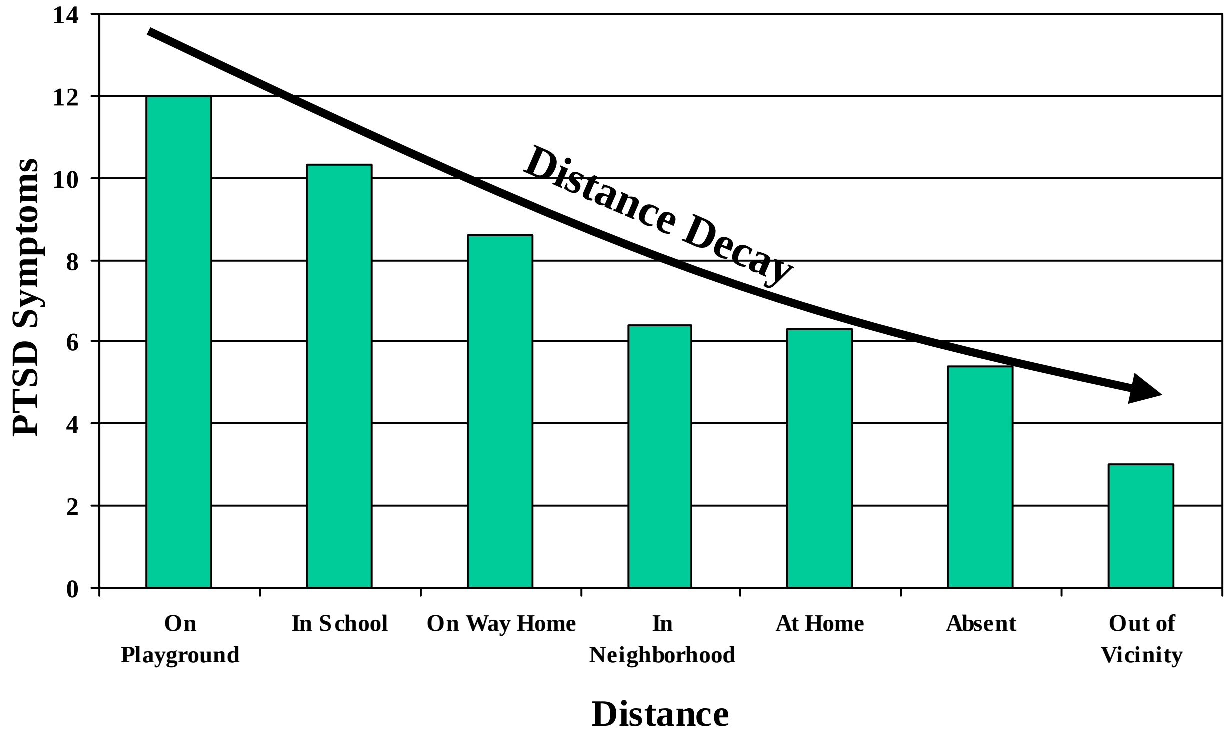
PTSD, a “person [has (1)] experienced, witnessed, or was confronted with an event or events that involved actual or threatened death or serious injury, or a threat to the physical integrity of self or others; (2) the person’s response involved intense fear, helplessness or horror’’ (1994, p. 428). Additional symptoms of (1) re-experiencing of the traumatic event with either nightmares, flashbacks, etc.; (2) persistently avoided trauma related stimuli and numbing such as avoiding thoughts, events and activities that remind the person of the event; (3) persistent symptoms of increased arousal by either difficulty falling or staying asleep, irritability, difficulty concentrating, etc.; (4) the symptoms mentioned above must persist for at least one month or more; and, (5) the person must also be clinically impaired (e.g., socially, occupationally, etc.) (American Psychiatric Association, 1994). Finally, PTSD is classified as *acute* (symptom duration is less than three months), *chronic* (symptom duration is more than three months), and *delayed* (onset of symptoms is at least 6 months after the traumatic event).

Pynoos et al. (1987) were the first to demonstrate the association between the physical proximity to a traumatic event and posttraumatic stress responses to an event exposure in children. On February 24, 1984, a sniper started shooting from across the street at the 49th Street Elementary School, Los Angeles, California. One child and one adult were killed, and thirteen children were injured. One month after the event, Pynoos and his colleagues administered the PTSD Reaction Index, a screen to assess posttraumatic stress disorder, based on DSM-III R criterion, to a random sample of 159 students in the school (14.5% of all students). Pynoos found that the mean number of PTSD symptoms decreased with physical proximity to the actual shooting (see Figure 3). Those students who were on the school playground had an average of 12 PTSD symptoms. The mean number of PTSD symptoms decreased with physical distance, measured in arbitrary distance categories.

Subsequently, Pynoos et al., (1987) regrouped the seven distance categories into four: playground, at school, not at school, and, off track, and compared them to the severity of PTSD (no PTSD; 2 to 7 symptoms; mild: 7 to 9 symptoms; moderate: 10 to 12 symptoms; and, severe: greater than 12 symptoms). A chi-square test showed that a statistically significant relationship existed between the four distance categories and the severity of PTSD. (χ^2=61.5, df=9, $p<0.001$) (Pynoos, et al., 1987, pg. 1059).

The work of Pynoos et al., in the early understandings of PTSD in children/adolescents made a very important contribution. However, it suffered from a critical limitation, in which distance categories were arbitrary. For example, “on the way home” and “at home” distances could, in fact, be similar if measured in Euclidean terms or in terms of travel distance/time. Also, the neighborhoods in which the students lived could be quite different in terms of socio-economic status, quality and safety.

Figure 3. Mean Posttraumatic Stress Disorder Reaction Index Scores by Exposure (F=16.06, df=6, p<0.001). (Adapted from Pynoos, et al., 1987, pg. 1059)



Severe levels of post-traumatic stress have also been recorded among adolescents in countries heavily affected by natural disasters and other post-disaster areas (Thienkrua et al., 2006; Neuner et al., 2006; Kar et al., 2007; Bokszczanin, 2007; Sahin et al., 2007; Weems & Overstreet, 2008; Weems et al., 2007). In Nicaragua, after Hurricane Mitch, post-traumatic stress reactions varied from 14 to 90% in three cities according to level of impact (Goenjian, 2001). Proximity to the epicenter of an earthquake among children in Armenia (Pynoos, et al., 1993) was also found to be significantly related to level of adverse effect. Similar findings (Groome and Soureti, 2004) were recorded five months after the 1999 earthquake in Athens, Greece, where the Impact of Event Scale (IES), the Revised Children's Manifest Anxiety Scale and the Earthquake Trauma Exposure Scale was administered to 178 children from three districts in Athens (Zefiri, closest to epicenter and most damaged, N. Iraklioafter, further from epicenter and moderately damaged, and Paiania, furthest from epicenter and only lightly damaged). As with Hurricane Mitch and the Armenian earthquake, proximity to the epicenter was found to be statistically significant in relation to PTSD symptoms ($F=6.29$, $df=2$, $p<0.01$). Unlike the school shootings, in each of these natural disasters, there was personal physical exposure to at least some damage. These results suggest that the nature of a traumatic experience might determine the strength of association between proximity to traumatic event and posttraumatic stress reactions in children. Yet, all of these studies measured distance in arbitrary terms and ignored other neighborhood level variables such as quality, safety, and socio-economic status.

2.3. 9/11 Related PTSD

On September 11, 2001, the US was impacted by the largest, costliest and deadliest terrorism attack in US history. In NYC alone, 2,749 persons died on the attacks of the World Trade Center (WTC) (USA Today, 2004). Several research studies have been done in the wake of the aftermath of the WTC attacks. One study (Schuster et al., 2001) used random-digit dialing (RDD) three to five days after 9/11 in a national representative sample of 560 adults. Respondents, who had children ages 5 to 18, were also interviewed about their child (170 children). For the measure of PTSD, the Posttraumatic Stress Disorder Checklist (PCL), a seventeen item survey instrument, was used. Measures of TV viewing, age, gender, race/ethnicity, and prior emotional health problems were also collected. The centroid of each respondent's zip code (and centroid of telephone-exchange area for those 8% who refused to provide their zip codes) was used to measure the distance from their residence to that of all the crash sites, as well as the takeoff and destination of the planes involved in the 9/11 attacks. The study found those who lived within 100 miles to have a statistically significantly higher rate of stress reaction – one or more questions endorsed as “quite a bit” or “extremely” on a five point likert scale – than those living between 101 and 1000 miles or those living 1001 or more miles from the WTC (61%, 48% and 36%, respectively, $p<0.001$). Similar analysis found no significant differences in children’s stress reactions to the attacks. Hours of TV viewing on September 11, was also statistically significant. Those viewing 13 hours or more reported statistically significantly higher rates than those viewing 8-12 hours, 4-7 hours and 0-3 hours (58%, 46%, 39%, and 37%, respectively, $p=0.001$). TV viewing was not asked of children. In addition to these variables, females, non-whites and those with prior emotional or mental health problems had statistically significantly higher rates of stress reaction.

Although this study found distance decay in the adult data, the comparison of 100 miles, 101-1000, and 1001 plus miles, is arbitrary. Also, nothing is known about the effect of close-proximity (e.g., within 10 miles) to the event on eventually developing PTSD, and data obtained on children were from parent reports, not from the children themselves.

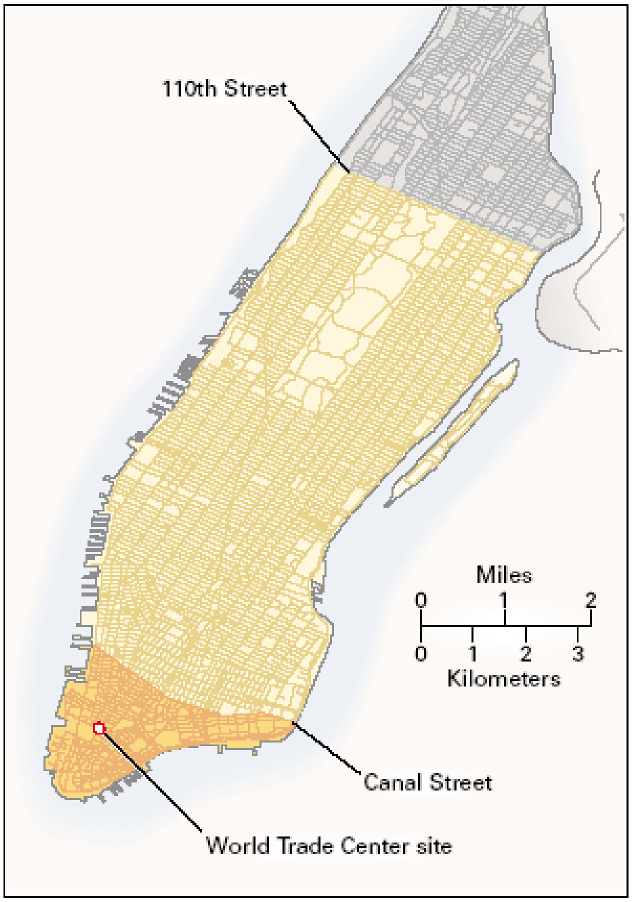
A nationally representative web-based epidemiological survey of the effects of 9/11, including over-samples of NYC and Washington DC Metropolitan Areas (N=2,273 adults), used the PTSD Check List (PCL) and the Brief Symptom Inventory (Schlenger et al., 2002). Using a multivariate logistic regression controlling for age, gender, race/ethnicity, and education, residing in the NYC Metropolitan area rates of PTSD were found to be statistically significantly higher for those residing in Washington DC, other metro areas, and the rest of the US (11.2%, 2.7%, 3.3%, and 4.0% respectively, $p=0.007$). TV viewing was also a strong predictor of probable PTSD (as only a physician can determine PTSD diagnosis, all survey instruments can only be considered to be "probable" PTSD), in addition to age and gender. For those residing within the NYC Metropolitan area, an analysis was performed focused on if they were in the WTC or surrounding buildings on September 11, had been close enough to see the smoke from the towers, having family, or had friends and/or co-workers killed or injured on September 11. In this analysis, age, gender, being in the WTC on September 11 and TV hours viewed, were the only predictors of probable PTSD, indicating that distance is not a factor.

At the college level, Blanchard et al. (2004 and 2005) performed two studies. In the first study, the researchers conducted a survey to 1,369 public college students from Albany, NY, Augusta, GA, and Fargo, ND (n=507, n=336 and n=526, respectively) from Mid-October through the end of November 2001, to assess Acute Stress Disorder (ASD) and PTSD (using the PCL) levels related to 9/11. Frequencies of PTSD symptoms were found to be statistically different between sites (Albany=11.3%, Augusta=7.4% and Fargo=3.4%) and probable PTSD (PCL score 40 or higher) was found to be statistically significant between the three sites (Albany=28.6, Augusta=26.2 and Fargo=23.6, $p<0.001$). For those students residing in NY at time of 9/11, an additional analysis to investigate the effects of proximity to the WTC from their residential zip codes was performed. NYC zip codes were compared to "Level 2 counties" (or those counties surrounding NYC including Nassau, Westchester and Rockland), "Level 3 counties" (Suffolk, Orange and Putnam), "Level 4 counties" (Dutchess, Ulster, and Sullivan) and "Level 5 counties (rest of NY State). One-way ANOVA on PTSD symptoms was not significant; however, when NYC and Level 2 counties (e.g., Westchester, Nassau, etc.) were combined, one-way ANOVA on PTSD symptoms was significant ($p=0.001$). As with other studies, gender, hours of TV viewed, past traumatic exposure and past mental health problems were statistically associated with number of PTSD symptoms.

Their second study within the same three public universities in Albany, Augusta and Fargo, three weeks following the first anniversary of the 9/11 attacks, sampled 1,313 students (Blanchard et al., 2005). Although differences in symptoms between the three sites continued to be statistically different, probable PTSD was not (Albany=7.9%, Augusta=6.4% and Fargo=5.2%). When comparing NYC+Level 2 counties to Level 3, Level 4 and Level 5 counties, distance to the WTC from permanent residence and location on September 11, 2001 continued to be statistically significant.

A random digit dialing (RDD) survey of adult NYC residents living below 110th street in Manhattan - stratified by home residence (see Figure 4) was conducted between October 16 and November 15, 2001 (Galea et al., 2002a). Throughout the catchment area, the researchers surveyed 1,008 adults, of which, 20 were dropped for missing data. (n=938 between 110th street; n=50 below Canal Street).

Figure 4. Catchment Area used by Galea et al. (2002a, pg. 983)



They found that prevalence of PTSD and Depression (the only two disorders studied) differed greatly in the two geographic areas of the study. Using bivariate analysis, the rates of PTSD among the sample that lived South of Canal Street was 20.0 versus 6.8 who lived from Canal to 110th Street (p=0.04). The result of a multivariate analysis, controlling for race/ethnicity, number of prior stressors in the past 12 months, symptoms of panic attack during or soon after the events, loss of possessions, social support in previous 6 months, friend or relative killed, and job loss due to the attacks, found that those living South of Canal Street had an Odds Ratio (OR) of 5.6 (2.5 - 12.4 95%CI), in relation to those living between Canal and

110th Streets. Therefore, those who resided South of Canal Street were more than 5 times more likely than those residing Canal to 110th Street. Although these findings are striking, it is surprising that researchers decided to aggregate the data into these two arbitrary geographic areas. First of all, residents living on the east side of Manhattan below (south of) Canal Street are actually further than those living just north of Canal Street in the central and western areas of the island (see Figure 4 above). Secondly, the areas between Canal and 110th Streets make up most of Manhattan Island. Finer spatial gradations (using the exact distance to the WTC site) may have identified certain neighborhoods with increased risk for PTSD.

DiMaggio et al. (2010) analyzed the relationship of proximity to the WTC among adult New York State Medicaid recipients using Bayesian hierarchical approach. In this study, the researchers used zip code level aggregated counts of anxiety-related diagnoses. This study found that each two mile increments towards the WTC resulted in a 7% increase in anxiety-related diagnoses. Although this study measured distance in Euclidian terms, instead of anecdotal aggregates, distance to the WTC in their sample ranged from 2.2 to 20.5 miles.

The NYC Board of Education study (NYC-BOE) (Hoven, et al., 2002) collected demographic information, measures of direct exposure (e.g., was in the cloud of smoke), family exposure (e.g., family member died or escaped hurt or unhurt), prior trauma (e.g., immigrant from a war torn country) and high media exposure (e.g., time spent watching 9/11 news on TV), as well as other health outcomes (see Table 1), and assessed eight disorders commonly found in children and adolescents including PTSD, as determined by the Diagnostic Interview Schedule for Children (DISC) (Shaffer, et al., 2000) Predictive Scales (DPS) (Lucas, et al., 2001). The DPS screen includes only those items that are most predictive for each of the disorders. The survey also obtained the home zip code of the students and if they were at school at the time of the attack. The eight probable disorders were all elevated and 10.6% of all public school children were estimated to be positive for probable PTSD (see Table 2) (Hoven, et al., 2002; Hoven, et al., 2005).

Table 1. Sociodemographics and Exposures for 8236 Sample Children: New York City School Survey Post–September 11th, Grades 4 Through 12

	Sample Size (Unweighted)	Unweighted Percentage (SE)	Weighted Percentage (SE)	New York City Public School Students Grades 4-12 (2001-2002), %*
Grade group				
4-5	1245	15.1 (4.7)	25.3 (9.6)	24.0
6-8	2924	35.5 (6.9)	33.7 (9.1)	34.4
9-12	4067	49.4 (6.6)	41.0 (10.0)	41.5
Female	4316	52.4 (1.8)	53.1 (2.8)	50.6
Race/ethnicity†				
African American	1855	22.5 (3.3)	27.9 (5.3)	34.6
Latino	2936	35.6 (3.3)	40.1 (4.4)	36.3
White	1489	18.1 (3.0)	13.4 (3.3)	15.8
Asian	1552	18.8 (2.2)	12.8 (3.2)	13.0
Mixed/other	404	4.9 (0.5)	5.7 (0.8)	0.3
Exposure				
Attendance in ground zero area school	2042	24.8 (1.3)	1.3 (0.1)	
Direct exposure (≥2)	3226	39.2 (1.9)	24.6 (2.3)	
Any family exposure	957	11.6 (0.6)	12.5 (1.0)	
Prior exposure (≥2)	2376	28.8 (1.2)	30.6 (2.1)	
High media exposure	5292	64.2 (1.3)	63.3 (2.5)	
Belle Harbor plane crash	258	3.1 (0.7)	2.9 (0.6)	
Mental health service use	1586	19.3 (0.9)	18.8 (1.2)	

*Source: New York City Department of Education.[24]

†The New York City Department of Education used US census 1990 race/ethnicity categories that do not include "mixed race." The "other" group reported by the Department of Education is Native American (0.3%). The study reported herein used US census 2000 race/ethnicity categories and allows for mixed race.

Hoven, et al., 2005, pg. 549

The NYC-BOE study identified expected risks, including being a girl (Adjusted Odds Ratio (AOR)=1.90, 95%CI=1.52-2.36), family exposure: AOR=1.80, 95%CI=1.28-2.55; prior trauma: AOR=2.01, 95%CI=1.55-2.62; and, high media expsosure: AOR=1.58, 95%CI=1.23-2.03), all consistent with other post-disaster studies of PTSD in children (see Pfefferbaum, et al., 2001; Pfefferbaum, et al., 2003). However, in these data, being a student in a Ground Zero Area school (South of Canal Street, similar to Galea, 2002), that is, one in "close proximity" to the WTC, was actually slightly *protective* against developing probable PTSD (AOR=0.66, 95%CI=0.51-0.85), contrary to prior literature (Pynoos, et al., 1987; Galea, et al., 2002a; Blanchard, et al., 2004).

Table 2. 6 Months' Post-September 11 Prevalence of Probable Mental Disorder by Exposure Level, Compared With Pre–September 11 US Community Rates, for 8236 New York City Public School Children in Grades 4-12*

	NYC-DOE WTC School Survey							
			Exposure Level†					
Probable Disorders‡	Estimated No. of Students	Total Sample (N = 8236)	Severe (n = 2650 [32.2%])	Moderate (n = 2840 [34.5%])	Mild (n = 2746 [33.3%])	*P* Value§	US Community Studies (Ages 9-17), Pre–September 11, %
PTSD	75 916	10.6 (1.50)	18.4 (2.3)	10.0 (1.7)	3.6 (1.1)	<.001	3.3 ‖
Major depression	58 011	8.1 (0.98)	11.0 (1.6)	8.0 (1.4)	5.4 (1.3)	.007	2.1-5.9 ‖¶#**
Generalized anxiety	73 767	10.3 (0.98)	14.1 (1.7)	9.8 (1.5)	7.2 (1.0)	.002	3.4-5.5 ‖**
Separation anxiety	88 091	12.3 (1.39)	20.1 (2.0)	11.8 (1.7)	5.4 (1.2)	<.001	1.7-7.7 ‖¶#**
Panic disorder	62 308	8.7 (0.83)	13.0 (1.7)	8.4 (1.3)	4.9 (0.9)	<.001	0.6-4.1 ‖**
Agoraphobia	105 996	14.8 (1.58)	21.8 (2.7)	15.4 (1.9)	7.6 (1.5)	<.001	1.3-4.5 ‖¶
Any anxiety/depressive disorder††	204 829	28.6 (1.47)	38.9 (2.8)	29.1 (2.2)	18.2 (1.8)	<.001	
Conduct disorder	91 672	12.8 (1.29)	14.3 (1.8)	12.5 (1.7)	11.6 (1.8)	.43	3.9-11.2 ‖#**
Alcohol abuse/dependence (grades 6-12)	24 461	4.5 (0.81)	6.0 (1.4)	4.2 (1.2)	3.6 (0.8)	.28	0.9-2.2 ‖¶**

Abbreviations: DISC, Diagnostic Interview Schedule for Children; DPS, Diagnostic Interview Schedule for Children Predictive Scales; NYC-DOE, New York City Department of Education; PTSD, posttraumatic stress disorder; WTC, World Trade Center.

*Weighted data. Values are expressed as percentage (standard error) unless otherwise indicated.

†Severe exposure = 2 or more direct and/or at least 1 family exposure; moderate exposure = 1 direct and no family exposure; and mild exposure = no direct or family exposure.

‡Reported rates are with impairment, except for alcohol abuse/dependence and conduct disorder.

§Overall χ^2 test. Results of paired χ^2 tests on exposure level. All comparisons are significant at *P*<.05, except for conduct disorder and alcohol abuse/dependence, major depressive disorder (moderate vs mild and moderate vs severe), and generalized anxiety disorder (moderate vs mild).

‖Lucas CP, 2002, DPS validation report; *DSM-IV;* 9 to 17 y; DPS (N = 687); DISC Version IV (N = 191) (unpublished data, 2002).

¶Bird et al[25]; *DSM-III;* 4 to 16 years; DISC Version 2.0 (2-stage sampling design; first stage [N = 777]; second stage [N = 386]).

#Cohen et al[26]; *DSM-III-R;* 9 to 18 years; DISC Version 1.0 (N = 776).

**Shaffer et al[27]; *DSM-III-R;* 9 to 17 years; DISC Version 2.3 (N = 356).

††"Any" is limited to PTSD, major depression, generalized anxiety, separation anxiety, panic, and agoraphobia.

Hoven, et al., 2005, pg. 549

In a study conducted in a Bronx, NY high school (N=1,214 predominantly Hispanic and African-American students), 20 miles north of WTC, using the PCL, the researchers attempted to identify racial/ethnic differences in PTSD by exposure to the 9/11 events (Calderoni, et al., 2006). A rate of 7.4% was found for probable PTSD – or "PTSD clusters" as termed by the researchers – in the high school. Although racial/ethnic differences (between African-Americans and Hispanics) were found in several symptoms, no differences were found between the racial/ethnic groups at the level of probable PTSD. Knowing someone who died, knowing someone who was injured, financial difficulties after 9/11, loss of psychosocial resources (feeling less safe and having less faith in the government after 9/11) and prior use of psychotropic medications were the only statistically significant predictors of probable PTSD in a multivariate logistic regression. The researchers compared their 7.4 rate of probable PTSD to that of the NYC-BOE High School rate of 6% (for all of NYC High Schools) and suggest that the difference in rates is related to more violence in their students' neighborhoods:

> The 2001 annual report of the Bronx County District Attorney indicates that the Bronx has higher rates of violent crimes than NYC as a whole. However, we did not directly measure violence exposure in our subjects. The high school we chose is a large, community public high school that serves several surrounding Bronx neighborhoods. Silver and Bauman studied 1052 Bronx youth, aged 14 to 17 years from the same neighborhoods as our subjects, and found that 58% reported having been direct victims of violent acts (being beaten, chased, threatened, robbed, mugged, shot, or stabbed). Of their sample, 90% reported witnessing a violent act happening to another person. Other studies indicate that minority, urban youth living in communities with high rates of poverty are exposed to violence more frequently than youth living in middle or higher socioeconomic communities. Thus, it is very likely that the minority, urban youth who participated in our study also have been exposed to similar levels of violence. (Calderoni et al. 2006, pg. 64).

However useful this quote may be, it is purely anecdotal and researchers showed no evidence that their study included measures to analyze the effects they claim was increasing their students' PTSD rates.

Until the NYC-BOE Study (Hoven et al., 2005) the literature on the associations of proximity to the traumatic event and rates of (probable) PTSD, indicated a distance decay effect. However, in most of studies, distance had been measured in aggregate terms – residing in a city/county or area of Manhattan – or anecdotal terms – being in the playground or in the woods surrounding the school. No study has been performed where distance was measured in Euclidian terms. Although neighborhood effects (e.g., rates of poverty, crime, etc.) on anxiety rates had been studied, none included its effects on PTSD in any published analysis.

This study, for the first time, includes Euclidian and transportation distances, neighborhood and school level variables (e.g., SES, crime, etc.) in standard statistical analyses as described above, a Hierarchal Linear Model (HLM) – to control for individual, school and neighborhood level differences – a well as geographic spatial analysis techniques (Spatial Regression and Geographically Weighted Regression) to investigate the possible effects of spatial autocorrelation. With these techniques, this study hopes to determine which school and neighborhood environmental variables are risk or protective factors in the NYC-BOE sample.

3. Research Aims and Hypotheses

AIM 1. To determine which individual factors are associated with PTSD Symptoms (Sy) and probable PTSD Diagnosis (Dx). In the original survey, students were asked eight questions related to their PTSD symptoms and eight symptoms related to their functional impairment. If a student endorsed more than 4 PTSD symptoms plus were impaired, they were considered to have the (probable) disorder, following DSM-IV criteria (see part 5 of PTSD definition described in Section 2.2 above). Prior analyses have shown that students' demographic factors (race/ethnicity, age, gender, etc), low maternal education and living with both parents are risk factors for PTSD Sy and Dx. Direct (2+ of 5 items endorsed), familial (any), and TV exposures (answered "a lot" to questionnaire item) to WTC, and previous exposure (2+ of 6 times endorsed) to trauma are risk factors for PTSD Sy and Dx. It is hypothesized that these same risk factors will continue to be high predictors of the number of PTSD Symptoms (Sy) endorsed and the (probable) PTSD diagnosis (Dx).

AIM 2. To determine which school level factors are associated with PTSD Sy and Dx. It is hypothesized here that low school performance, and low school quality are risk factors for PTSD Sy and Dx.

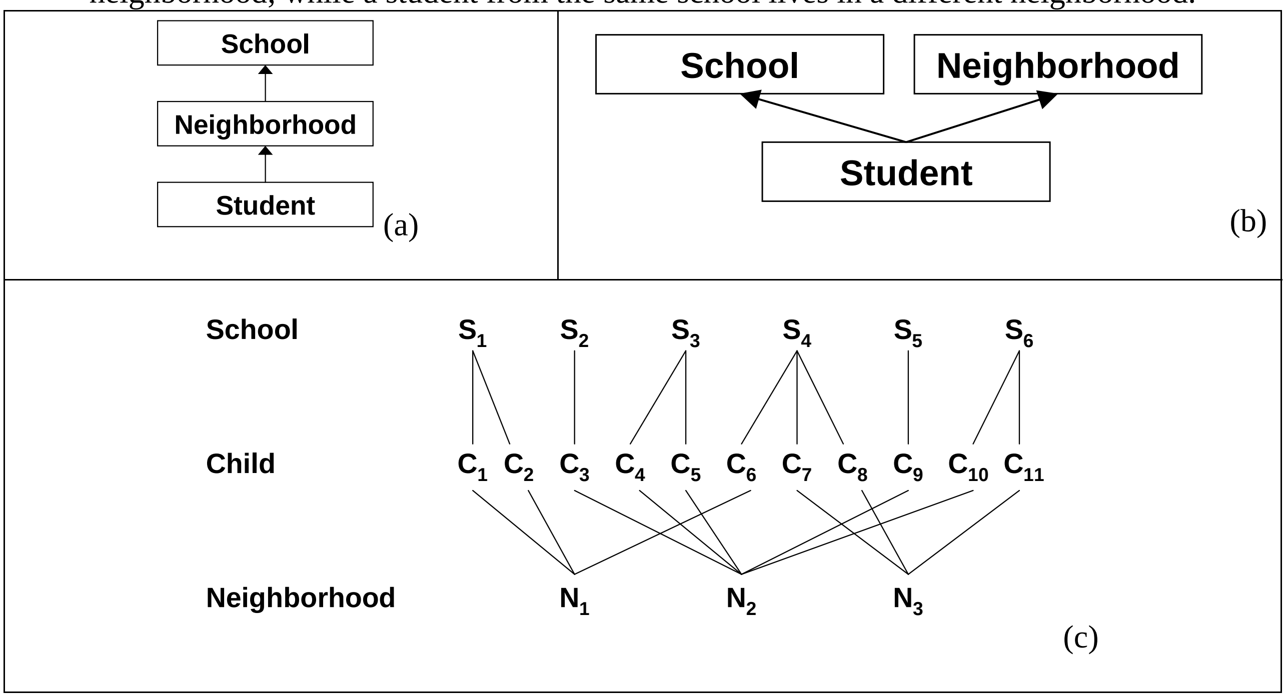
AIM 3. To determine which neighborhood level factors are associated with PTSD Sy and Dx. Low neighborhood SES and residential mobility have been shown to be risk factors for anxiety in other studies. Since PTSD is a type of anxiety disorder, it is hypothesized here that there are also risk factors for PTSD Sy and Dx. High crime, or low neighborhood safety, and low neighborhood quality are also risk factors for PTSD Sy and Dx. Because distance has not been a factor in prior analysis of this data, it is hypothesized that Euclidian distance, transportation distance and time of travel from the students' zip code to their school is not a risk factor for PTSD Sy and Dx. However, having Line-Of-Site from the students' zip code to the WTC towers and living in a zip code which was under the plume of smoke from the WTC attack is hypothesized to be a risk factor for PTSD Sy and Dx.

4. Methods

In this research, traditional statistical approaches (ordinary least square and logistic regressions) are performed and compared to hierarchical linear models, as well as spatial regression and geographical regression, in order to observe if the hierarchical structure (e.g., grouping students among certain schools and/or neighborhoods) and spatial aggregation (to the zip code) affect the traditional analytical approaches. Neighborhood and school level indices were created using principal component analysis (PCA) techniques and used in ordinary least square (OLS) multivariate regressions and logistic regressions to test and compare the effect of the individual, neighborhood and school level variables on PTSD Sy and Dx (Silver et al., 2002; Duncan, Jones & Moon, 1993; Jackson, Richarson & Best, 2008; Harvard et al., 2008; Krieger, Williams & Moss, 1997; Krieger et al., 2003; Galea et al., 2005; Galea et al., 2007).

Statistical models, where the hierarchical structure (e.g., student attending a school living in different neighborhoods share the school level information with other students in the same school and neighborhood level information with other students living in the same neighborhood), if not taken into account may result in incorrect standard errors as well as loss of information regarding inter-unit variation (Goldstein & Steele, 2007). Because of this, a Hierarchical Linear Model – also known as mixed models, random coefficient models, and multilevel models – was created to examine the effects of the school and neighborhood environments on the individual. Two types of multilevel models can be considered. A simple hierarchy - where the students are nested within a given school and again nested within a specific neighborhood – would apply to public school students in the lower grades where they attend a school within their given geographic region, but not the case in these data (see Figure 5a). For students in the 6^{th} grade and above, a cross-classification model (see Figure 5b) – where students from one school live in different neighborhoods – represents a more complete model and enables comparison of school vs. residential effects (see Figure 5c) and was used here (Goldstein & Steele, 2007). In this model (Figure 5c), it is assumed that variables that are obtained to reflect the school which the student attended and the neighborhood in which the student resided have interactive effects on their PTSD Status.

Figure 5. Simple (a) and Cross-Classification HLM.
In a Cross-Classification HLM (b and c), A student attends one school and lives in a given neighborhood; while a student from the same school lives in a different neighborhood.



To observe the effects of the individual, school and neighborhood levels, Hierarchical Linear Models (HLM) were created in the SAS statistical software. HLM fits models to dependent variables that control for variations at each level (eg., school, neighborhood). It estimates model coefficients at each hierarchical level and odd ratios (OR) for each of the dependent variables using the form in equation (1):

$$y_{i(j1,j2)} = \beta x_{i(j1j2)} + u_{1j1} + u_{2j2} + e_{i(j1j2)} \quad (1)$$

Where:
$y_{i(j1,j2)}$ = *PTSD Sy (number of positive symptoms) or PTSD Dx (4+ positive symptoms plus impairment) for student i in neighborhood* j_1 *and school* j_2
$u_{1,j1}$ = *the random neighborhood effect*
$u_{2,j2}$ = *the random school effect*
$e_{i(j1j2)}$ = *error for student i in neighborhood* j_1 *and school* j_2

Ordinary Least Squares regression (OLS) and Logistic Regressions (LR) have been widely used by statisticians, psychologists, sociologists, economists and geographers to describe the relationship among independent and dependent variables. However, traditional statistics that fail to account for spatial dependence and spatial autocorrelation in the dependent variable, are unreliable or unstable.

Spatial Regression incorporates individual level and sub-country level data in regional econometric models (Anselin, 1999; Florax, & Nijkamp, 2004; Petrucci, Slavati & Seghieri, 2003). It has been used throughout the world in regional sciences, using aggregated data, which found that traditional econometrics failed to account for spatial dependence; therefore, their OLS are unreliable or unstable. Spatial regression models use a spatial lag operator, or a weighted average of its neighbors, as a spatial smoother, via a weight matrix to control for spatial autocorrelation. Weights can be calculated as neighbors, distance or k-nearest neighbors (usually standardized) (Anselin, 1999). With this approach, much like OLS, independent variables predict the dependent variables. Unlike OLS, however, due to the spatial weights applied, spatial autocorrelation (spatial interaction of the terms) is controlled for by weighting those cases which are closer in space differently than those which are further apart.

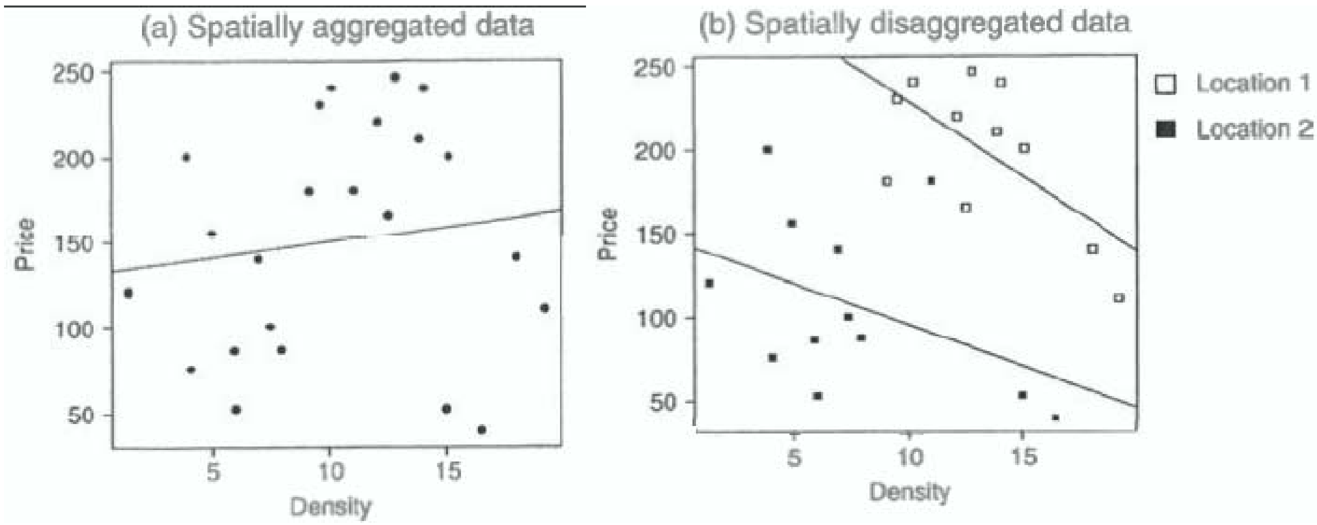
A functional relationship between a random variable at a given location and this same random variable at other locations is expressed in a spatial autocorrelation operator (a weight).

The operator is computed as either a simultaneous Spatial Autoregressive Process (SAR), or a Spatial Moving Average (SMA). While the SAR uses spatial multiplier effect or, global interaction, the SMA observes “local” interactions between a location and its neighbors but does not yield a spatial multiplier, or global interaction. In addition to two types of spatial autocorrelation operators, the spatial regression model can be defined as a Spatial Lag Model (where the spatial interaction is observed in the independent variable itself) or a Spatial Error Model (where the spatial interaction is observed in the error term). The focus of interest of the Spatial Lag Model is the assessment of the existence and strength of spatial interaction. The Spatial Error Model (known as “nuisance dependence”) is appropriate when the concern is with correcting for the potentially biasing influence of the spatial autocorrelation, due to the use of spatial data (irrespective of whether the model of interest is spatial or not). A Maximum Likelihood Estimation incorporates spatial effects, while the Moran’s *I* and Lagrange Multiplier tests serve as diagnostics for the presence of spatial effects and specification test of robustness against an a χ^2 distribution (Anselin, 1999).

Since the only geographic identifier available in the data is the zip code, point pattern analysis is not possible. Therefore, for this research, all data were aggregated back to the zip code. All binary variables (PTSD Dx, Female, Racial/Ethnic categories, Exposures, etc.) were summed to the zip code level; while the mean and the median of all continuous variables (PTSD Sy, age, and all indices) were calculated. To observe if the aggregation of mean or median has an effect on this analysis, separate models for median and mean were conducted and differences were observed. Moran’s I, to determine if there is a spatial interaction in the outcome variables was calculated. In order to observe any localized clustering of PTSD, a Local Indicator of Spatial Autocorrelation (LISA) was also calculated. Even if these indicators were found to be non-significant, the Spatial Lag and Spatial Error models were performed for the PTSD Sy and Dx for the purpose of observing any spatial patterns that may be found in these variables and to compare the results of the OLS and spatial models.

While the spatial regression model addresses the global model, Geographically Weighted Regressions address localized spatial autocorrelation, or regional effects (Fotheringham, Brundson and Charlon, 2002). GWR for Windows was used. If local spatial relationships exist in a global model, regression estimates can be incorrect if the data is disaggregated or aggregated to sub-regions (see Figure 6). When data is aggregated to one global spatial area, regression results may indicate an association that behaves quite differently when the data is spatially disaggregated or regional analyses is performed. GWR incorporates local spatial relationships into a traditional regression framework using a “bandwidth” or kernel as a spatial filter (spatial window). Here, only those cases that fall within this spatial window are included in the regression. Local regressions are performed at each observation point or at each centroid of a grid placed over the study area. For this research, the centroid of the zip code was used. Since the model is sensitive to the bandwidth chosen, the models were configured to let the software select the bandwidth by using the Akeike’s Information Criterion (AIC) (a measure of the "goodness" of fit of a statistical model) to determine the best bandwidth. GWR models were performed for both PTSD Dx and PTSD Sy (with mean and median aggregations to observe differences in the results).

Figure 6. Global versus Local Regressions



(From Fotheringham, Brundson & Charlton, 2002)

4.1. Sample

Students not at school at the time of the attack (10.7%) were excluded from this analysis since there is no way to determine where they were or how far from the WTC they were at the time. Students in grades 4 and 5 were also excluded in order to keep a more homogeneous sample, since both the questionnaire (some questions omitted for younger students due to the nature of the question) and method of administering the survey in grades 4 and 5 differed from grades 6 through 12 due to age (the survey monitor read out loud the survey while the younger students completed it, while the older students did the survey themselves). A final sample of 6,189 students in grades 6 through 12 attending 76 remaining schools (after excluding schools with only 4th and 5th grades) and those present on September 11, 2001, is used here. A majority of the students in the sample attended and were present in a school within 10 miles from the WTC attack. Because the original study wanted to have enough power to address GZA students, more students were attending schools closer to the WTC site than those 1 to 5 miles (see Table 3). This is due to the high concentration of premier high schools located within the GZA, such as Stuyvesant and Murry Bergtraum high schools, and the overall sampling design of the study where GZA was oversampled. A sampling weight is available in the data that can be applied to better estimate the number of students, thus controlling for bias in the distribution of students. However, since the main goal of this research is not to estimate the number of students but to determine if school and neighborhood level variables are associated with PTSD, the sampling weight was not applied and only distributions are reported here.

Table 3. Frequency of Schools and Students and Participating NYC Public School Students, Grades 6-12, by Distance from Ground Zero (N=6,189)

Distance	Schools (N = 76)	Students (N=6,189)
< 1 mile	6 (7.89)	1,621 (26.2)
1 – 4.99 miles	13 (16.41)	711 (11.5)
5 – 9.99 miles	33 (42.11)	2,112 (34.1)
10 – 14.99 miles	20 (26.32)	1,308 (21.1)
≥ 15 miles	5 (6.58)	437 (7.1)

4.1.1. Individual Level Variables

At the individual level, basic demographics (age, female and race/Hispanic ethnicity), mother's maternal education (high school graduate), whether the child lives with both parents, and the exposure variables (direct, family, previous and TV exposure) will be included in binary form (except for age) (see Table 4). Since these variables have consistently been the highest predictors of both PTSD Symptoms (PTSD Sy) and probable PTSD Diagnosis (PTSD Dx), they are included in the model. As with the original Hoven et al. (2005) paper, direct exposure is defined as “2 or more of the following: personally witnessed the attack, hurt in the attack, in or near the cloud of dust and smoke, evacuated to safety, or being extremely worried about the safety of a loved one; (3) family exposure, defined as having a family member (mother, father, stepmother, stepfather, foster mother, foster father, sister, brother, grandmother, grandfather, aunt, uncle, or other family member) killed or injured in the attack, or witnessing the attack but escaping unharmed . . . [and] previous exposure to traumatic situations [is] defined as having had a severe injury in violent circumstances or having lived through war or another major pre-September 11 disaster” (Hoven et al., 2005, pg. 547).

Since the data used for this analyses excluded 4th and 5th graders, and as age is a major risk factor for PTSD (and most anxiety disorders), the proportion of students included in this paper is lower than those in the original Hoven et al. (2005) paper – 7.55 versus 10.6. Students included in this analysis have a mean age of 14, 52% are female, 67% are black/African American or Hispanic, with 43% not living with both biological parents. Between 11% and 33% reported having direct, family, or prior traumatic exposures and 66% reported high TV exposure to the WTC events.

Table 4. Proportions of Dependent and Independent Individual Level Variables: NYC-BOE School Survey, Grades 6-12 (N=6,189)

Variables	Proportion
Dependent Variables:	
Probable PTSD Diagnosis	7.55
PTSD Symptoms (mean)	2.14
Independent Variables:	
Age (mean)	14.02
Gender, Female	51.93
Ethnicity (White is Reference)	
Black/African-American	28.63
Hispanic/Latino	38.51
Asian	11.94
Mixed/Other	4.60
Low Maternal Edu. (≤high school)	19.39
Not Live w/ both parents	43.16
Direct exposure (≥ 2 symptoms)	26.70
Any family exposure	11.01
Prior trauma (≥ 2 symptoms)	32.51
High TV exposure	65.82

4.1.2. Neighborhood Variables

At the time of the study, only the student's home zip code could be obtained. Therefore, for this analysis, a student's zip code will be used as their neighborhood. A GIS polygon dataset of US Zip Codes was obtained from ESRI's USA Data CD (www.esri.com). GIS analysis has been performed to determine the location of the students' home zip codes and Euclidian distance to their GZA School (see Figure 7). Five types of neighborhood variables are considered for his analysis: Socio-Economic Status, Residential Mobility, Neighborhood Safety, Neighborhood Quality, and Location-Based Physical Exposure Measures (LBPEM) (see Table 5).

Figure 7. Students per Zip Code

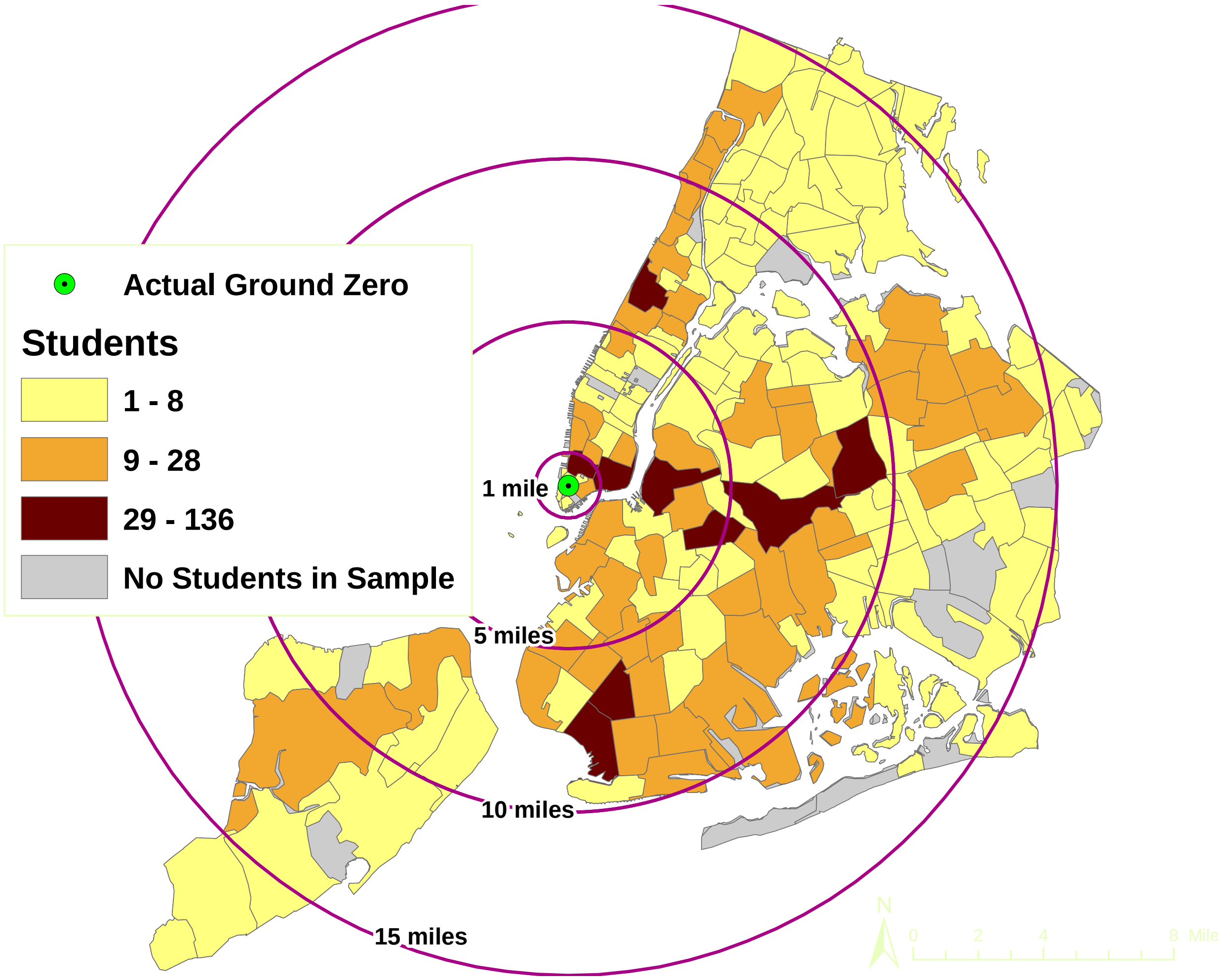


Table 5. Neighborhood Level Variables

Variable	Source	Spatial Resolution
Socio-Economic Status (SES):		
Population Density (Rate)		
Non-White Persons (%)	US Census	Zip Code
Households (HHs) with public assistance (%)	US Census	Zip Code
Single Parent HHs (%)	US Census	Zip Code
Persons living below poverty (%)	US Census	Zip Code
Unemployment (%)	US Census	Zip Code
Annual income above $30,000 (%)	US Census	Zip Code
Foreign Born (%)	US Census	Zip Code
Persons with at least High School Diploma (%)	US Census	Zip Code
Residential Mobility:		
Persons (5+ yrs old) who resided in same HH 5+ yrs (%)	US Census	Zip Code
Rental to Privately Owned Housing Units (Ratio)	US Census	Zip Code
Neighborhood Safety:		
Robbery (Persons)	NYC.gov	NYPD Precinct
Felonious Assault (Persons)	NYC.gov	NYPD Precinct
Forcible Rape (Persons)	NYC.gov	NYPD Precinct
Major Felony Crime (Persons)	NYC.gov	NYPD Precinct
Murder and Non-Negligent Manslaughter (Persons)	NYC.gov	NYPD Precinct
Burglary (Incidence)	NYC.gov	NYPD Precinct
Grand Larceny (Incidence)	NYC.gov	NYPD Precinct
Structural Fires (Incidence)	NYC.gov	Fire District
Non-Structural Fires (Incidence)	NYC.gov	Fire District
Civilian Fire Fatalities (Persons)	NYC.gov	Fire District
Drug Abuse Deaths (Persons)	NYC.gov	Health District
Neighborhood Quality:		
Complaints Regarding Disorderly Youths (Count)	NYC.gov	Comm. Board
Complaints Regarding Derelict Vehicles (Count)	NYC.gov	Comm. Board
Rodent Complaints (Count)	NYC.gov	Comm. Board
Noise Complaints (Count)	NYC.gov	Comm. Board
Air Quality Complaints (Count)	NYC.gov	Comm. Board
Tons of Refuse Per Day Collected for Disposal (Count)	NYC.gov	Comm. Board
Acceptably Clean Streets (%)	NYC.gov	Comm. Board
Acceptably Clean Sidewalks (%)	NYC.gov	Comm. Board
Small Parks and Playgrounds - Acceptably Clean (%)	NYC.gov	Comm. Board
Small Parks and Playgrounds - Acceptable Conditions (%)	NYC.gov	Comm. Board
Open Space (%)	DoITT	Block
Location-Based Physical Exposure Measures (LBPEM)**:**		
Distance (Euclidian or Transportation) to the WTC	Calculated	NA
Line of Site to WTC Towers (%)	Calculated	Pixel
Under WTC Plume of Smoke (%)	Calculated	Pixel

4.1.2.a. Socio-Economic Status (SES): To control for SES, population variables (population density, non-white distributions, household income, etc.) was downloaded from the U.S. Census American FactFinder website (www.census.org) at the zip code level (see Table 6). An SES index was computed following the methodology developed by Krieger et al. (see Krieger, Williams and Moss, 1997; Krieger, et al., 2003; Subramanian, et al., 2005). By performing a Principal Component Analysis (PCA) on Census variables at the tract, block groups and zip code levels, researchers were able to create an index which measures occupational class, income, poverty, wealth, education and crowding. Although research indicates that the tract and block group level indices show stronger socio-economic gradients than the zip code level, the SES Index created here has been done at the zip code level to be consistent with the individual level data.

A matrix of the Spearman correlation coefficients (a non-parametric test measuring the strength of the relationships of the variables) of the SES variables is represented in Table 6. All variables are significantly correlated. Foreign born (%), however, is not correlated with households on public assistance (%), single parent households (%) and unemployment (%) and therefore not included in the factor analysis. A separate analysis to determine if a neighborhood level variable of percent foreign born has an impact on PTSD was performed.

Table 6. Socioeconomic Status Spearman Correlation Matrix

	Pop. Density (Rate)	% Non-White	% HHs on Pub. Assist.	% Single Parent HHs	% Persons below Poverty	% Unem-ployed	% Income < $30k	% Foreign Born	% Persons w/ HS Diploma+
Pop. Density (Rate)	---	0.26**	0.37**	0.34**	0.39**	0.30**	0.38**	0.18*	0.32**
% Non-White	0.26**	---	0.78**	0.79**	0.68**	0.83**	0.65**	0.22**	0.76**
% HHs on Pub. Assist.	0.37**	0.78**	---	0.84**	0.86**	0.86**	0.87**	0.12	0.87**
% Single Parent HHs	0.34**	0.79**	0.84**	---	0.76**	0.82**	0.75**	-0.04	0.66**
% Persons below Poverty	0.39**	0.68**	0.86**	0.76**	---	0.89**	0.94**	0.17*	0.82**
% Unemployed	0.30**	0.83**	0.86**	0.82**	0.89**	---	0.84**	0.09	0.83**
% Income < $30k	0.38**	0.65**	0.87**	0.75**	0.94**	0.84**	---	0.20**	0.85**
% Foreign Born	0.18*	0.22**	0.12	-0.04	0.17*	0.09	0.20**	---	0.28**
% Persons w/ HS Diploma+	0.32**	0.76**	0.87**	0.66**	0.82**	0.83**	0.85**	0.28**	---

**$p \leq 0.01$

A varimax rotated principle component analysis (PCA) was performed with the remaining variables to observe if any of the variables measured were contextually one or more than one component (Silver et al., 2002 and Galea, et al., 2205; Galea, et al., 2007; Harvard et al., 2008). One main component (eigenvalue above 1) and one minor component (population density) (eigenvalue 0.964) was found (see Figure 8 and Table 7). The total variance increases from 71.9% to 83.9% by including the minor component; however, since population density is the only variable which loads on the minor component it was removed and tested separately to investigate its influence on PTSD. Reliability analysis was performed with the remaining variables. A Cronbach's Alpha (coefficient measuring the internal consistency of a given set of variables identifying if the combination of the variables measures a one-dimensional concept) of $\alpha=0.904$ indicates that the remaining variables (% Non-White, % Households on Public Assistance, % Single Parent HHs, % Persons below Poverty, % Unemployed, % Income < $30k and % Persons with at least a High School Diploma) are good summary measures of Socioeconomic Status in NYC at the zip code level. The final SES Index was created by standardizing the sum of the remaining SES variables. Since the proportions of the original variables measure negative consequences of SES, the sum of the remaining variables were subtracted from the maximum index value before standardization (see equation 2 below).

$$SES\_sum=\Sigma(nw, pa, sp, bp, ump, inc, hs) \quad (2a)$$

where:
nw=% Non-White,
pa=% HHs on Pub. Assist.,
sp=% Single Parent HHs,
bp=% Persons below Poverty,
ump=% Unemployed,
inc=% Income < $30k,
hs=% Persons w/ at least HS Diploma

$$SES = z(\max(SES\_sum) - SES\_sum_i) \quad (2b)$$

Figure 8. SES Factor Scree Plot

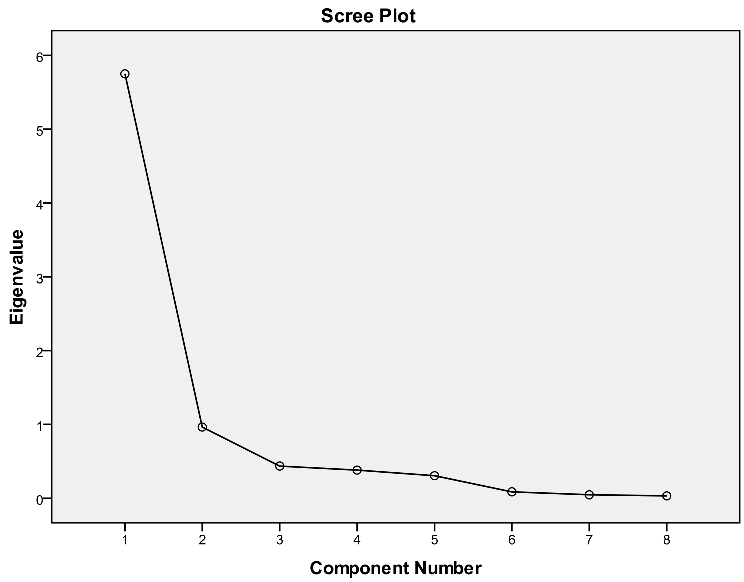
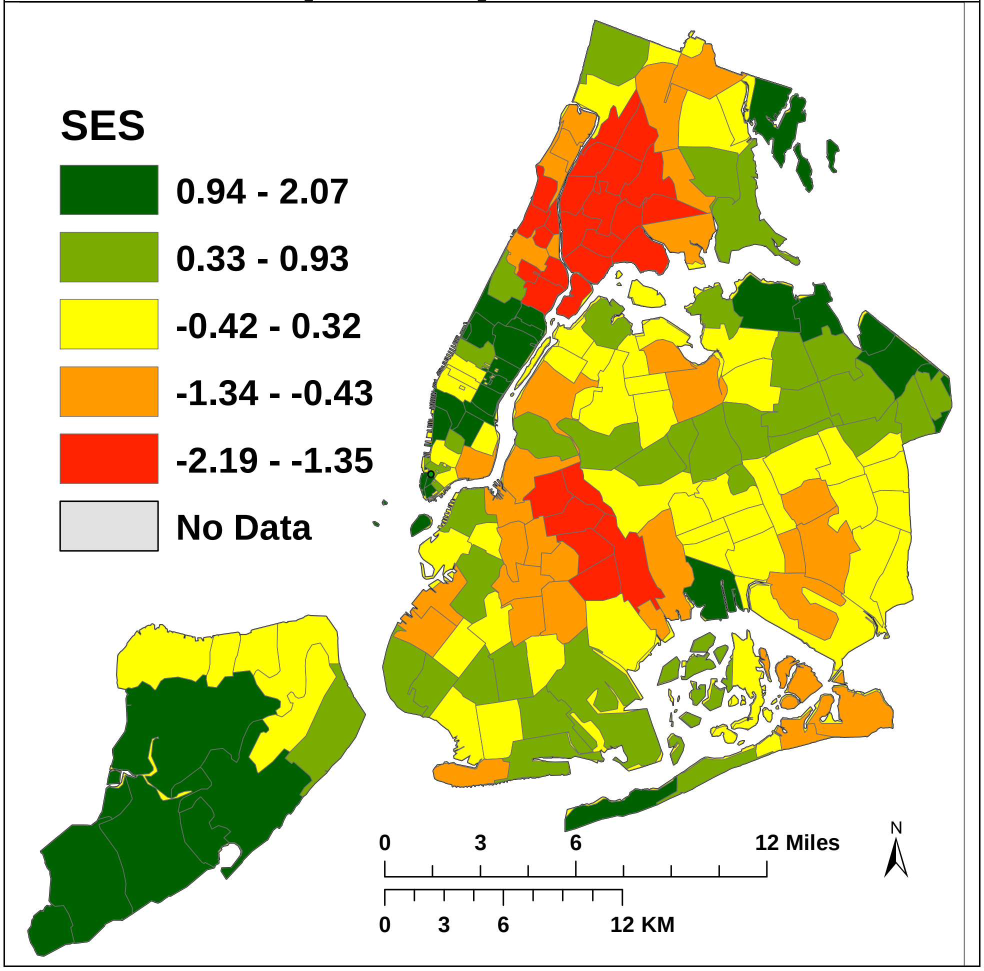


Table 7. SES PCA Total Variance Explained

Comp.	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Var.	Cum. %	Total	% of Var.	Cum. %	Total	% of Var.	Cum. %
1	5.75	71.88	71.88	5.75	71.88	71.88	5.59	69.81	69.81
2	.96	12.05	83.92	.96	12.05	83.92	1.13	14.11	83.92
3	.44	5.45	89.37						
4	.38	4.76	94.13						
5	.30	3.81	97.94						
6	.09	1.09	99.03						
7	.05	.58	99.61						
8	.03	.39	100.00						

The standardized SES Index is a continuous number between -2.19 and 2.07, where the higher the value represents higher socio-economic status. Not surprisingly to those who know the SES landscape of NYC, the lowest SES Indices are found in the South Bronx, Harlem and across the borders of Queens and Brooklyn (see Map 1).

Map 1. NYC Zip Code SES Index

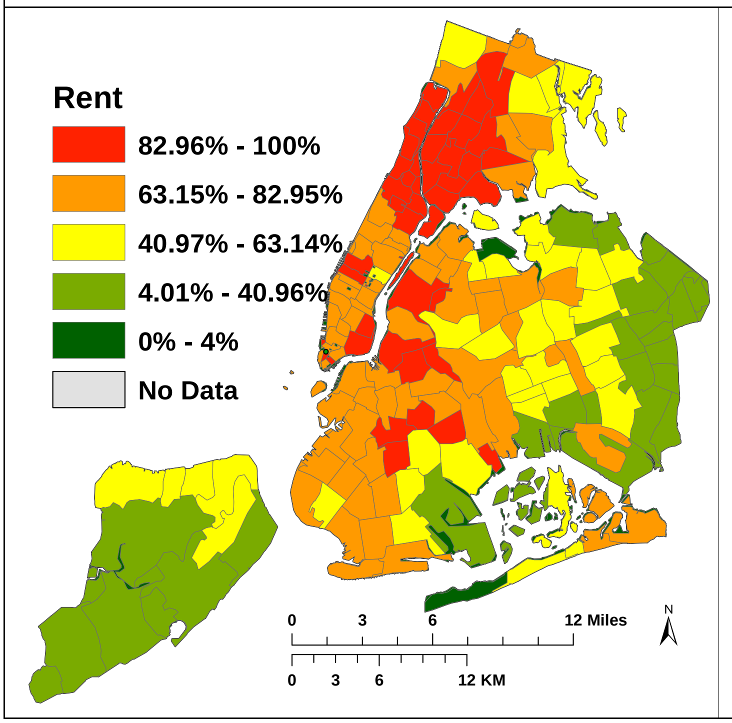


4.1.2.b. Residential Mobility: To observe effects of residential mobility on PTSD (as in anxiety, see Silver et al., 2002; Faris and Dunham, 1939; Sampson, 1985, 1987; Byrne & Sampson, 1986; Gorman-Smith, et al., 1996; Dohrenwend, et al., 1992), US Census 2000 variables measuring persons (5+ years old) who resided in same household (HH) for 5+ years, and the ratio of rental to privately own housing were used to measure residential mobility at the zip code level. Although these two variables are significantly correlated (0.379, $p \leq 0.01$), the Cronbach's Alpha of α=0.029 indicates that they should not be combined into one measure of

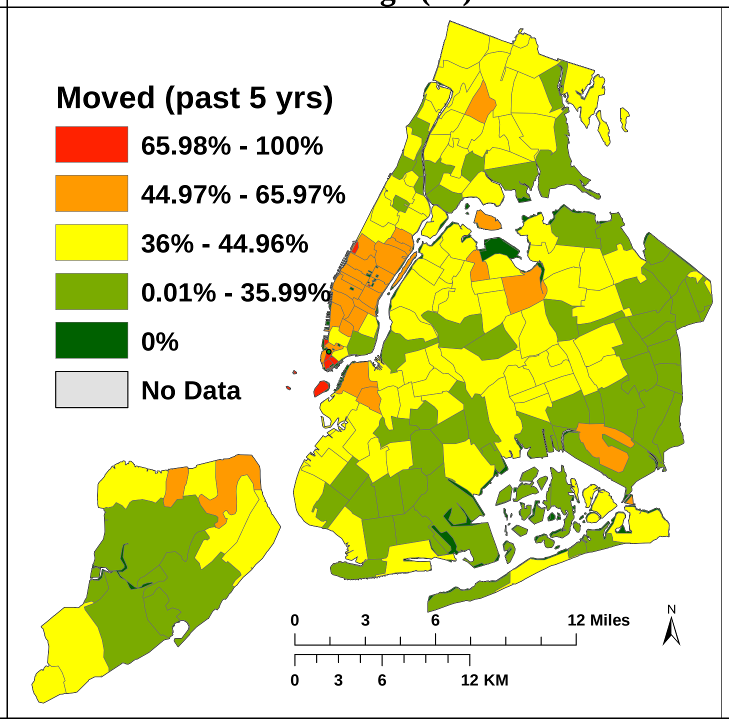
Residential Mobility; and thus, were tested independently to examine which measure best predicts PTSD in these data.

Again, not surprising to those familiar with the NYC landscape, the highest neighborhoods with highest percent of renters are the South Bronx, Harlem, Washington Heights and borders across Brooklyn and Queens (similar to SES). Interestingly, those zip codes within midtown and lower Manhattan (including most of Ground Zero) have the highest residentially mobile populations (see Maps 2A and 2B).

Map 2A. NYC Zip Code Rental Housing Units (%)



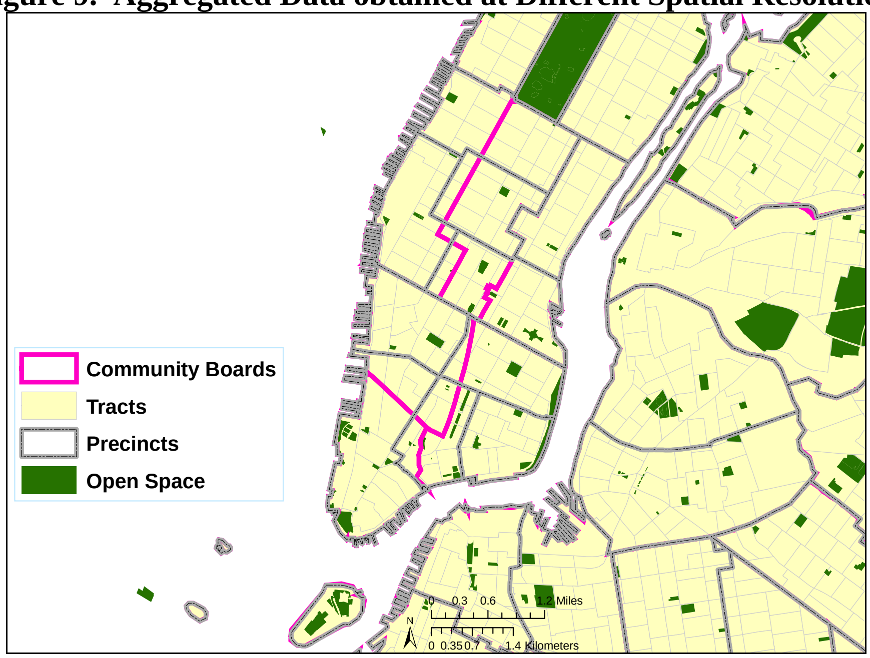
Map 2B. NYC Zip Code Resided in Residence 5 Years ago (%)



4.1.2.c. Neighborhood Safety Index (NSI): Neighborhood Safety (i.e., crime and fire statistics), data for 2002 was downloaded from NYC's My Neighborhood Statistics website (http://gis.nyc.gov/ops/mmr/address.jsp?app=MMR). Since these data are available at the non-spatially consistent/overlapping aggregates of NY Police Department Precinct and/or NYC Fire

District (not at the zip code level) (see Figure 9), it was disaggregated to the Census Block level using dasymetric mapping methods. If the variable obtained was a count, apportionment using areal-weighted dasymetry was performed to estimate the proportion of the variable found within the block. If the variable of interest was a rate or percent, inverse distance weighted interpolation with zonal statistics was used to obtain the average rate/percent for the block. Although more advanced dasymetric techniques exist, such as Cadastral-based Expert Dasymetric System (CEDS), developed by Maantay (see Maantay, Maroko and Herrmann, 2007), the objective of this disaggregation is to then re-aggregate to the zip code level, thus this simple form of dasymetry of measures is more than adequate.

Figure 9. Aggregated Data obtained at Different Spatial Resolution



These disaggregated populations/counts were then re-aggregated to the zip code level by summing the populations/counts of the tax blocks that comprise the zip code. For rates/percentages, the mean rate/percent was calculated for all blocks that compose a zip code. As with the SES measures, it was expected that multicollinearity (independent variables correlated with each other) exists among these variables; therefore, a Neighborhood Safety Index (NSI) was calculated based on findings of a PCA. Spearman correlation matrix of the NSI variables is represented in Table 8. All variables are significantly correlated.

Table 8. Neighborhood Safety Spearman Correlation Matrix

	Fire deaths	Drug deaths	Structure Fires	Non-structure fires	Robbery	Assault	Rape	Major Felony	Murder	Burglary	Grand Larceny	Grand Larceny - Auto
Fire deaths	---	0.63**	0.63**	0.57**	0.61**	0.58**	0.55**	0.60**	0.55**	0.62**	0.50**	0.52**
Drug deaths	0.63**	---	0.91**	0.82**	0.87**	0.87**	0.86**	0.87**	0.83**	0.83**	0.69**	0.74**
Structure Fires	0.63**	0.91**	---	0.86**	0.94**	0.94**	0.91**	0.93**	0.86**	0.89**	0.75**	0.74**
Non-structure fires	0.57**	0.82**	0.86**	---	0.84**	0.85**	0.81**	0.83**	0.78**	0.84**	0.75**	0.84**
Robbery	0.61**	0.87**	0.94**	0.84**	---	0.97**	0.93**	0.96**	0.90**	0.92**	0.75**	0.81**
Assault	0.58**	0.87**	0.94**	0.85**	0.97**	---	0.95**	0.91**	0.93**	0.87**	0.68**	0.76**
Rape	0.55**	0.86**	0.91**	0.81**	0.93**	0.95**	---	0.87**	0.92**	0.84**	0.63**	0.76**
Major Felony	0.60**	0.87**	0.93**	0.83**	0.96**	0.91**	0.87**	---	0.81**	0.96**	0.84**	0.80**
Murder	0.55**	0.83**	0.86**	0.78**	0.90**	0.93**	0.92**	0.81**	---	0.78**	0.55**	0.74**
Burglary	0.62**	0.83**	0.89**	0.84**	0.92**	0.87**	0.84**	0.96**	0.78**	---	0.79**	0.84**
Grand Larceny	0.50**	0.69**	0.75**	0.75**	0.75**	0.68**	0.63**	0.84**	0.55**	0.79**	---	0.70**
Grand Larceny - Auto	0.52**	0.74**	0.74**	0.84**	0.81**	0.76**	0.76**	0.80**	0.74**	0.84**	0.70**	---

**$p \leq 0.01$

Using an eigenvalue above 1 as the threshold, two factors were found explaining 80.36% of the variance (see Figure 10 and Table 9). Major felony and grand larceny were the only two variables that loaded in factor 2. Removing these two variables improves the reliability of the measure by increasing the Cronbach's Alpha from a 0.782 to a 0.893. Therefore, these two variables were removed from the NSI and tested separately to observe its influence on PTSD. A new PCA was performed without these two variables and only one factor was found explaining 74.73% of the variance. The final NSI was computed similarly to the SES Index, and standardized.

Map 3 illustrates the distribution of the NSI (standardized sum of the NSI variables) at the zip code level throughout NYC, where the most unsafe zip codes are found throughout the Bronx, Spanish Harlem and, again, areas that borders of Brooklyn and Queens (such as Bushwick and East NY).

Figure 10. NSI Factor Scree Plot

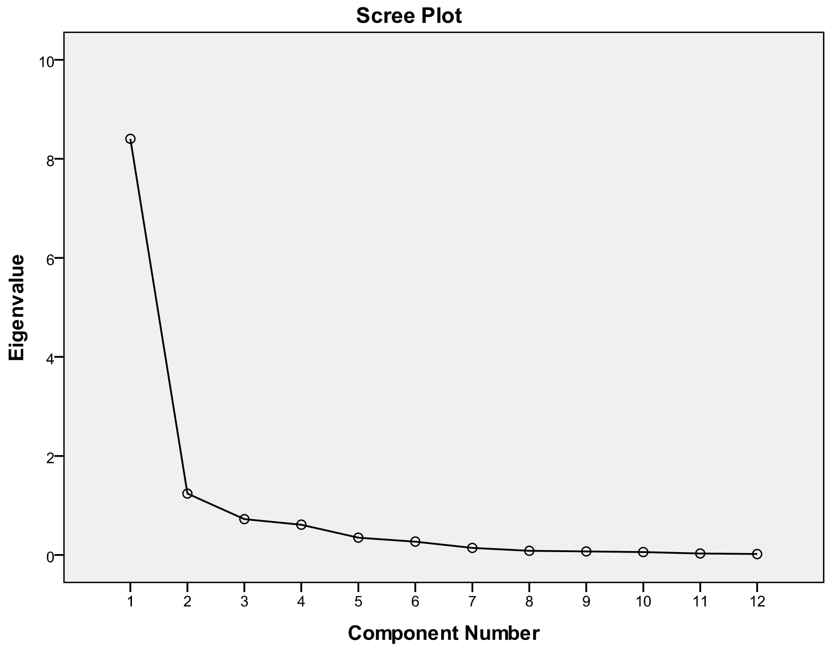
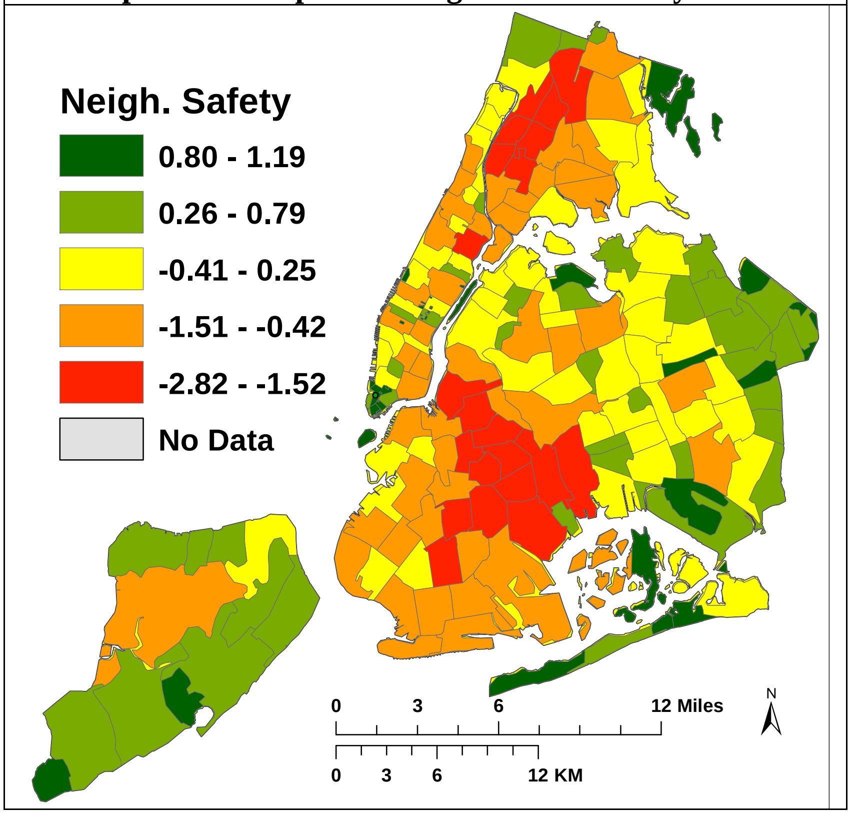


Table 9. NSI PCA Total Variance Explained

Comp.	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Var.	Cum. %	Total	% of Var.	Cum. %	Total	% of Var.	Cum. %
1	8.4	70.03	70.03	8.4	70.03	70.03	7.11	59.27	59.27
2	1.24	10.33	80.36	1.24	10.33	80.36	2.53	21.09	80.36
3	0.72	6.033	86.39						
4	0.61	5.096	91.49						
5	0.35	2.911	94.4						
6	0.27	2.242	96.64						
7	0.14	1.188	97.83						
8	0.08	0.696	98.53						
9	0.07	0.599	99.13						
10	0.06	0.485	99.61						
11	0.03	0.242	99.85						
12	0.02	0.148	100						

Map 3. NYC Zip Code Neighborhood Safety Index



4.1.2.d. Neighborhood Quality (NQI): To observe if neighborhood quality may be associated with PTSD Sy and PTSD Dx, data was obtained from the NYC's My Neighborhood Statistics website for 311 complaints and other measures of quality (cleanliness of streets, etc.) Along with crime and fire, these variables attempt to measure neighborhood deterioration. As with the crime and fire variables, these neighborhood quality variables are not available at the zip code level, mostly at the Community Board Level (see Figure 9 above). Any variable obtained at the Community Board Level was disaggregated using dasymetry and re-aggregated to the zip code level to be consistent with the individual level data. Percent of Open Space (obtained from NYC Department of Information Technology and Telecommunications (DoITT)) was aggregated to the zip code level (no disaggregation needed). As with the SES and the Neighborhood Safety measures, an index was created using PCA.

Spearman correlation matrix of the NQI variables is represented in Table 10. Most variables are significantly correlated. Lack of Clean Playground is not significantly correlated with Derelict Cars and Open Space; and, Lack of Good Playground Condition is not significantly correlated with Rodent Complaints. These two variables will be kept in the model to observe the influence of the Cronbach's Alpha. The summary measure is improved from $\alpha=0.250$ to $\alpha=0.506$ with the removal of noise complaints. The score's reliability is further increased to $\alpha=0.512$ with the removal of Lack of Clean Playground and further to $\alpha=0.520$ with the removal of Lack of Good Playground Condition.

Table 10. Neighborhood Quality Spearman Correlation Matrix

	Dis-orderly Youth	Derelict Cars	Rodent Com-plaints	Noise Com-plaints	Air Com-plaints	Garbage Tonnage	Open Space (%)	Lack of Clean Sidewalks (%)	Lack of Clean Street (%)	Lack of Clean Playground (%)	Lack of Good Playground Condition (%)
Disorderly Youth	---	0.72**	0.89**	0.89**	0.70**	0.79**	0.63**	0.60**	0.30**	0.52**	0.28**
Derelict Cars	0.72**	---	0.58**	0.54**	0.45**	0.70**	0.65**	0.29**	0.35**	0.04**	0.30**
Rodent Complaints	0.89**	0.58**	---	0.92**	0.77**	0.71**	0.47**	0.58**	0.19**	0.54**	0.12
Noise Complaints	0.89**	0.54**	0.92**	---	0.83**	0.72**	0.49**	0.60**	0.24**	0.63**	0.18**
Air Complaints	0.70**	0.45**	0.77**	0.83**	---	0.67**	0.42**	0.34**	0.24**	0.48**	0.16*
Garbage Tonnage	0.79**	0.70**	0.71**	0.72**	0.67**	---	0.68**	0.45**	0.38**	0.40**	0.32**
Open Space (%)	0.63**	0.65**	0.47**	0.49**	0.42**	0.68**	---	0.27**	0.28**	0.09**	0.30**
Lack of Clean Sidewalks	0.60**	0.29**	0.58**	0.60**	0.34**	0.45**	0.27**	---	0.43**	0.79**	0.35**
Lack of Clean Street	0.30**	0.35**	0.19**	0.24**	0.24**	0.38**	0.28**	0.43**	---	0.17*	0.89**
Lack of Clean Playground	0.52**	0.04	0.54**	0.63**	0.48**	0.40**	0.09	0.79**	0.17*	---	0.14*
Lack of Good Playground Condition	0.28**	0.30**	0.12	0.18**	0.16*	0.32**	0.30**	0.35**	0.89**	0.14*	---

*$p \leq 0.05$; **$p \leq 0.01$

Three factors were found to explain 75.91% of the variance (see Figure 11 and Table 11). Air Complaints is the only variable that loads on factor 3. Removing this variable improves the reliability of the measure by increasing Cronbach's Alpha from α=0.520 to α=0.531; however, its removal results in a 2 two-factor model that only explains 69.49% of the variance and will be kept in the model. Map 4 illustrates the distribution of the NQI (standardized sum of NQI variables) at the zip code level throughout NYC, where, as with prior maps, the Bronx and the borders of Brooklyn and Queens are overrepresented by low Neighborhood Quality zip codes.

Figure 11. NQI Factor Scree Plot

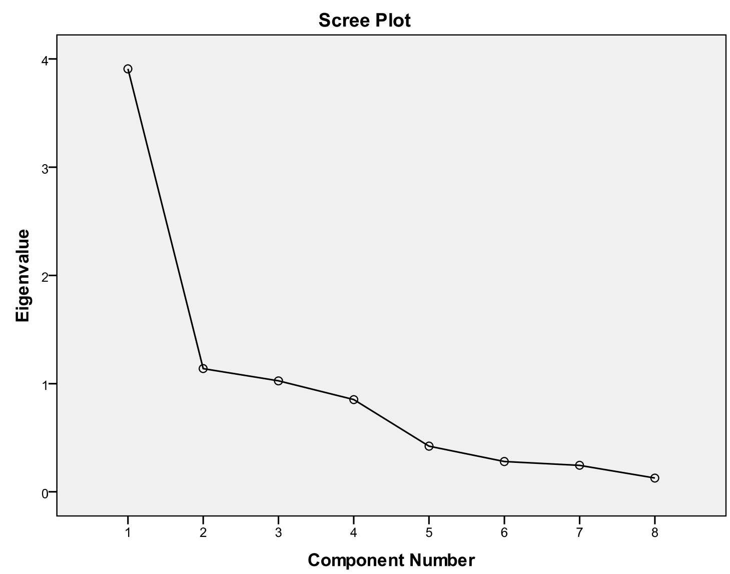
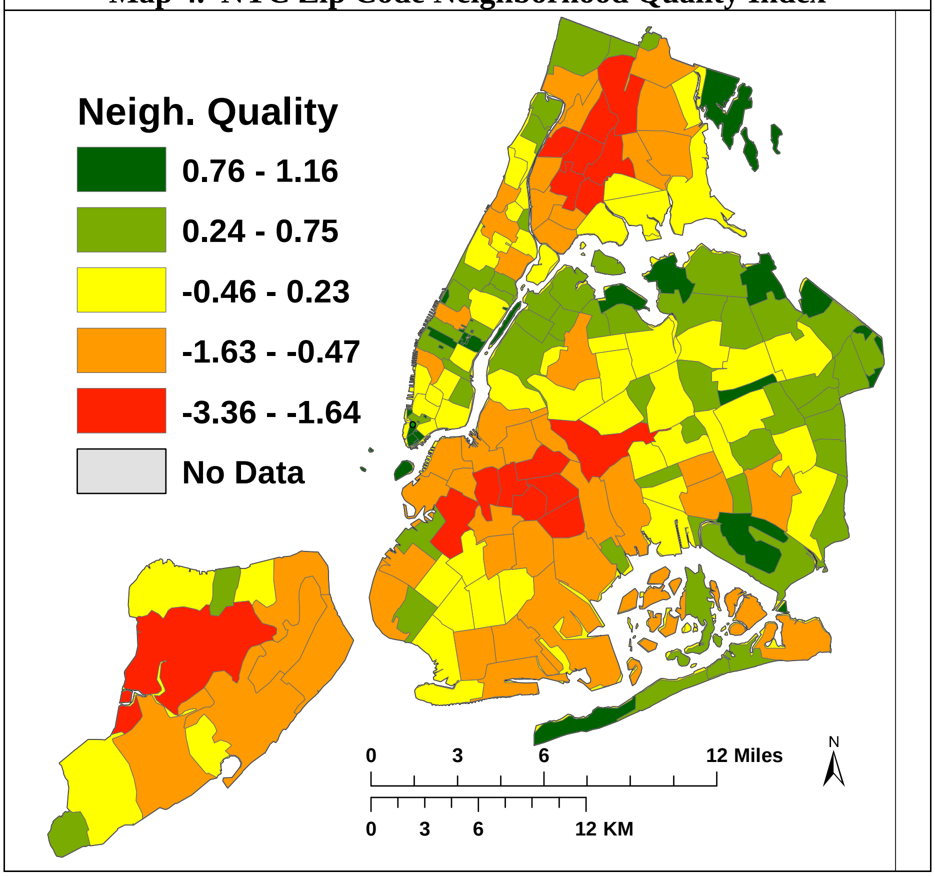


Table 11. NQI PCA Total Variance Explained									
Comp.	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Var.	Cum. %	Total	% of Var.	Cum. %	Total	% of Var.	Cum. %
1	3.91	48.85	48.85	3.91	48.85	48.85	2.47	30.87	30.87
2	1.14	14.23	63.09	1.14	14.23	63.09	2.38	29.70	60.57
3	1.03	12.82	75.91	1.03	12.82	75.91	1.23	15.34	75.91
4	.85	10.66	86.56						
5	.42	5.28	91.84						
6	.28	3.50	95.34						
7	.25	3.07	98.41						
8	.13	1.59	100.00						

Map 4. NYC Zip Code Neighborhood Quality Index



4.1.2.e. Location-Based Physical Exposure Measures (LBPEM): LBPEM measures the effect of the built-environment on the physical exposure to the WTC attacks. Preliminary analysis has shown that Euclidian distance from the original 94 schools to the WTC towers was not a factor in probable PTSD. For this new analysis, in addition to the Euclidean measurement of school distance to the WTC, zip code Euclidean distance, transportation distance and time to the WTC was calculated. In addition to these distance measures, school and zip code location in relation to the plume emitted from the WTC site and if the WTC was visible from the students' zip codes were calculated.

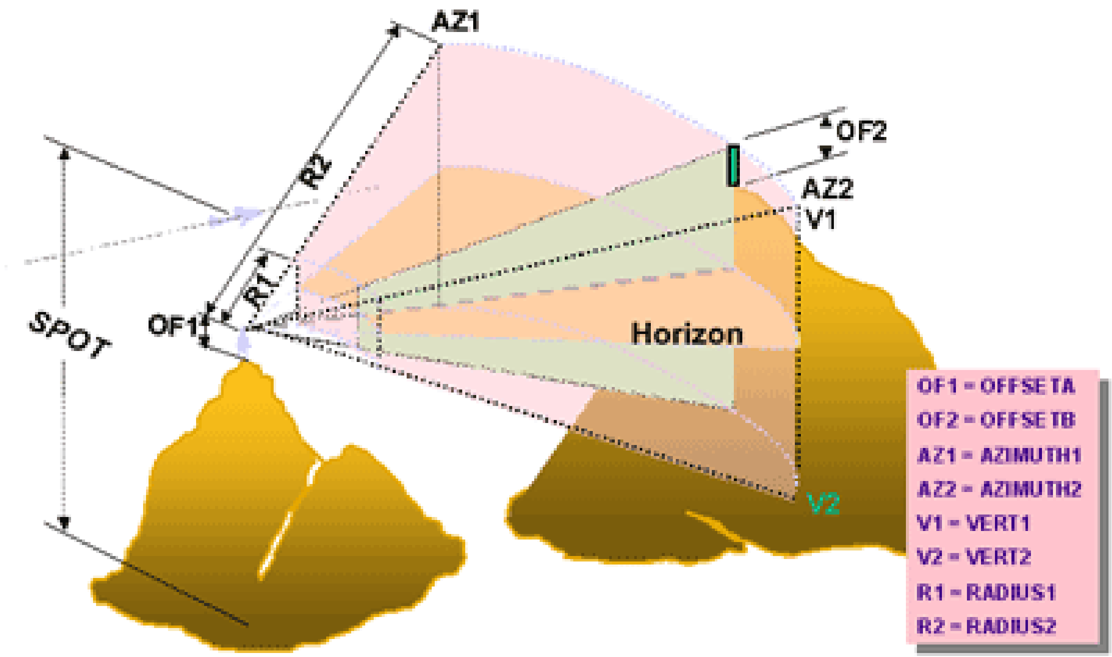
4.1.2.e.1. Distance: To determine if distance measured in travel time from their school to their home is a factor, a transportation model was created by Michael Minn (former graduate student at Hunter College) and made available to this researcher, to determine time and modality of travel via public bus, subway and walking (see Appendix I) for each of the students using the MTA's "Google" or General Transit Feed Specification (GTFS, see http://mta.info/developers/download.html and http://spatialityblog.com/2010/05/06/mta-data-in-gis-format/). The GTFS provides all subway and bus routes, stop coordinates, and scheduled arrival date and times for each stop. Minn's transportation model calculated all possible bus, subway and combined routes from every bus/subway stop located within every zip code. Table 12 represents descriptive statistics of the model results. The mean and median transportation distance and time, as well as the Euclidean distance from the zip code and school, to the GZA was computed and standardized. These were compared and contrasted to determine if either is associated with PTSD Sy and/or PTSD Dx. Mean Euclidean zip code and travel distances did not differ much; while Travel median distance is considerably lower than Travel and Euclidean means.

Table 12. Unstandardized Euclidean and Travel Distances from Students' School and Zip Code to the Ground Zero Area

Statistic	Euclidian		Travel (Mean)		Travel (Median)	
	School	Zip Code	Minutes	Distance	Minutes	Distance
Mean	10,498.5	15,407.2	63.6	15,670.9	62.2	15,224.9
Std. Deviation	8,040.1	6,850.1	17.4	6,856.7	17.3	6,760.6
Median	10,101.9	16,479.4	61.8	15,636.5	61.5	14,765.1
Minimum	275.9	72.9	17.5	1,415.5	17.6	1,199.1
Maximum	29,853.1	29,845.7	112.8	33,375.3	113.1	34,418.9

4.1.2.e.2. Line-Of-Sight: Having "experienced, witnessed, or … confronted with an event … that involved actual or threatened death or serious injury, or a threat to the physical integrity of self or others" is a criteria for PTSD (American Psychiatric Association, 1994); therefore, it is postulated here that having a direct Line-Of-Site (LOS) to the WTC from their home zip code on September 11, 2001 is a risk factor for PTSD – as not being in close proximity to the WTC Towers does not necessarily indicate whether they saw the attacks first-hand. Line-Of-Sight can be defined as someone/something in position *A* having an uninterrupted view of someone/something in position *B.* Complex LOS algorithms have been developed by geographic information scientists and computer scientists alike (Liberti & Rappaport, 1996; Wylie & Holtzman, 2004). To model the LOS of multiple spatial objects to one object, a viewshed analysis was performed ArcGIS's Spatial Analyst, where the raster cell locations visible to a set of observer features are determined using bilinear interpolation to determine the elevation of each observation point (ESRI) and whether each cell has direct LOS to the observer feature (see Figure 12).

Figure 12. Viewshed Analysis in ArcGIS (ESRI, 2005)



A vector GIS dataset of the footprints for all buildings in NYC, derived from areal photographs of NYC at 12 inch accuracy, covering approximately 35 miles, was obtained from DoITT (see http://home2.nyc.gov/html/doitt/html/eservices/eservices_gis_downloads.shtml) (Dunlap, 2001). The original footprints of the WTC towers were extracted from this dataset. Although the building footprints do not contain building heights, a point vector GIS dataset was obtained from the CARSI Lab, which contains the elevation of 733,122 buildings throughout NYC. These building elevations were converted from feet to meters and spatially joined to the building footprints (N=1,064,849) of the building footprint polygon in which the elevation point fell. After the spatial join, 421,894 (39.6%) building polygons still did not have building heights.

Shapefiles of NYC tax parcels – Manhattan, Bronx, Brooklyn, Staten Island, Queens North and Queens South – containing the number of stories per lot and land use (see Table 13). This dataset was used to calculate tax parcel height based on land use, for those building footprint polygons that were lacking building heights, (using 2.7432 meters for residential and 3.6576 meters for commercial tax parcels per story, 9 and 12 feet respectively).

Table 13. NYC Tax parcel Land Use

	Total	Unknown		Residential		Business	
Borough	**N**	**N**	**%**	**N**	**%**	**N**	**%**
Manhattan	44,278	1,881	4.25	28,272	63.85	14,125	31.9
Bronx	88,062	2,678	3.04	69,068	78.43	16,316	18.53
Brooklyn	276,981	2,316	0.84	236,635	85.43	38,030	13.73
Queens (N)	198,736	1,131	0.57	178,202	89.67	19,403	9.76
Queens (S)	120,793	988	0.82	106,948	88.54	12,857	10.64
Staten Island	118,303	6,775	5.73	96,133	81.26	15,395	13.01
All of NYC	847,153	15,769	1.86	715,258	84.43	116,126	13.71

Source: NYC Tax parcel GIS Vector Data

To act as the point of reference for the LOS, 253 points were drawn along the perimeter one meter apart, using the outline of each of the WTC tower footprints and given their height (415 meters for tower 1 and 417 meters for tower 2) as an attribute. These points act as OF1 in the viewshed analysis within the ArcGIS environment (refer back to Figure 12). A spatial union was performed with the tax parcel height polygons and the building footprints which had no height attributes. The building footprint polygons from the union were selected and extracted into a new shapefile. The two sets of building footprint polygons (spatially joined and calculated heights) were merged and converted to raster for the analysis.

In a preliminary viewshed model, LOS was calculated assuming a flat isotropic landscape resulting in inaccurate model result (see Figure 13). In reality, the WTC Towers were actually below mean sea-level while northern Manhattan, northern Bronx and parts of the remaining three boroughs were as high as 400 feet above mean sea-level. This has major implications as illustrated in Figure 13 below. To correct this, a digital elevation model using inverse distance weighted (IDW) was performed on the NYC elevation sampling points obtained from the NYCMAP dataset at 100 meter^2 cells (see Appendix II). The raster building heights were merged with the resultant IDW using the raster calculator. This final raster output was used in the viewshed analysis. Using the zonal statistics calculator, the number of pixels of each zip code that had line-of-sight to the WTC towers was derived (see Table 14).

Figure 13. Problems with Preliminary Line-Of-Sight Model

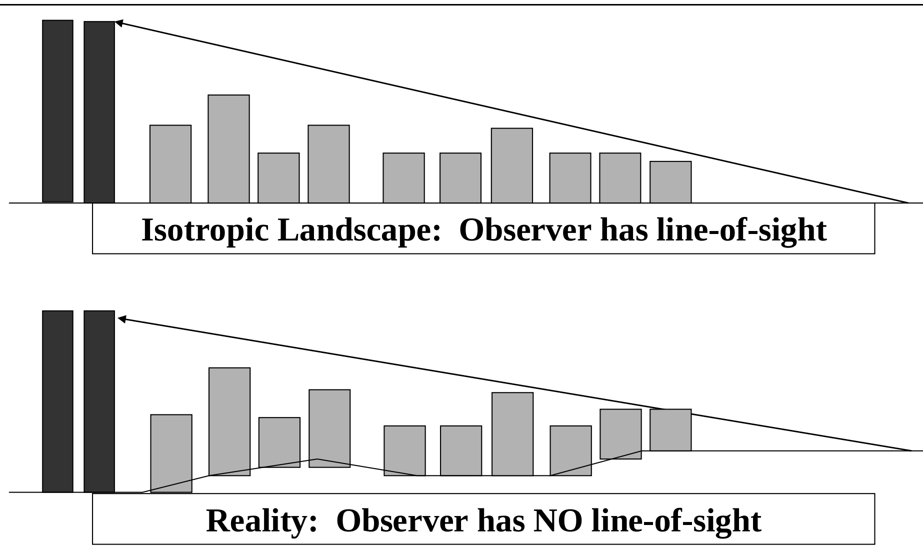
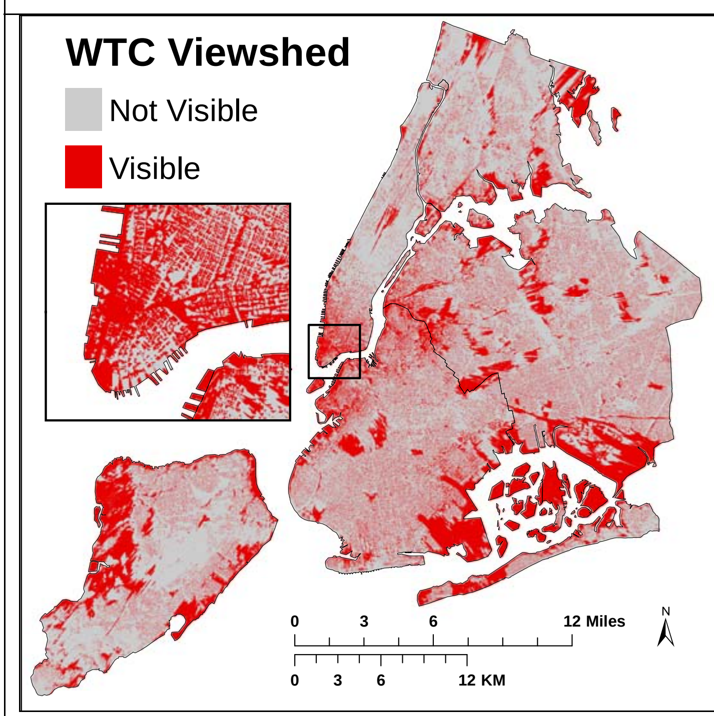


Table 14. Percent of Pixels with Rooftop View of the WTC

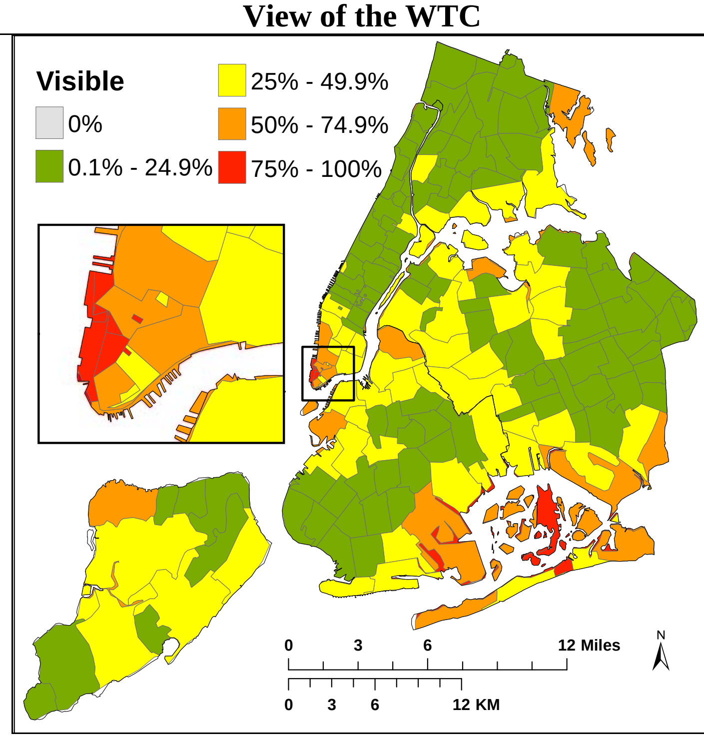
Borough	Total Pixels	View to WTC Pixels (%)
Manhattan	5,922	1,367 (23.1)
Bronx	10,932	2,449 (22.4)
Brooklyn	18,575	6,766 (36.4)
Queens	28,300	8,646 (30.6)
Staten Island	15,309	4,596 (30.0)
NYC	**79,038**	**23,824 (28.5)**

With 36.4% of pixels, Brooklyn has the largest percentage of pixels with roof-top view of the WTC followed by Queens and Staten Island. Both Manhattan and the Bronx have less than 25% of pixels with roof-top view of the WTC. The percent of zip codes with roof-top views was computed and standardized. Due to the tall buildings in lower Manhattan, midtown and upper Manhattan zip codes have the least visibility of the WTC center; while the western shores of Brooklyn and Queens and the northwestern shores of Staten Island the highest (see Maps 5A and 5B). Surprisingly, the eastern shores of the Bronx, and the southeast shores of Brooklyn and Queens also have higher proportions of zip codes with roof-top visibility of the WTC. This may be due to the low-lying lands in and around these shores, combined with relatively low building heights directly in the view path of the WTC.

Map 5A. Pixels with Rooftop View of the WTC

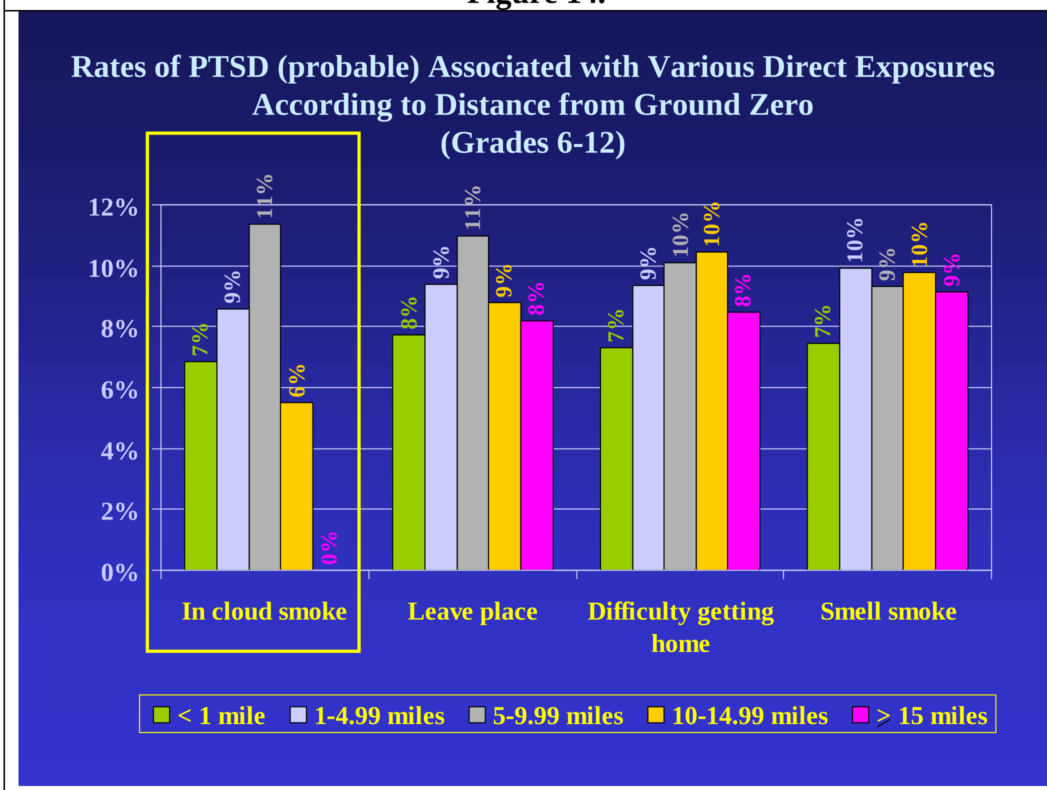


Map 5B. Percent of Zip Code with Rooftop View of the WTC

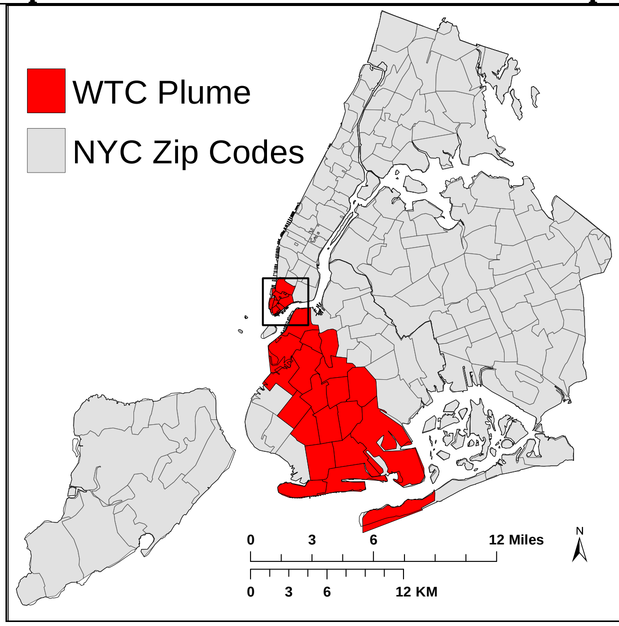


4.1.2.e.3. WTC Plume: In the original survey, the students were asked, "on Sept. 11th, were you in or near the cloud of smoke or dust from the WTC?" Exploratory data analysis of rates of PTSD Dx who perceived being "in the cloud of smoke" (answered positive to the survey question) indicated that there is an increase of PTSD Sy rates for those students who were within 10 miles of the WTC and then a sharp decrease in these rates (see Figure 14). An International Space Station (ISS) Satellite Image of the Plume of Smoke from the WTC Attack at approximately 11:20 AM on September 11, 2001 (see Appendix III) was used to determine if the students' perception of being in the cloud of smoke is a stronger predictor of developing PTSD.

Figure 14.



Map 6. Zip codes within 1km of WTC Plume on Sept. 11, 2001



A Kappa statistic (an index comparing agreement among two measures) was calculated to determine if the students' perception of being in the plume was consistent with their actual location (students who were not at school were not included in the prior analysis). A Kappa score ranges from a -1 (complete disagreement) to +1 (complete agreement). Kappa scores ranged from 0.20 to 0.22 indicating that although there is much agreement in those who said that they were not in the plume and actually were not under the plume, little agreement exists between those who perceived that they were under the plume and their actual physical location (see Table 15). Secondly, and more importantly, analysis substituting their physical location under the plume of smoke for their survey response indicated that the students' perception of being in the cloud of smoke was a stronger predictor of PTSD Dx than their actual location (see Table 16).

Table 15. Interview Question and Plume Model

Variable	% Consistent	Kappa	ASE
School Under/Near Plume:			
• under plume	89.64	0.22	0.022
• within 1 KM of plume	89.66	0.23	0.022
Residence Under/Near Plume:			
• under plume	87.69	0.07	0.017
• within 1 KM of plume	85.08	0.11	0.018
School or Residence Under/Near Plume:			
• under plume	87.33	0.21	0.020
• within 1 KM of plume	84.87	0.20	0.019

Substituting the question of being in or near the cloud of smoke remained the highest risk factor when combined with the other direct exposure measures. Being present at a school which was under the plume or within 1 km of the plume results in an Odds Ratio of 2.06, indicating that substitution of this question is valid (see Table 16). In this paper, the plume was added separately to observe, if independently, it has an impact on PTSD in these data.

Table 16. Comparison of Modeled Physical Location vs. Perceived Location under the Plume

Measure of Direct Exposure (2+ exposures)	Odds Ratio	95% Confidence
Risk Perception (Question)	2.12	1.70 ± 2.65
School under plume	2.06	1.64 ± 2.60
School within 1 KM of plume	2.06	1.64 ± 2.59
School or Residence under plume	1.98	1.58 ± 2.48
School or Residence within 1 KM of plume	1.92	1.54 ± 2.40

The list of final neighborhood measures computed for this analysis is shown in Table 17. Variables included in the index, the corresponding Cronbach's Alpha and numbers of Factors identified were also included for ease of comparison. Those variables not included in the index have been tested separately to observe their influence on PTSD and to determine if any interactions are found. The SES and NSI indices have the highest α (0.904 and 0.893, respectively), with only one factor, while NQI has the lowest α (0.520), with three factors.

Table 17. Neighborhood Level Measures

Measure	Variables Included	Cronbach's Alpha	Number of Factors
Socio-Economic Status Index (SES):	Non-White Persons (%), HHs with public assistance (%), Single Parent HHs (%), Persons living below poverty (%), Unemployment (%), Annual income above $30,000 (%), Persons with at least High School Diploma (%)	0.904	1
Not in Index: Foreign Born (%),Population Density (Rate)	---	---	---
Residential Mobility:			
Persons (5+ yrs old) who resided in same HH 5+ yrs (%), Rental HHs (%)	---	---	
Neighborhood Safety Index (NSI):	Robbery (Persons), Felonious Assault (Persons), Forcible Rape (Persons), Murder and Non-Negligent Manslaughter (Persons), Burglary (Incidence), Structural Fires (Incidence), Non-Structural Fires (Incidence), Civilian Fire Fatalities (Persons), Drug Abuse Deaths (Persons)	0.893	1
Not in Index: Major Felony Crime (Persons), Grand Larceny (Incidence)	---	---	---
Neighborhood Quality Index (NQI):	Complaints Regarding Disorderly Youths (Count), Complaints Regarding Derelict Vehicles (Count), Rodent Complaints (Count), Air Quality Complaints (Count), Tons of Refuse Per Day Collected for Disposal (Count), Acceptably Clean Streets (%), Acceptably Clean Sidewalks (%), Recreational facilities (Count), Open Space (%)	0.520	3
Not in Index: Noise Complaints (Count), Small Parks and Playgrounds - Acceptably Clean (%), Small Parks and Playgrounds - Acceptable Conditions (%)	---	---	---
Location-Based Physical Exposure Measures (LBPEM)**:**			
Distance (Euclidian or Transportation) to the WTC	---	---	---
Line of Site to WTC Towers (%)	---	---	---
Under WTC Plume of Smoke (%)	---	---	---

4.1.3 School Level Variables

Intermediate Schools/Junior High Schools (IS) and High Schools (HS) are included in this study. In addition, school size and distance to Ground Zero, the school environment (expenditure, teacher-student ratio, etc.) and student performance on math and English city/state-wide standardized exams, varies greatly within these schools. All of the school environment variables (school expenditures, teacher-student ratios, etc.) are available for all school types (see Table 17) and were obtained from the NYC Department of Education for the 2001-2002 school year (NYC DOE, 2002). Unfortunately, the school performance variables available also differ based on type of school (see Table 18). Therefore, percent of students meeting English and Math graduation assessment state standards are used for HS and percent of students meeting English and math state standards are used for IS schools.

Table 18. School Level Variables

Variables	**Available for IS**	**Available for HS**
School Environment:		
Enrollment	Yes	Yes
Recent Immigrants (%)	Yes	Yes
Attendance (%)	Yes	Yes
Student Instability (%)	Yes	Yes
Eligible for Free Lunch (%)	Yes	Yes
Suspensions (per 1,000)	Yes	Yes
Student-Teacher Ratio (Rate)	Yes	Yes
Teachers with 2+ years teaching at school (%)	Yes	Yes
Teachers with 5+ years experience (%)	Yes	Yes
School Capacity (%)	Yes	Yes
School Expenditure	Yes	Yes
School Performance:		
Students meeting English Language Arts State Standards (%)	Yes	***No***
Students meeting Mathematics State Standards (%)	Yes	***No***
Meeting English Graduation Assessment Requirements (%)	***No***	Yes
Meeting Math Graduation Assessment Requirements (%)	***No***	Yes

4.1.3a. School Environment Index (SEI).

Table 19 illustrates the Spearman correlations of the School Environment Index (SEI). Although most of the variables are significantly correlated, Enrollment is not correlated with Student Instability (proportion of students attending different school in prior school year), Attendance and Suspensions. While Student Instability is positively correlated with most, it is negatively correlated with Enrollment, Recent Immigrants, and Teacher/Student Ratio. Because of its direction problems, Student Instability was removed from the composite SEI. Teacher/Student Ratio also suffers from the challenge of being positively correlated with some of the SEI variables and negatively with others. Instability and Teacher/Student Ratio were also removed from the SEI and tested independently.

Table 19. School Environment Spearman Correlation Matrix

	Enroll-ment	Recent Immigrant (%)	Attend-ance	Not on Free Lunch (P)	Student In-stability (%)	Sus-pension (%)	Teacher/ Student Ratio	Capacity	Expenditure (per student)	Teachers 2+ yrs at school	Teachers 5+ yrs experience
Enrollment	---	0.38**	0.04	0.11**	0.03	0.02	0.84**	0.34**	0.48**	0.28**	0.28**
Recent Immigrants (%)	0.38**	---	0.31**	0.10**	0.18**	0.17**	0.22**	0.33**	0.38**	0.17**	0.17**
Attendance	0.04	0.31**	---	0.30**	-0.45**	0.48**	-0.16**	0.19**	0.32**	0.15**	0.15**
Not on Free Lunch (P)	0.11**	0.10**	0.30**	---	-0.45**	0.11**	-0.04	0.17	0.33**	0.37**	0.37**
Student Instability (%)	0.03	0.18**	-0.45**	-0.45**	---	-0.17**	0.10**	-0.08**	-0.25**	-0.15**	-0.15**
Suspension (%)	0.02	0.17**	0.48**	0.11**	-0.17**	---	-0.13**	0.24**	0.19**	0.07*	0.07*
Teacher/ Student Ratio	0.84**	0.22**	-0.16**	-0.04	0.10**	-0.13**	---	0.19**	0.17**	0.21**	0.21**
Capacity	0.34**	0.33**	0.19**	0.17**	-0.08**	0.24**	0.19**	---	0.45**	0.17**	0.17**
Expenditure (per student)	0.48**	0.38**	0.32**	0.33**	-0.25**	0.19**	0.17**	0.45**	---	0.05	0.05
Teachers 2+ yrs at school	0.33**	0.22**	0.22**	0.32**	-0.16**	0.20**	0.27**	0.30**	0.14**	---	0.74**
Teachers 5+ yrs experience	0.15**	0.20**	0.35**	0.66**	-0.49**	0.25**	-0.11**	0.33**	0.42**	0.32**	---

*$p \leq 0.05$; **$p \leq 0.01$**

The Cronbach's Alpha of the remaining variables was extremely low with α=0.062. After removing School Expenditure (per student), Enrollment and Suspensions, the α was increased to 0.565. As with the other indices, a PCA was performed (see Figure 15 and Table 20), indicating three factors explaining 65.3% of the total variance. Because the variance explained by the third factor increased from 49.6% to 65.3%, Attendance, the only variable that loaded on factor 3, was kept in the SEI. A standardized sum of the remaining six variables (Recent Immigrants (%), Attendance, Not on free lunch (%), Capacity (%), Teachers 2+ yrs. at School (%), and Teachers 5+ yrs Experience (%)) in the SEI was created.

Figure 15. SEI Factor Scree Plot

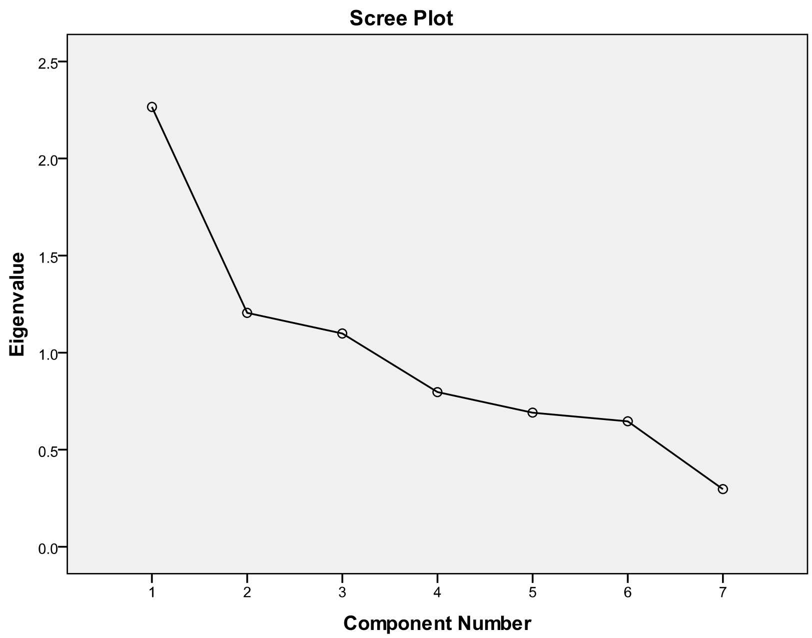


Table 20. SEI PCA Total Variance Explained									
Comp.	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Var.	Cum. %	Total	% of Var.	Cum. %	Total	% of Var.	Cum. %
1	2.27	32.37	32.37	2.27	32.37	32.37	1.94	27.69	27.69
2	1.20	17.21	49.58	1.20	17.21	49.58	1.39	19.82	47.51
3	1.10	15.69	65.28	1.10	15.69	65.28	1.24	17.76	65.28
4	.80	11.38	76.66						
5	.69	9.87	86.53						
6	.65	9.23	95.76						
7	.30	4.24	100.00						

4.1.3.b. School Performance Index (SPI).

School Performance is measured by percent of Students meeting English and Mathematics Standardized Tests Standards. As expected, the two variables are highly correlated (0.94, $p \leq 0.01$), with a Cronbach's Alpha of α =0.971 after combining into one measure.

As with the neighborhood level variables, a list of final school measures computed for this analysis is shown in Table 21, with variables included and not included in the index. The corresponding Cronbach's Alpha and numbers of Factors identified are also included for ease of comparison, and those variables not included in the index have been tested separately to observe their influence on PTSD and to determine if any interactions are found.

Table 21. School Level Indices and Measures

Measure	Variables Included	Cronbach's Alpha	Number of Factors
School Environment Index (SEI):	Recent Immigrants (%), Attendance (%), Not Eligible for Free Lunch (%), Teachers with 2+ years teaching at school (%), Teachers with 5+ years experience (%), School Capacity (%)	0.565	3
Not in Index: School Expenditure (per Student), Enrollment, Suspensions (per 1,000), Student-Teacher Ratio (Rate), Student Instability (%)	---	---	---
School Performance Index (SPI):	Students meeting English Language Arts State Standards (%), Students meeting Mathematics State Standards (%), Meeting English Graduation Assessment Requirements (%), Meeting Math Graduation Assessment Requirements (%)	0.971	1

5. Results

Table 21 represents the Spearman Correlations with PTSD Sy and each of the variables under consideration. PTSD Sy is significantly negatively correlated with both Zip code under the Plume and Zip Code within 1km of the Plume (see Table 22). As with prior analyses, none of the distance measures, Euclidean and transportation, are correlated with PTSD Sy. Neighborhood roof-top view of the WTC was also not significantly correlated with PTSD Sy. Zip code within 1km was further tested in bivariate regression analysis, remaining a significant predictor of PTSD Sy (p=0.001). However, when controlling for demographic variables (age, gender, race/ethnicity), the plume was no longer a predictor (p=.0199).

The SES index and Foreign Born (%) are significantly negatively associated with PTSD Sy and remained significant in the bivariate (p<0.001) and multivariate (p=0.037) analyses while controlling for demographics. Because both are significant at the multivariate level, they were further evaluated in multivariate regression. Population Density was not significant at any level. Of the Residential Mobility variables, % of Households Renting was significant at the correlation and bivariate levels but not at the multivariate; while Moving in Past 5 Years was not significant at any level, and thus, not evaluated further.

The NSI, NQI and Major Felony variables remained significant at all levels, with the NSI and NQI negatively associated and Major Felony positively associated with PTSD. Although Noise Complaints and Lack of Clean Playground remained significant predictors of PTSD Sy at the bivariate level, their effect on PTSD may be explained by the demographic variables.

Of the School Environment variables, Student Instability and School Expenditure remained significant predictors of PSTD Sy at all levels. Interestingly, School Expenditure is positively associated with PTSD Sy. Surprisingly, the SEI variable was not significant after controlling for demographics in the OLS regressions; yet, the SPI remained negatively associated with symptoms after controlling for demographics.

Table 22. Spearman Correlations between PTSD Symptoms and Standardized Indices/Variables

Measure	ρ	Bivariate		Controlling for Age, Gender, Race/Ethnicity	
		β^2	P	β^2	P
Distance					
Zip code under plume[1]	**-.032***				
Zip code within 1 KM of plume[1]	**-.040****	**-.041**	**.001**	-.016	.199
Zip code Euclidian Distance to GZ	.012				
Zip code Travel distance (mean)	.004				
Zip code Travel distance (median)	.007				
Zip code Travel Time (mean)	-.006				
Zip code Travel Time (median)	-.010				
Zip code view of WTC (%)	.004				
School Euclidian Distance to GZ	.086				
SES	**-.082****	**-.077**	**.000**	**-.033**	**.037**
Foreign Born (%)	**-.068****	**-.064**	**.000**	**-.028**	**.037**
Population Density	.010				
Residential Mobility					
HH Moved past 5 yrs (%)	-.010				
HH Rent (%)	**.051****	**.036**	**.004**	.000	.978
NSI	**-.055****	**-.058**	**.000**	**-.034**	**.011**
Major Felony	**.035****	**.037**	**.004**	**.027**	**.043**
Grand Larceny	-.011				
NQI	**-.084****	**-.080**	**.000**	**-.047**	**.000**
Noise complaints	**.046****	**.047**	**.000**	.011	.419
Lack of Clean Playground	**.040****	**.051**	**.005**	.010	.464
Lack of Playground Condition	**-.031***	-.017	.171		
Air Complaints	-.022				
SEI	**-.125****	**-.107**	**.000**	-.015	.348
Instability	**.113****	**.095**	**.000**	**.049**	**.001**
Teacher-Student Ratio	**-.093****	**-.085**	**.000**	-.002	.899
Suspension (%)	**.081****	**.043**	**.001**	.001	.915
School Expenditure	**.054****	**.049**	**.000**	**.028**	**.029**
SPI	**-.169****	**-.153**	**.000**	**-.087**	**.000**

[1]Binary Variable, not standardized; [2]Standardized β reported.

5.1. OLS Regression Results

All variables that remained significant predictors of PTSD Sy were further tested in multivariate regressions (see Table 23). Model 1 includes all individual level variables found in the original analysis (see Hoven et al., 2005); where the exposure measures (direct, family, previous and TV exposures) are the strongest predictors of PSTD Sy, in addition to being female, age, minority and low maternal education. Four additional regression models were run to observe the effects of the SES variables on the standardized β of the individual level variables. When the SES index was included (Model 2), low maternal education and being Black/African American no longer remained significant predictors of PSTD Symptoms, indicating that SES is also correlated with these two variables, and is marginally associated with symptoms (p=0.080). Foreign Born (%) did not affect these two variables as the SES Index (Model 3) and is a significant predictor of PTSD Sy (p=0.038). When both the Foreign Born and SES Index were included in the same model (Model 4), both remained significant predictors of PTSD Sy (p=0.034 and p=0.016, respectively); indicating that there may be an interaction between these two variables. As with Model 2, being Black/African American and low maternal education were no longer significant. Model 5 tests the interaction between SES and Foreign Born (%). The SES Index, percent Foreign Born and their interaction term are all significant predictors of PTSD Sy (p=0.002 , p=0.008 and p=0.001, respectively). It is clear from these models that SES explains PTSD Sy more than low maternal education. Interestingly, when the interaction term was introduced, being Black/African American was once again a significant predictor of PTSD Sy, indicating that Foreign Born may be related to this demography.

Table 23. Multivariate Regressions* SES and Foreign Born Predicting PTSD Symptoms

	Model 1 Adj. R^2=0.106; F=62.136; p=0.000		**Model 2** Adj. R^2=0.106; F=57.305; p=0.000		**Model 3** Adj. R^2=0.106; F=57.414; p=0.000		**Model 4** Adj. R^2=0.107; F=53.665; p=0.000		**Model 5** Adj. R^2=0.108; F=50.900; p=0.000	
	β	**p**	**β**	**p**	**β**	**P**	**β**	**p**	**β**	**p**
Female	**0.127**	**0.000**	**0.126**	**0.000**	**0.126**	**0.000**	**0.125**	**0.000**	**0.124**	**0.000**
Age	**-0.155**	**0.000**	**-0.154**	**0.000**	**-0.150**	**0.000**	**-0.148**	**0.000**	**-0.147**	**0.000**
Black/A.A.	**0.052**	**0.001**	0.034	0.067	**0.053**	**0.001**	0.033	0.078	**0.038**	**0.042**
Hispanic	**0.084**	**0.000**	**0.067**	**0.001**	**0.090**	**0.000**	**0.070**	**0.000**	**0.071**	**0.000**
Asian	-0.014	0.366	-0.021	0.186	-0.005	0.766	-0.011	0.510	-0.004	0.799
Other/Mixed	**0.026**	**0.048**	0.020	0.137	**0.027**	**0.038**	0.021	0.125	0.023	0.092
Low Maternal Education	**0.026**	**0.039**	0.023	0.066	**0.027**	**0.031**	0.024	0.056	0.022	0.085
Not living 2 Bio. Parents	-0.002	0.875	-0.004	0.786	-0.002	0.865	-0.005	0.707	-0.005	0.729
Direct Exp. (2+)	**0.147**	**0.000**	**0.146**	**0.000**	**0.147**	**0.000**	**0.146**	**0.000**	**0.148**	**0.000**
Family Exp. (Any)	**0.087**	**0.000**	**0.087**	**0.000**	**0.086**	**0.000**	**0.086**	**0.000**	**0.086**	**0.000**
Previous Exp. (2+)	**0.114**	**0.000**	**0.114**	**0.000**	**0.114**	**0.000**	**0.114**	**0.000**	**0.114**	**0.000**
TV Exposure	**0.122**	**0.000**	**0.122**	**0.000**	**0.121**	**0.000**	**0.122**	**0.000**	**0.123**	**0.000**
SES			-0.027	0.080			**-0.033**	**0.034**	**-0.050**	**0.002**
Foreign Born					**-0.027**	**0.038**	**-0.032**	**0.016**	**-0.035**	**0.008**
SES * Foreign Born									**-0.044**	**0.001**

* Standardized β reported here.

Five multivariate regression models were created to test the effects of the neighborhood safety and quality variables – NSI, Major Felony and NQI (see Table 24). While Major Felony is not a significant predictors of PSTD Sy (Models 7), NSI was marginally associated (p=0.056 and p=0.062, in Models 6 and 8, respectively). NQI is significantly negatively associated with PSTD Sy in both Models 9 and 10 (p=0.001 and p=0.007, respectively). Unlike the SES variables in Models 2-5, NQI did not interact with any of the individual level variables; thus, contributing independently to PTSD Sy. When included with NSI and Major Felony, NQI still remained significantly negatively associated with PSTD Sy (Model 10), with a p-value of 0.007.

As with the neighborhood level variables, six OLS regression models were created to observe the influence of the school environment and performance variables (see Table 25). Keeping with prior models, SEI is not associated with PTSD Sy, while Student Instability is (see Models 11 and 12). When Student Instability was introduced to the model (Model 12), being Black/African American was no longer significant, indicating that Student Instability may also be associate with being Black/African American.

Table 24. Multivariate Regressions Neighborhood Safety, Major Felony and Neighborhood Quality Predicting PTSD Symptoms

	Model 1		**Model 6**		**Model 7**		**Model 8**		**Model 9**		**Model 10**	
	Adj. R^2=0.106; F=62.136; p=0.000		Adj. R^2=0.106; F=57.332; p=0.000		Adj. R^2=0.106; F=57.153; p=0.000		Adj. R^2=0.107; F=53.341; p=0.000		Adj. R^2=0.106; F=57.332; p=0.000		Adj. R^2=0.107; F=50.319; p=0.000	
	β	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Female	**0.127**	**0.000**	**0.126**	**0.000**	**0.126**	**0.000**	**0.126**	**0.000**	**0.125**	**0.000**	**0.125**	**0.000**
Age	**-0.155**	**0.000**	**-0.155**	**0.000**	**-0.156**	**0.000**	**-0.154**	**0.000**	**-0.152**	**0.000**	**-0.151**	**0.000**
Black/A.A.	**0.052**	**0.001**	**0.041**	**0.015**	**0.045**	**0.007**	**0.041**	**0.016**	**0.043**	**0.007**	**0.046**	**0.007**
Hispanic	**0.084**	**0.000**	**0.075**	**0.000**	**0.079**	**0.000**	**0.075**	**0.000**	**0.079**	**0.000**	**0.082**	**0.000**
Asian	-0.014	0.366	-0.018	0.242	-0.018	0.252	-0.016	0.311	-0.011	0.461	-0.009	0.557
Other/Mixed	**0.026**	**0.048**	0.023	0.085	0.024	0.071	0.023	0.083	0.023	0.073	0.024	0.066
Low Maternal Education	**0.026**	**0.039**	0.024	0.054	**0.025**	**0.048**	0.024	0.053	**0.025**	**0.047**	**0.025**	**0.044**
Not living 2 Bio. Parents	-0.002	0.875	-0.002	0.854	-0.002	0.882	-0.003	0.826	-0.003	0.847	-0.003	0.845
Direct Exp. (2+)	**0.147**	**0.000**	**0.145**	**0.000**	**0.145**	**0.000**	**0.147**	**0.000**	**0.147**	**0.000**	**0.148**	**0.000**
Family Exp. (Any)	**0.087**	**0.000**	**0.088**	**0.000**	**0.087**	**0.000**	**0.087**	**0.000**	**0.087**	**0.000**	**0.086**	**0.000**
Previous Exp. (2+)	**0.114**	**0.000**	**0.114**	**0.000**	**0.114**	**0.000**	**0.113**	**0.000**	**0.113**	**0.000**	**0.113**	**0.000**
TV Exposure	**0.122**	**0.000**	**0.121**	**0.000**	**0.121**	**0.000**	**0.121**	**0.000**	**0.120**	**0.000**	**0.120**	**0.000**
Neigh. Safety (NSI)			-0.025	0.056			-0.060	0.062			-0.005	0.897
Major Felony					0.016	0.209	-0.037	0.236			-0.013	0.678
Neigh. Quality (NQI)									**-0.043**	**0.001**	**-0.047**	**0.007**

Table 25. Multivariate Regressions School Environment (SEI), Instability, Expenditure and School Performance (SPI) Predicting PTSD Symptoms

	Model 1 Adj. R^2=0.106; F=62.136; p=0.000		**Model 11** Adj. R^2=0.105; F=55.825; p=0.000		**Model 12** Adj. R^2=0.112; F=59.913; p=0.000		**Model 13** Adj. R^2=0.105; F=55.823; p=0.000		**Model 14** Adj. R^2=0.112; F=51.917; p=0.000		**Model 15** Adj. R^2=0.112; F=59.648; p=0.000		**Model 16** Adj. R^2=0.114; F=49.725; p=0.000	
	β	**p**	**β**	**p**	**β**	**P**	**β**	**p**	**β**	**p**	**β**	**p**	**β**	**p**
Female	**0.127**	**0.000**	**0.127**	**0.000**	**0.126**	**0.000**	**0.127**	**0.000**	**0.126**	**0.000**	**0.130**	**0.000**	**0.128**	**0.000**
Age	**-0.155**	**0.000**	**-0.146**	**0.000**	**-0.145**	**0.000**	**-0.150**	**0.000**	**-0.145**	**0.000**	**-0.070**	**0.000**	**-0.097**	**0.000**
Black/A.A.	**0.052**	**0.001**	**0.043**	**0.012**	0.021	0.212	0.046	0.005	0.021	0.236	0.017	0.300	0.014	0.410
Hispanic	**0.084**	**0.000**	**0.077**	**0.000**	**0.056**	**0.001**	**0.079**	**0.000**	**0.056**	**0.001**	**0.050**	**0.004**	**0.047**	**0.007**
Asian	-0.014	0.366	-0.016	0.287	-0.008	0.585	-0.016	0.290	-0.008	0.586	-0.014	0.373	-0.009	0.557
Other/Mixed	**0.026**	**0.048**	0.024	0.074	0.014	0.272	0.024	0.063	0.014	0.277	0.014	0.299	0.012	0.378
Low Maternal Education	**0.026**	**0.039**	**0.031**	**0.014**	**0.026**	**0.040**	**0.031**	**0.014**	**0.026**	**0.040**	**0.025**	**0.049**	0.024	0.061
Not living 2 Bio. Parents	-0.002	0.875	-0.004	0.775	-0.011	0.423	-0.003	0.796	-0.011	0.424	-0.011	0.415	-0.012	0.344
Direct Exp. (2+)	**0.147**	**0.000**	**0.145**	**0.000**	**0.173**	**0.000**	**0.144**	**0.000**	**0.174**	**0.000**	**0.165**	**0.000**	**0.179**	**0.000**
Family Exp. (Any)	**0.087**	**0.000**	**0.088**	**0.000**	**0.084**	**0.000**	**0.088**	**0.000**	**0.084**	**0.000**	**0.084**	**0.000**	**0.083**	**0.000**
Previous Exp. (2+)	**0.114**	**0.000**	**0.116**	**0.000**	**0.114**	**0.000**	**0.117**	**0.000**	**0.114**	**0.000**	**0.114**	**0.000**	**0.113**	**0.000**
TV Exposure	**0.122**	**0.000**	**0.123**	**0.000**	**0.121**	**0.000**	**0.122**	**0.000**	**0.122**	**0.000**	**0.120**	**0.000**	**0.120**	**0.000**
SEI			-0.013	0.418					-0.002	0.886			0.012	0.488
Instability					**0.099**	**0.000**			**0.100**	**0.000**			**0.067**	**0.000**
Expenditure							0.010	0.428	-0.005	0.720			-0.012	0.390
SPI											**-0.128**	**0.000**	**-0.090**	**0.000**

* Standardized β reported here.

Although School Expenditure (per student) was significant in prior models, when included in models with the other independent variables, it was no longer significantly associated with PSTD Sy. A negative SPI is the strongest predictor of PTSD Sy among all school level variables and is a stronger predictor than Family Exposure, Previous Exposure and TV Exposure (Model 15). When introduced into a model with the other school level variables, the SPI (β=-0.090) was still a stronger predictor than Family Exposure (β=0.083) but not as strong as Previous or TV exposure, and Student Instability remained a significant predictor of PTSD Sy.

Two cumulative OLS regression models were conducted (see Table 26). Model 17 included all neighborhood level variables that were statistically significantly associated with PTSD Sy in prior models. When included with Neighborhood Quality, SES and Foreign Born (%) were marginally significant (p=0.054 and p=0.060, respectively); yet, the interaction term remained significant (p=0.002). Negative Neighborhood Quality remained a significant contributor to PSTD Sy (p=0.015), even after significant school level variables were introduced. Both the Student Instability and the Student Performance Index remained significantly associated with PSTD Sy (see Model 18). When these neighborhood and school level variables were included in the same model, being Black/African American, and of Other or Mixed Race were no longer significant, while having a low educated mother was marginally significant (p=0.092), indicating that these school and neighborhood level variables are stronger contributors to PSTD Sy. Yet, the exposure variables (Direct, Family, Previous and TV Exposure) along with being female, Hispanic and young, remained the strongest predictors of PTSD Sy in these data.

Table 26. Multivariate Regressions SES. Foreign Born, Neighborhood Quality (NQI), Student Instability, and School Performance (SPI) Predicting PTSD Symptoms

	Model 1 Adj. R^2=0.106; F=62.136; p=0.000		**Model 17** Adj. R^2=0.116; F=45.068; p=0.000		**Model 18** Adj. R^2=0.116; F=45.068; p=0.000	
	β	**p**	**β**	**p**	**β**	**p**
Female	**0.127**	**0.000**	**0.124**	**0.000**	**0.126**	**0.000**
Age	**-0.155**	**0.000**	**-0.147**	**0.000**	**-0.097**	**0.000**
Black/A.A.	**0.052**	**0.001**	**0.041**	**0.030**	0.012	0.513
Hispanic	**0.084**	**0.000**	**0.075**	**0.000**	**0.047**	**0.017**
Asian	-0.014	0.366	-0.002	0.910	0.002	0.880
Other/Mixed	**0.026**	**0.048**	0.023	0.081	0.012	0.367
Low Maternal Education	**0.026**	**0.039**	0.022	0.080	0.021	0.092
Not living 2 Bio. Parents	-0.002	0.875	-0.004	0.775	-0.013	0.341
Direct Exp. (2+)	**0.147**	**0.000**	**0.149**	**0.000**	**0.179**	**0.000**
Family Exp. (Any)	**0.087**	**0.000**	**0.086**	**0.000**	**0.082**	**0.000**
Previous Exp. (2+)	**0.114**	**0.000**	**0.113**	**0.000**	**0.112**	**0.000**
TV Exposure	**0.122**	**0.000**	**0.122**	**0.000**	**0.120**	**0.000**
SES			-0.035	0.054	-0.014	0.442
Foreign Born			-0.026	0.060	-0.010	0.487
SES * Foreign Born			**-0.042**	**0.002**	**-0.045**	**0.001**
Neigh. Quality Index (NQI)			**-0.031**	**0.028**	**-0.034**	**0.015**
Student Instability					**0.070**	**0.000**
Student Performance Index (SPI)					**-0.071**	**0.002**

* Standardized β reported here.

5.2. Logistic Regression Results

Four logistic regression models were created to examine the effects of these significant neighborhood and school level variables on (probable) PTSD Diagnosis (including Impairment) (see Table 27). As with the OLS Model 1 above, Model 19 includes only individual level variables from the Hoven et al. (2005) paper, where the exposure measures were the strongest risk factors for PTSD Dx, as well as being young, female and Hispanic. Model 20 includes the neighborhood level variables SES, Foreign Born and their interaction, and the NQI. Unlike the regression Model 17 where the SES x Foreign Born interaction was statistically significantly associated with PTSD Sy, the interaction term was not a significant risk factor for PTSD Dx, along with SES and being Foreign Born. Yet, negative NQI remained a strong risk factor for PTSD Dx (Adjusted Odds Ratio (AOR)=1.160). Surprisingly, neither of the school level variables (Student Instability and a low SPI) were significant risk factors for PTSD Dx (with Adjusted Odds Ratios raging from 0.9 through 1.4 in Models 21 and 22). The logistic regression model which includes all the independent variables tested (Model 22), identifies lower Neighborhood Quality as the only significant risk factor for PTSD Dx with an AOR 1.191 (95% Confidence Interval of 1.065 to 1.332) among all neighborhood and school level variables. None of the previously identified risk factors for (probable) PTSD Dx were affected by the NQI, indicating that residing in a zip code with low NQI independently contributes to the development of the (probable) PTSD Dx (including Impairment).

Table 27. Logistic Regression Models Predicting (probable) PTSD Diagnosis (with Impairment)

	Model 19		Model 20		Model 21		Model 22	
	AOR[1]	95%CI[2]	AOR[1]	95%CI[2]	AOR[1]	95%CI[2]	AOR[1]	95%CI[2]
Female	**1.591**	**(1.295, 1.954)**	**1.590**	**(1.293, 1.954)**	**1.577**	**(1.28, 1.944)**	**1.577**	**(1.279, 1.945)**
Age	**1.160**	**(1.105, 1.218)**	**1.156**	**(1.099, 1.215)**	**1.169**	**(1.086, 1.258)**	**1.173**	**(1.088, 1.264)**
Black/A.A.	1.312	(0.943, 1.826)	1.238	(0.84, 1.826)	1.215	(0.856, 1.725)	1.187	(0.797, 1.769)
Hispanic	**1.606**	**(1.193, 2.163)**	**1.551**	**(1.092, 2.202)**	**1.524**	**(1.115, 2.082)**	**1.517**	**(1.06, 2.171)**
Asian	1.026	(0.72, 1.46)	1.070	(0.733, 1.562)	1.041	(0.73, 1.483)	1.080	(0.739, 1.579)
Other/Mixed	1.465	(0.88, 2.437)	1.419	(0.836, 2.407)	1.458	(0.871, 2.44)	1.439	(0.845, 2.451)
Low Maternal Education	1.103	(0.849, 1.435)	1.096	(0.841, 1.428)	1.127	(0.864, 1.47)	1.124	(0.86, 1.468)
Not live w/ both parents	1.012	(0.815, 1.256)	1.014	(0.815, 1.262)	0.994	(0.797, 1.241)	0.999	(0.799, 1.25)
Direct Exposure	**2.106**	**(1.72, 2.58)**	**2.110**	**(1.721, 2.586)**	**2.103**	**(1.701, 2.601)**	**2.113**	**(1.707, 2.616)**
Family Exposure	**1.939**	**(1.5, 2.506)**	**1.943**	**(1.502, 2.512)**	**1.901**	**(1.463, 2.47)**	**1.908**	**(1.468, 2.481)**
Previous Exposure	**1.926**	**(1.572, 2.362)**	**1.904**	**(1.552, 2.336)**	**1.940**	**(1.577, 2.385)**	**1.921**	**(1.56, 2.364)**
TV Exposure	**1.608**	**(1.278, 2.023)**	**1.595**	**(1.267, 2.008)**	**1.620**	**(1.283, 2.047)**	**1.603**	**(1.268, 2.026)**
SES			1.014	(0.874, 1.176)			1.044	(0.897, 1.216)
Foreign Born			1.003	(0.891, 1.131)			1.033	(0.914, 1.168)
SES x Foreign Born			1.004	(0.897, 1.124)			1.003	(0.895, 1.124)
NQI			**1.160**	**(1.04, 1.294)**			**1.191**	**(1.065, 1.332)**
Instability					1.174	(0.93, 1.481)	1.180	(0.933, 1.494)
SPI					1.037	(0.899, 1.196)	1.051	(0.908, 1.216)

1. Adjusted Odds Ratio; 2. 95% Confidence Interval

5.3. Hierarchical Linear Model Results

Two Hierarchical Linear Models predicting PTSD Symptoms and (probable) Disorder (PTSD Dx) were created to test for the effect of the hierarchy found in modeling individual, neighborhood level and school variables (see Figure 5c above and Table 28 below). Odds Ratios (OR) and p-values are provided for Model 23 – predicting the continuous symptoms variable (PTSD Sy) – and for Model 24 – predicting the binary (probable) disorder variable (PTSD Dx). The HLM predicting PTSD Sy behaved in similar fashion to the other multivariate OLS regression models (Models 2 through 18). At the individual level, Direct Exposure, with an OR of 2.04 ($p<0.001$), is the strongest risk factor for PTSD Sy, followed by the other exposure measures (Family Exposure: OR=1.56, $p<0.001$; TV Exposure: OR=1.52, $p<0.001$; Female: OR=1.51, $p<0.001$; and Previous Exposure: OR=1.47, $p<0.001$). Age was also significant predictors (OR=0.93, $p<0.001$; protective against PTSD Sy as the student gets older), yet being Hispanic, unlike prior models, is no longer significant. While the interaction between SES and Foreign Born remained significant predictors (OR=0.94; $p=0.019$) at the Neighborhood level, NQI is marginal (OR=0.95; $p=0.065$), indicating, as with prior models, that students living in neighborhoods with better neighborhood quality report less PTSD Symptoms. At the school level, both the Student Instability (OR=1.15, $p=0.040$) and SPI (OR=0.91, $p=0.021$) were statistically significantly associated with PTSD Sy, with Instability a risk factor and School Performance a protective factor for PTSD Sy.

Model 24, predicting (probable) PTSD Diagnosis (PTSD Dx) also behaved similarly to the multiple regression cumulative Model 22. At the individual level, the four exposure measures (Direct: OR=2.19, $p<0.001$; Family: OR=1.92, $p<0.001$; Previous: OR=1.88, $p<0.001$; and High TV Exposure: OR=1.61, $p<0.001$) remained high risk factors for developing (probable)

PTSD, along with being female (OR=1.55, p<0.001); while being Hispanic is marginal (OR=1.38, p=0.087). As with all other models, the age is a significant protective factor (OR=0.85, p<0.001). After controlling for the hierarchical nature of the data, none of the school level variables were significant and at the neighborhood level, residing in a higher quality neighborhood (NQI) was a protective factor against developing (probable) PTSD Dx (OR=0.85, p=0.010).

Table 28. Hierarchical Linear Models Predicting PTSD Symptoms and (probable) Disorder

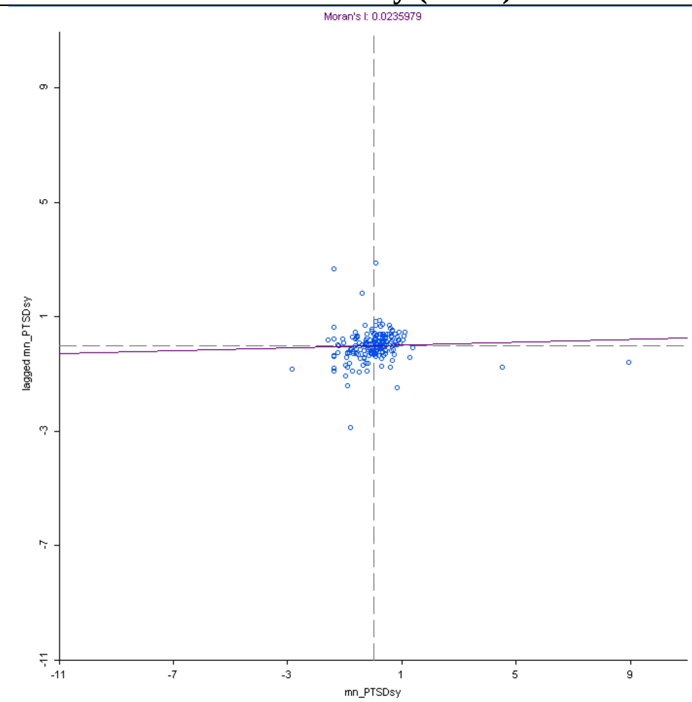
	Model 23 PTSD Sy		Model 24 PTSD Dx	
	OR	**p**	**OR**	**p**
Female	**1.51**	**<0.001**	**1.55**	**<.0001**
Age	**0.93**	**<0.001**	**0.85**	**0.0001**
Black/A.A.	0.99	0.862	1.07	0.736
Hispanic	1.12	0.131	**1.38**	**0.087**
Asian	1.03	0.681	1.10	0.639
Other/Mixed	1.07	0.555	1.33	0.304
Low Maternal Education	1.06	0.291	1.07	0.604
Not live w/ both parents	0.96	0.366	0.99	0.948
Direct Exposure	**2.04**	**<0.001**	**2.19**	**<.0001**
Family Exposure	**1.56**	**<0.001**	**1.92**	**<.0001**
Previous Exposure	**1.47**	**<0.001**	**1.88**	**<.0001**
TV Exposure	**1.52**	**<0.001**	**1.61**	**<.0001**
SES	0.98	0.493	1.05	0.546
Foreign Born	0.97	0.248	1.03	0.643
SES x Foreign Born	**0.94**	**0.019**	1.01	0.818
NQI	**0.95**	**0.065**	**0.85**	**0.010**
Instability	**1.15**	**0.040**	1.17	0.277
SPI	**0.91**	**0.021**	1.05	0.602

5.4. Spatial and Geographically Weighted Regression Results

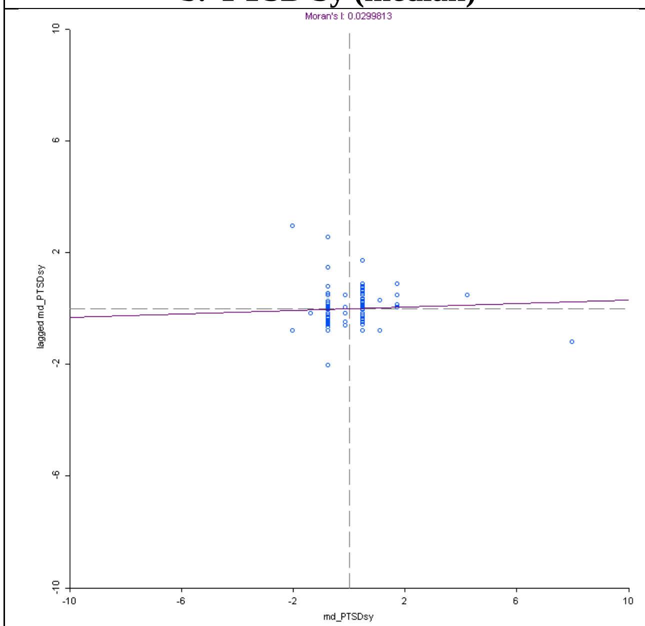
Data aggregated to the zip code level was merged back to an ESRI shapefile and brought into the Open GeoDa 1.20 software (see https://geodacenter.asu.edu/ogeoda), where queen spatial weights were calculated. Univariate Moran's I calculated for the PTSD Sy (mean and median) and the PTSD Dx variables (see Figures 16 A to C) indicate no significant spatial autocorrelation for either of the two PTSD Sy (mean and median) variables, with Moran's I of 0.024 ($p=0.257$ with 9999 Monte Carlo simulations) and 0.030 ($p=0.233$ with 9999 Monte Carlo simulations), respectively. There is, however, significant positive spatial autocorrelation within the PTSD Dx aggregated to the zip code level (Moran's I=0.253, $p<0.001$ with 9999 Monte Carlo simulations).

Figure 16. Univariate Moran's I of PTSD Sy (mean), PTSD Sy (median) and PTSD Dx

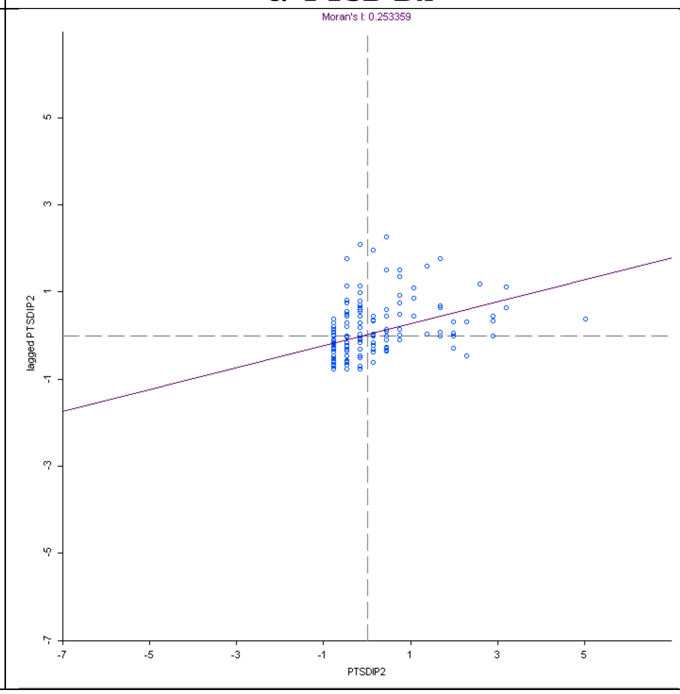
a. PTSD Sy (mean)



b. PTSD Sy (median)



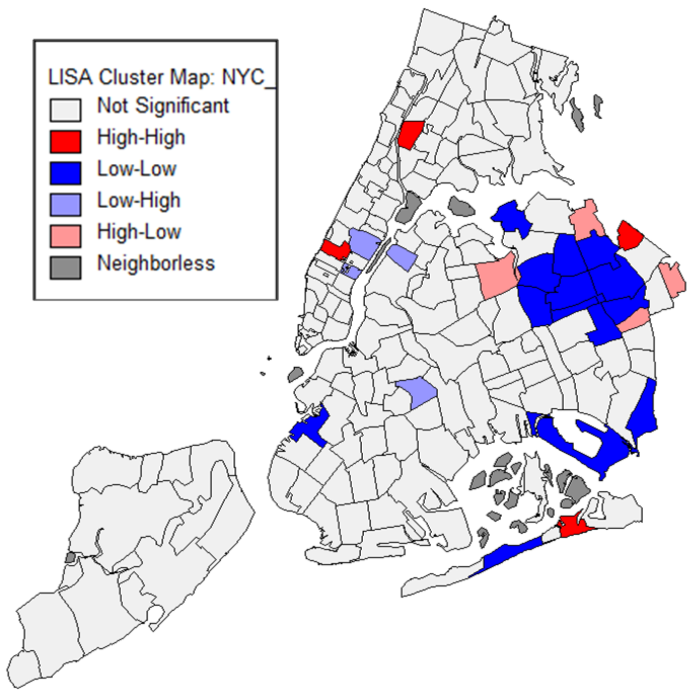
c. PTSD Dx



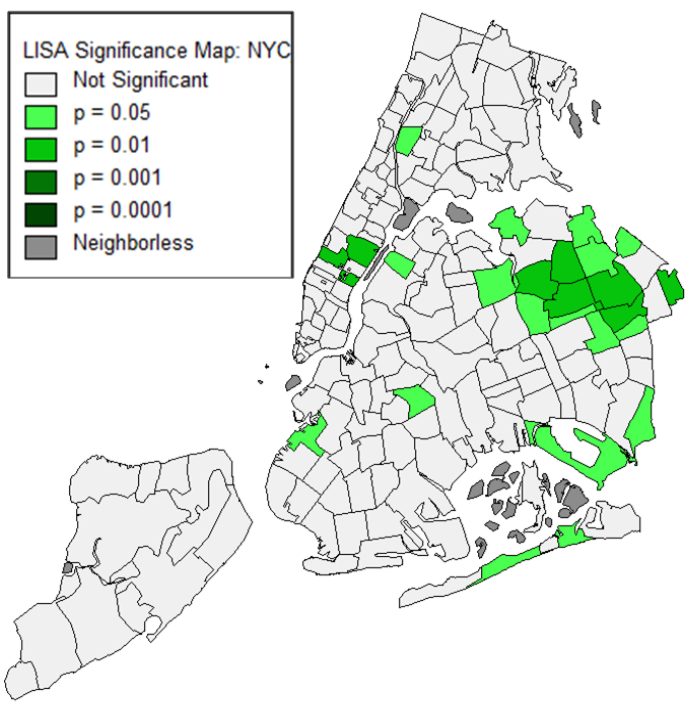
To observe if any local clusters of PTSD are found in these data, the Local Indicator of Spatial Autocorrelation (LISA) was calculated and mapped (see Maps 7A through Maps 7F). As expected, very little difference is observed between the PTSD Sy mean and median maps, with low PTSD Sy clusters in northeast Queens and western Brooklyn (Maps 7A and 7C). A mixture of high and low PTSD Sy is found in midtown Manhattan and the PTSD mean Sy cluster map illustrates a few clusters of high PTSD Sy, including one in the southwest Bronx. While some of the clusters of low PTSD Sy from northeast Queens is also evident in the PTSD Dx maps (see Maps 7E and 7F), the spatial patterns of the significant LISA statistic clusters of the PTSD Dx and Sy are quite dissimilar. Clusters of high PTSD Dx zip codes are found in the northern edge of Brooklyn and a large proportion of Staten Island.

Map 7. PTSD Sy and Dx LISA Cluster and Significance Maps

(a) PTSD Sy (mean) Cluster Map

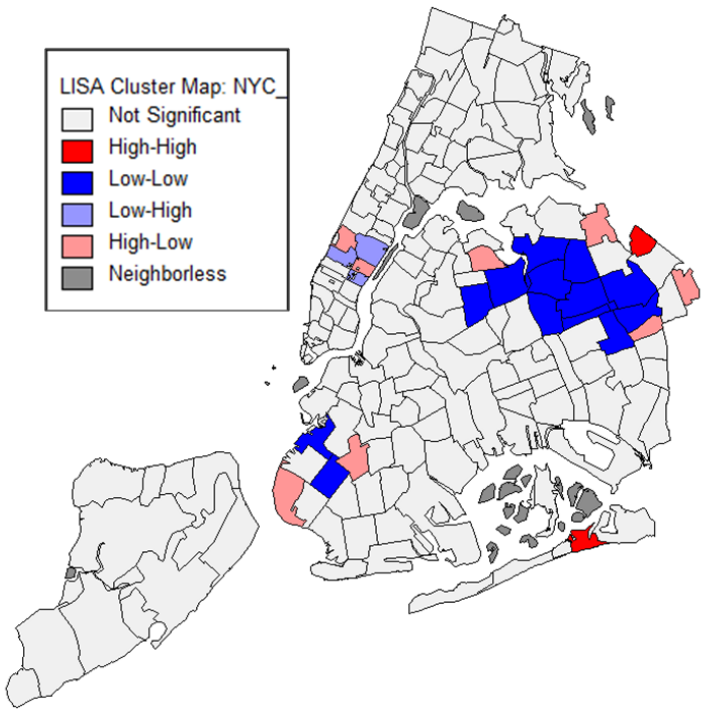


(b) PTSD Sy (mean) Significance Map

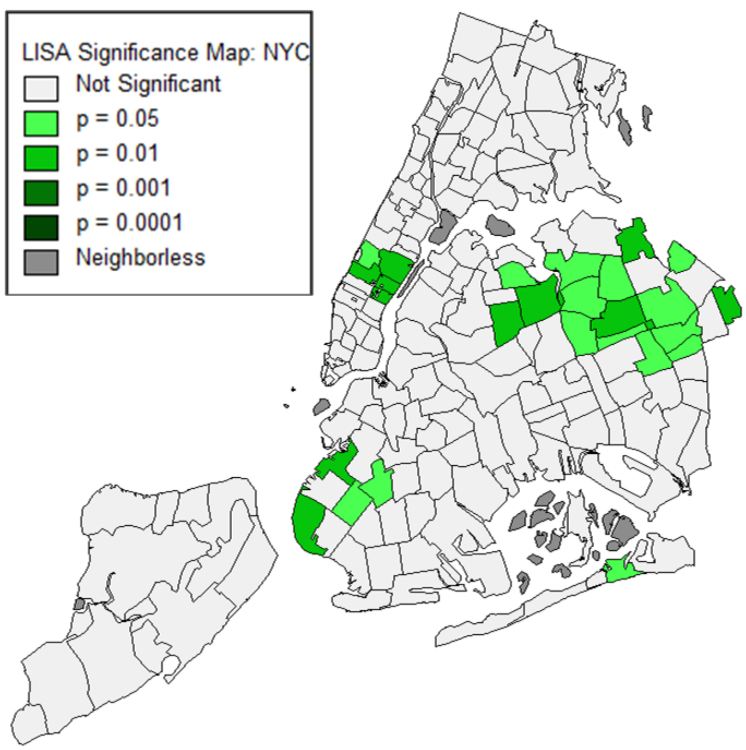


Map 7. PTSD Sy and Dx LISA Cluster and Significance Maps *(continued)*

(c) PTSD Dx (median) Cluster Map

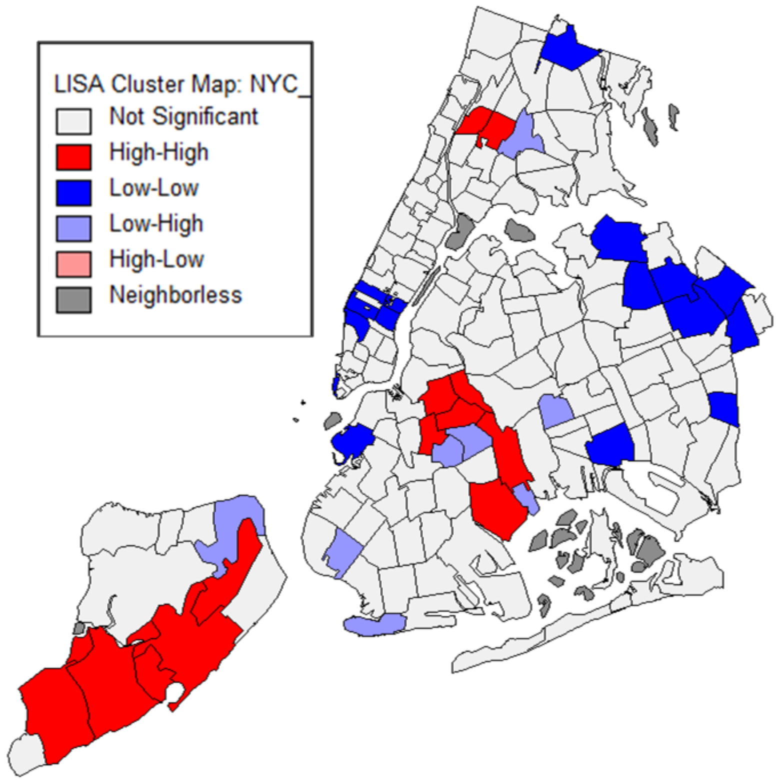


(d) PTSD Sy (median) Significance Map

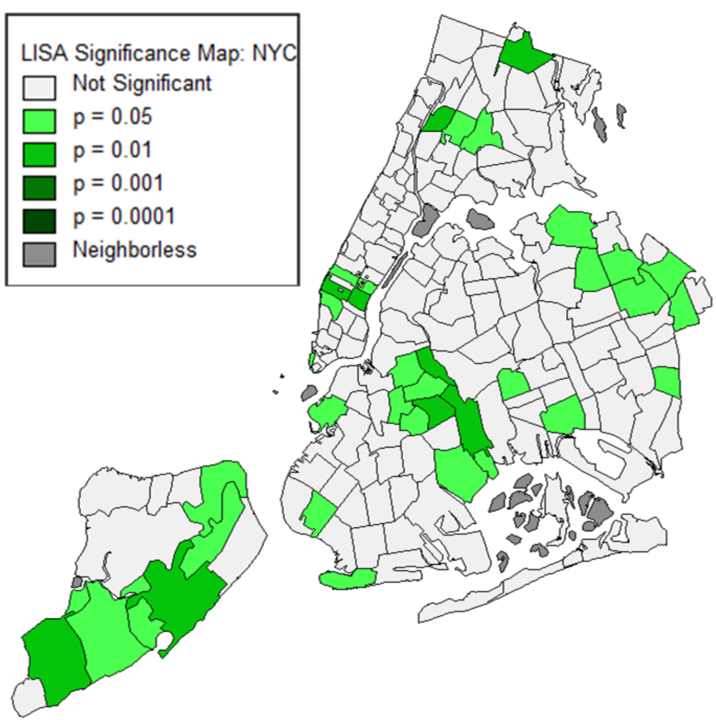


Map 7. PTSD Sy and Dx LISA Cluster and Significance Maps *(continued)*

(e) PTSD Dx Cluster Map



(f) PTSD Dx Significance Map



Although no significant spatial autocorrelation was found in any of the PTSD Sy mean and median aggregated variables, spatial regressions were performed to observe the difference of the effects of the independent variables after the aggregation. For each of the two PTSD Sy (mean and median) variables, three separate regressions were performed: 1) OLS; 2) Spatial Lag; and, 3) Spatial Error. The results of the spatial regressions for PTSD Sy (mean) are illustrated in Table 29. Using the Akaike's Information Criterion (AIC) as a measure of model fit, each of the three spatial regression models predicting PTSD Sy (mean) were similar (with similar R^2). Surprisingly, in neither of these three models (Models 25 – 27), being female or being younger were significant predictors of PTSD Sy (mean), unlike any prior models reported here. Of the four exposure measures, the strongest predictors of PTSD Sy, only Direct and TV Exposure were significant. In these three models, including the OLS, TV Exposure is protective (negative β coefficient) in completely the opposite direction than all prior models. Of the neighborhood level variables, lower SES was the only significant predictor, and Student Instability was the only significant school level predictor of PTSD Sy (mean). Across all three models, the β remained fairly constant indicating no difference within these three model runs. The spatial lag nor the spatial error coefficients were significant predictors of PTSD Sy (mean).

Table 29. Spatial Regression Model Results Predicting PTSD Sy (mean)

	Model 25 (OLS)		Model 26 (Spatial Lag)		Model 27 (Spatial Error)	
	R^2=0.333		R^2=0.339		R^2=0.333	
	AIC=325.191		AIC=325.725		**AIC=325.19**	
	β	**P**	**β**	**p**	**β**	**p**
CONSTANT	3.381	0.000	3.698	0.000	3.384	0.000
Female	0.017	0.195	0.017	0.165	0.017	0.165
Age	-0.045	0.465	-0.050	0.389	-0.045	0.435
Black/A.A.	-0.002	0.843	-0.001	0.906	-0.002	0.826
Hispanic	-0.007	0.548	-0.006	0.531	-0.007	0.521
Asian	-0.010	0.242	-0.011	0.154	-0.010	0.206
Other/Mixed	-0.019	0.576	-0.021	0.515	-0.019	0.546
Low Maternal Education	0.007	0.630	0.009	0.530	0.008	0.594
Not live w/ both parents	-0.007	0.619	-0.009	0.481	-0.007	0.596
Direct Exposure	**0.017**	**0.028**	**0.019**	**0.012**	**0.017**	**0.019**
Family Exposure	0.006	0.808	0.008	0.729	0.006	0.795
Previous Exposure	0.018	0.279	0.019	0.228	0.019	0.244
TV Exposure	**-0.024**	**0.041**	**-0.025**	**0.022**	**-0.024**	**0.028**
SES	**0.221**	**0.012**	**0.236**	**0.004**	**0.223**	**0.007**
Foreign Born	0.066	0.267	0.073	0.188	0.067	0.229
SES x Foreign Born	0.043	0.477	0.045	0.427	0.044	0.433
NQI	-0.024	0.722	-0.047	0.470	-0.024	0.706
Instability	**1.044**	**0.000**	**1.038**	**0.000**	**1.041**	**0.000**
SPI	-0.086	0.566	-0.109	0.439	-0.088	0.534
Lag Coefficient (Rho)			-0.117	0.107		
Lag Coefficient (Lambda)					-0.008	0.937

The results for using the median as the aggregation method for the spatial regression models predicting PTSD Sy varied greatly (Models 28 – 30 in Table 30). A slight difference is observed in the AIC with the spatial error (Model 30) and the regular OLS (Model 28) having the lowest AIC of these models. Again, age was a not a significant predictor, yet, being female was marginal in both the spatial lag and spatial error models ($p<0.10$). TV Exposure remained protective while Direct Exposure was not significant. While Student Instability remained a significant predictor across these three models, lower SES was marginal ($p<0.10$) in both the spatial lag and spatial error models predicting PTSD Sy (median) and not significant in the OLS model. It is clear that the aggregation methods (mean vs. median) for these models has had an effect on both, the AIC and the β coefficients, with the median having the lower of the AIC, thus a better model fit.

Table 30. Spatial Regression Model Results Predicting PTSD Sy (median)

	Model 28 (OLS) R^2=0.240 **AIC=406.242**		**Model 29 (Spatial Lag)** R^2=0.241 AIC=407.894		**Model 30 (Spatial Error)** R^2=0.240 **AIC=406.234**	
	β	**P**	**β**	**p**	**β**	**p**
CONSTANT	1.864	0.021	2.046	0.007	1.899	0.012
Female	0.026	0.118	**0.027**	**0.090**	**0.027**	**0.091**
Age	0.020	0.719	0.016	0.759	0.017	0.738
Black/A.A.	-0.005	0.668	-0.004	0.692	-0.005	0.637
Hispanic	-0.007	0.638	-0.006	0.635	-0.006	0.619
Asian	-0.016	0.131	**-0.017**	**0.088**	**-0.017**	**0.097**
Other/Mixed	-0.009	0.837	-0.011	0.792	-0.011	0.799
Low Maternal Education	0.019	0.333	0.020	0.274	0.019	0.280
Not live w/ both parents	-0.003	0.852	-0.004	0.780	-0.003	0.838
Direct Exposure	0.010	0.337	0.010	0.271	0.010	0.300
Family Exposure	0.024	0.477	0.024	0.442	0.024	0.451
Previous Exposure	0.010	0.642	0.010	0.616	0.010	0.613
TV Exposure	**-0.028**	**0.057**	**-0.029**	**0.036**	**-0.028**	**0.040**
SES	0.162	0.126	**0.174**	**0.080**	**0.168**	**0.089**
Foreign Born	-0.011	0.877	-0.012	0.867	-0.010	0.890
SES x Foreign Born	0.001	0.994	0.003	0.970	0.005	0.944
NQI	0.001	0.989	-0.014	0.864	-0.001	0.992
Instability	**0.763**	**0.000**	**0.765**	**0.000**	**0.759**	**0.000**
SPI	0.006	0.959	0.000	0.997	0.006	0.958
Lag Coefficient (Rho)			-0.072	0.388		
Lag Coefficient (Lambda)					-0.019	0.847

Since the mean aggregation proved to be the better of the aggregation methods in the spatial regression models, it was used for aggregating continuous variables (e.g., age, SES, NQI, SPI) in the three spatial regression models predicting PTSD Dx. As in the six models predicting PTSD Sy, these three models have mixed results (see Table 31). While the R^2 of these three models are very strong (R^2>0.80), the AIC are substantially higher than the past 6 spatial regression models, thus indicating a worse model fit. With an AIC of 660.3, the spatial error model had the best fit of the three models predicting PTSD Dx.

Age and being female were, again, not significant predictors of PTSD Dx, while being Hispanic was marginal in the spatial error model ($p<0.10$). Interestingly, being of Other/Mixed race was a significant predictor in each of the three models, while having a mother with low education was a marginally significant predictor of PTSD Dx. Unlike all other models, living in a single parent household was protective, in opposite direction of prior models reported. Of the exposure measures, Direct and Previous Exposure were significant predictors of PTSD Dx (although Direct Exposure was not significant in the OLS model). While none of the school level predictors were significant, both the SES and the interaction between SES and Foreign Born (%) were significant predictors in the spatial error model only. While the lag coefficient (rho) of the spatial lag mode was not significant, the lag coefficient (lambda) of the spatial error model was highly significant ($p<0.001$), indicating that the spatial autocorrelation (Moran's I=0.253, $p<0.001$ with 9999 Monte Carlo simulations) found of the PTSD Dx has an effect on the error, not the spatial lag.

Table 31. Spatial Regression Model Results Predicting PTSD Dx

	Model 31 (OLS) R^2=0.802 **AIC=663.322**		**Model 32 (Spatial Lag)** R^2=0.803 AIC=664.067		**Model 33 (Spatial Error)** R^2=0.807 **AIC=660.252**	
	β	**P**	**β**	**p**	**β**	**p**
CONSTANT	1.914	0.405	2.327	0.285	2.537	0.186
Female	0.045	0.203	0.037	0.263	0.030	0.334
Age	-0.157	0.337	-0.174	0.258	-0.211	0.126
Black/A.A.	0.029	0.250	0.026	0.275	0.028	0.201
Hispanic	0.037	0.198	0.036	0.185	**0.043**	**0.085**
Asian	-0.016	0.485	-0.022	0.294	-0.024	0.209
Other/Mixed	**0.216**	**0.018**	**0.203**	**0.017**	**0.198**	**0.018**
Low Maternal Education	0.053	0.189	0.061	0.105	**0.077**	**0.024**
Not live w/ both parents	**-0.074**	**0.038**	**-0.075**	**0.023**	**-0.094**	**0.004**
Direct Exposure	0.034	0.105	**0.037**	**0.061**	**0.036**	**0.041**
Family Exposure	0.014	0.841	0.035	0.590	0.084	0.177
Previous Exposure	**0.148**	**0.001**	**0.152**	**0.000**	**0.189**	**0.000**
TV Exposure	-0.006	0.849	-0.001	0.960	-0.015	0.582
SES	0.256	0.268	0.245	0.261	**0.406**	**0.034**
Foreign Born	-0.140	0.370	-0.132	0.368	-0.067	0.585
SES x Foreign Born	0.183	0.249	0.184	0.218	**0.314**	**0.018**
NQI	-0.178	0.322	-0.214	0.211	-0.131	0.378
Instability	0.136	0.786	0.162	0.731	0.349	0.408
SPI	0.035	0.930	0.034	0.926	0.235	0.488
Lag Coefficient (Rho)			-0.082	0.187		
Lag Coefficient (Lambda)					**-0.432**	**0.000**

Because significant LISA clusters were observed in the PTSD Sy (mean and median) and PTSD Dx measures (see Maps 7A through 7F above), three Geographically Weighted Regressions (GWR) Gaussian models were performed on these data. In each of the three GWR models, adaptive bandwidths were chosen by lowest AIC. Overall, the results of these three GWR models contradicted the spatial regression, other OLS and HLM models described above. Age was only significant in the PTSD Sy (median) model, while being Asian was a significant predictor of PTSD Sy (mean and median) and PTSD Dx (see Table 32). Being female and none of the exposure measures (with the exception of Family Exposure in the median, Model 35) were significant. Only the interaction term between SES and Foreign Born (%) was significant in Model 35, while Student Instability and SPI (although the β coefficient is too small to have any influence) were significant predictors of PTSD Dx (Model 36).

Table 32. Geographically Weighted Regression (Guassian) Models Predicting PTSD Sy (mean and median) and PTSD Dx

	Model 34 PTSD Sy (mean)		**Model 35 PTSD Sy (median)**		**Model 36 PTSD Dx**	
	Bandwidth	169.4m	**Bandwidth**	169.4m	**Bandwidth**	169.4m
	Global R^2	0.333	**Global R^2**	0.240	**Global R^2**	0.802
	Global AIC	332.682	**Global AIC**	413.732	**Global AIC**	670.812
	GWR R^2	0.792	**GWR R^2**	0.402	**GWR R^2**	**0.845**
	GWR AIC	**311.983**	**GWR AIC**	405.623	**GWR AIC**	662.241
	β	**Sig.**	**β**	**Sig.**	**β**	**Sig.**
Intercept	0.17		**0.02**	*	0.22	
Female	0.89		0.34		0.11	
Age	0.10		**0.02**	*	0.08	
Hispanic	0.06		0.89		0.10	
Black/A.A.	**0.03**	*	0.78		**0.03**	*
Asian	**0.01**	**	**0.02**	*	**0.05**	*
Other/Mixed	0.60		0.58		0.39	
Low Maternal Education	**0.02**	*	0.12		0.68	
Not live w/ both parents	0.56		0.07		0.54	
Direct Exposure	0.60		0.32		0.26	
Family Exposure	0.30		**0.05**	*	0.48	
Previous Exposure	0.43		0.91		0.44	
TV Exposure	0.22		0.65		0.59	
SES	0.37		0.79		0.20	
Foreign Born	0.43		0.60		0.13	
SES x Foreign Born	0.29		**0.04**	*	0.12	
NQI	0.61		0.20		0.75	
Instability	0.76		0.91		**0.02**	*
SPI	0.06		0.22		**0.00**	***

*p<0.05; **p<0.01; ***p<0.001

6. Discussion

Across most of the thirty-six individual models conducted for these analyses, several individual level variables consistently predicted both the frequency of PTSD symptoms and (probable) disorder, including impairment. As expected, being a female, younger and Hispanic continued to be major risk factors for PTSD in these data (females and younger children are at higher risk for anxiety disorders, such as PTSD). Although their β Coefficients and Odds Ratios fluctuated slightly with inclusion of new variables, they remained fairly stable across all models. As with prior analysis, being African-American, Asian or of Other/Mixed race did not influence the frequency of symptoms or the development of the (probable) disorder. Low Maternal education and single parent households did not have any effect on symptoms or the (probable) disorder in these data.

With the exception of the spatial and geographically weighted regressions, the four exposure measures also remained fairly constant and were, overall, the strongest risk factors for frequency of symptoms and the development of the (probable) PTSD disorder. Students attending a NYC public school at the time of the event were more than twice as likely to develop PTSD symptoms and/or the disorder if they were directly exposed to the attacks and almost twice as likely if they had a family member exposed (escape hurt or unhurt from the WTC area). Those students with Previous Exposure and those who viewed the events repeatedly on the television were approximately 1.5 times as likely to have PTSD symptoms or the (probable) disorder, than those who did not.

As in prior analysis, no distance decay was found in these analyses. The substitution of transportation distance and/or time did not predict any better (or worse) than Euclidian distance. Similarly, residing in a neighborhood having direct line-of-sight to the event, did not predict the symptoms. Although residing in a zip code within 1 kilometer from the plume of smoke of the WTC attacks was predictive of PTSD symptoms at the bivariate level, once demographic variables were introduced into the model, they ceased to be predictive, possibly indicating that residing in a zip code within 1 kilometer from the plume is confounded by demographic factors, such as age and gender in these data.

Many neighborhood level variables were tested in these models. Similarly to residing near the plume of smoke, residing in a zip code with a higher proportion of rental units predicted the frequency of PTSD symptoms at the bivariate level but not after controlling for demographic factors. Unlike what has been suggested by some in the literature, residential mobility and population density did not predict the level of PTSD symptoms. The measure of SES, coupled with Foreign Born (%), however, has shown much predictability of the disorder and symptom count. Although some models differed, NYC public school students residing in a zip code with higher SES and higher percent of Foreign Born were, generally, less likely to develop PTSD symptoms.

Of the Neighborhood Safety variables tested, Major Felony and the overall Neighborhood Safety Index (NSI) performed in the OLS regression analyses, predicted PTSD Sy, even after controlling for demographics. However, once the exposure variables were included, their predictability of the symptom frequency was no longer significant; indicating that the exposure variables explained some of the influence of neighborhood safety in these data.

The Neighborhood Quality Index (NQI) developed here, on the other hand, not only consistently predicted PTSD symptoms but also (probable) PTSD disorder. In fact, the magnitude of the odds ratio of low NQI was found to be equal to that of age. Even after controlling for the hierarchical nature of the data, low NQI remained a significant risk factor or PTSD symptoms and (probable) disorder.

In terms of the school environment, Teacher-Student Ratio and Suspension rates predicted PTSD symptoms at the bivariate levels but not after controlling for demographic factors. And, although school expenditure and the School Environment Index, developed here, predicted the symptom count after controlling for demographic factors, this predictability ceased after including the exposure variables, again, indicating that exposure may be confounding the effects of these variables in these data. The effect of Student Instability on PTSD symptoms, however, did not diminish after the inclusion of the exposure variables or neighborhood level variables. Possibly suggesting that the measure of mobility is best gathered at the school level rather than the neighborhood level (as in the residential mobility measure derived from Census data at the zip code level). In addition to Student Instability, the School Performance Index (SPI), developed here, consistently significantly predicted PTSD symptoms in these data. Students attending a NYC Public School, on September 11, 2001 with a lower SPI, reported a significantly higher number of PTSD symptoms. Interestingly, SPI was not found to be a significant risk factor for the development of the (probable) disorder. The algorithm used here to determine (probable) PTSD disorder includes functional impairment (consistent with the APA criteria for PTSD), that is, the reported symptoms impair the students' school and/or social functioning. This SPI may be affected by this inclusion of impairment or threshold (number of positive symptoms required for diagnosis) used in the PTSD disorder algorithm. Because the focus of this paper is to identify the effects of school and neighborhood level variables on these data, the original algorithms for PTSD and the exposures used in Hoven, et al. (2002 and 2005) are also used here.

Surprisingly, the findings of the spatial and geographically weighted regressions were inconsistent with prior knowledge of the etiology of PTSD and other statistical models tested here. Most likely, this inconsistency is related to the necessary aggregation of variables to an areal unit, thus possibly violating the modifiable areal unit problem. Also, the sampling unit for this data is the student, not the zip code. Aggregating caused this researcher to use the zip code as the unit of analysis, thus possibly violating the original sampling design of these data.

The findings of the Hierarchical Linear Models (HLM) performed here support the findings from the OLS and logistic regressions, where being female, Hispanic, of younger age, highly exposed to the events (either directly or indirectly through family or television), and previously exposed to traumatic events remained the strongest risk factors for PTSD symptoms and the (probable) disorder in these data. Residing in a zip code with higher SES, coupled with higher percent of Foreign Born, was found to be protective against developing symptoms, but not against developing the (probable) disorder. Like SES/Foreign Born (%), the SPI also was found to be protective against symptoms but not the disorder, while Student Instability was found to be a significant risk factor for the symptoms but not the disorder after controlling for the hierarchical nature of the data. The NQI, on the other hand, was the only new measure developed here that maintained its predictability of both PTSD symptoms and (probable) disorder, even after controlling for the hierarchical nature of the data.

NYC is a vast and complex urban landscape comprised of many ethnically and socio-economically clustered zip codes. With such, come disparities in terms of neighborhood safety and quality is expected. Not surprisingly, students who resided in zip codes with lower quality indices, such as the South Bronx and the borders of Brooklyn and Queens, reported higher numbers of PTSD symptoms and were more likely to meet criteria for (probable) PTSD disorder;

while those NYC Public School students residing in Bayside Queens, Upper Westside and Eastside of Manhattan reported fewer number of symptoms and were less likely to develop the (probable) disorder.

Overall, the three aims of this research have been met. Having been exposed (directly or indirectly through family or television viewing) to the WTC events, and having been previously exposed to traumatic events, in addition to being female, Hispanic, of younger age remain the strongest risk factors for PTSD symptoms and (probable) disorder in these data, supporting the findings of the original Hoven (2002 and 2005) papers. The hypotheses (AIM II) postulated here that attending a low performing school is a risk factor for PTSD Sy and Dx was accepted while the hypothesis that attending a school with negative school environment was rejected.

Several neighborhood level factors have been determined to be significantly associated with PTSD Sy and Dx. Low neighborhood SES coupled with low percent foreign born are risk factors for PTSD symptoms; while low neighborhood quality is a significant risk factor for both symptoms and the (probable) disorder. The hypothesis that low neighborhood safety is a risk factor for PTSD Sy and Dx, however, has been rejected by these findings. Likewise, residing in a zip code with Line-Of-Site to the WTC towers or living in a zip code which was under the plume of smoke from the WTC was not significantly associated with PTSD symptoms or (probable) disorder, after including the individual level variables. Finally, Euclidian and transportation (distance and time) are not associated with PTSD symptoms or the disorder, supporting all prior analysis of this data.

7. Limitations

The diagnostic assessment measure used for PTSD, the DPS, was designed for screening, not diagnosis, so cases here are probable, not definite. Due to IRB limitations of the original study, only the students' zip codes were obtained and thus are used here as the neighborhood level. Although finer spatial resolution is preferred (e.g., at the Census Tract level), much can be learned from developing these new techniques for assessing risks for PTSD. Also, it is unclear how a child perceives distance and the child's perception of a "bad" or unsafe neighborhood or school is similar to those measured using Census and school level data. Data of which schools received funding for mental health services to directly deal with the WTC attack was unavailable and thus not included in these analyses. However, measuring neighborhood quality and school performance using Census and school level data has shown to be predictive in this and other studies involving child mental health issues.

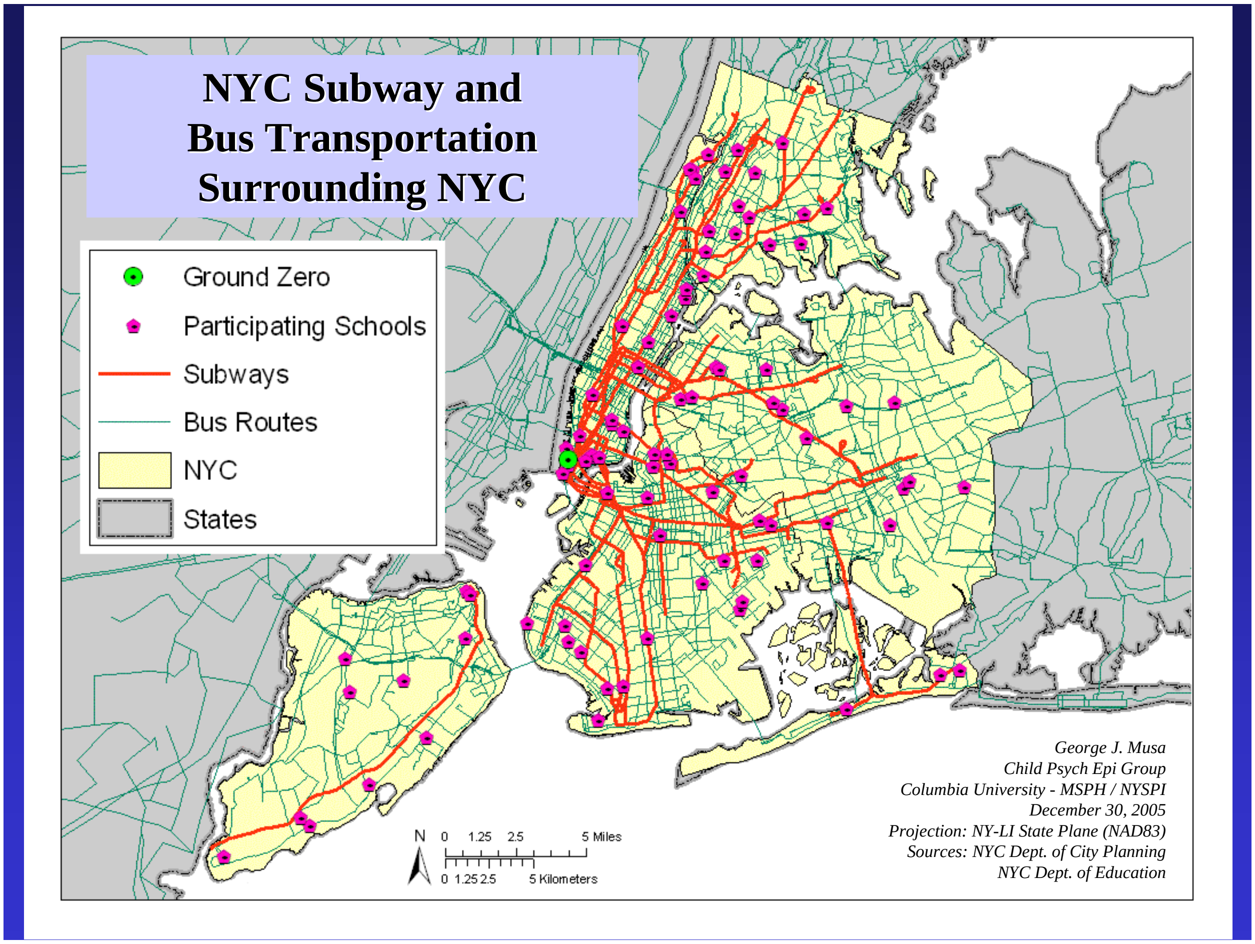
8. Conclusion

Much is yet to be learned regarding the etiology of PTSD and other psychiatric disorders. Although the literature on several psychiatric disorders speaks to the effects of neighborhoods, very little empirical work had been done to quantify this effect. The assessment of the neighborhood and school effects on PTSD, conducted here, has shed much light on implications of the urban landscape and what it might impose on mental health of children. Students attending schools with high student instability and low performance higher number of PTSD symptoms; and, students residing in low quality neighborhoods reported higher number of PTSD symptoms and were at higher risk of developing (probable) PTSD disorder.

It is the belief of this researcher that this analysis is exhaustive in scope and unique in the world of geographic information sciences and spatial analysis of mental health. This study informs the epidemiological, mental health and geographic literature concerning new methodologies and helps to expand the overall understanding of PTSD, the geographies of mental health, and the role and definition of risk and exposure after a large-scale event, such as that of 9/11. Although it is the wish of this researcher that events like that of September 11, 2001 never happen again, disadvantaged, low quality and low SES neighborhoods, as well as low performing schools need to be a top priority for intervention efforts by local, state and national government and health agencies, in the aftermath of such disaster.

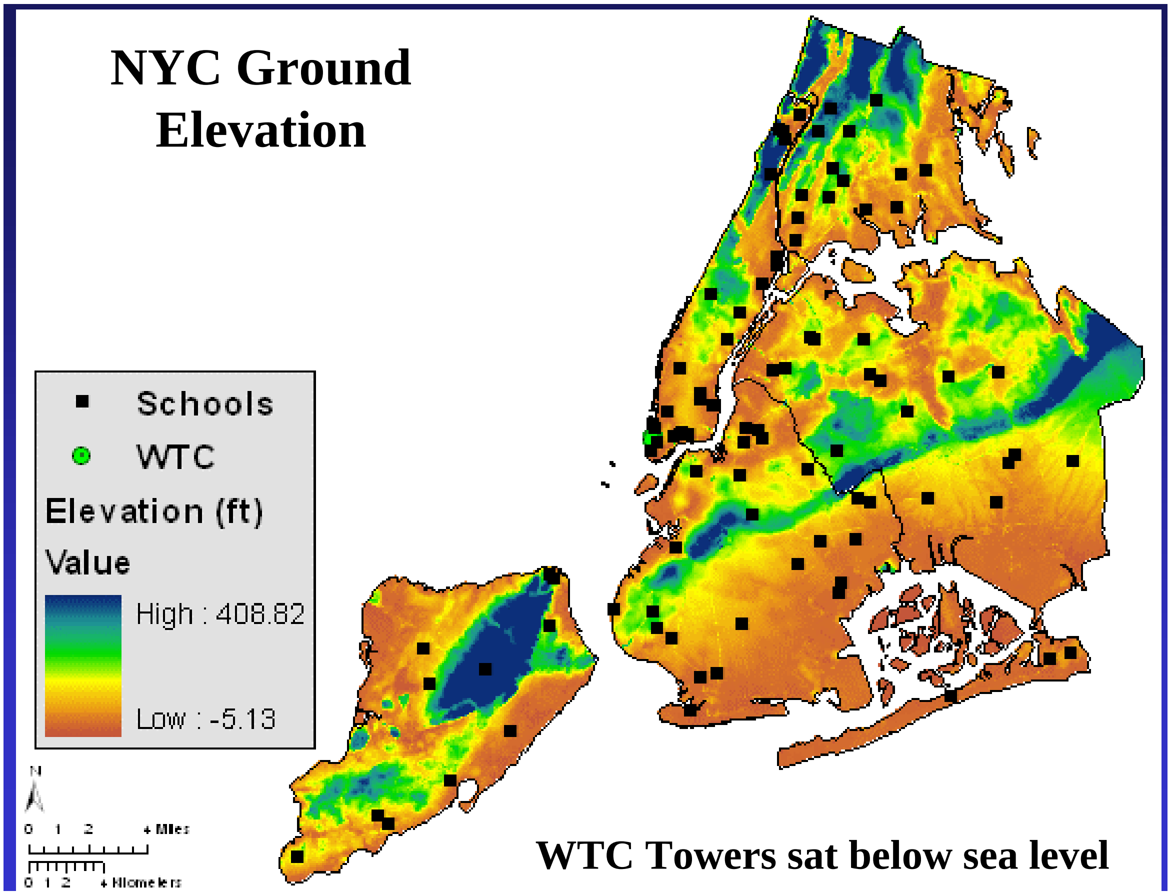
So, in response to the question "does geography matter?" Yes, neighborhoods did affect Post-Traumatic Stress symptoms and (probable) disorder in NYC Public School Children after 9/11.

Appendix I.

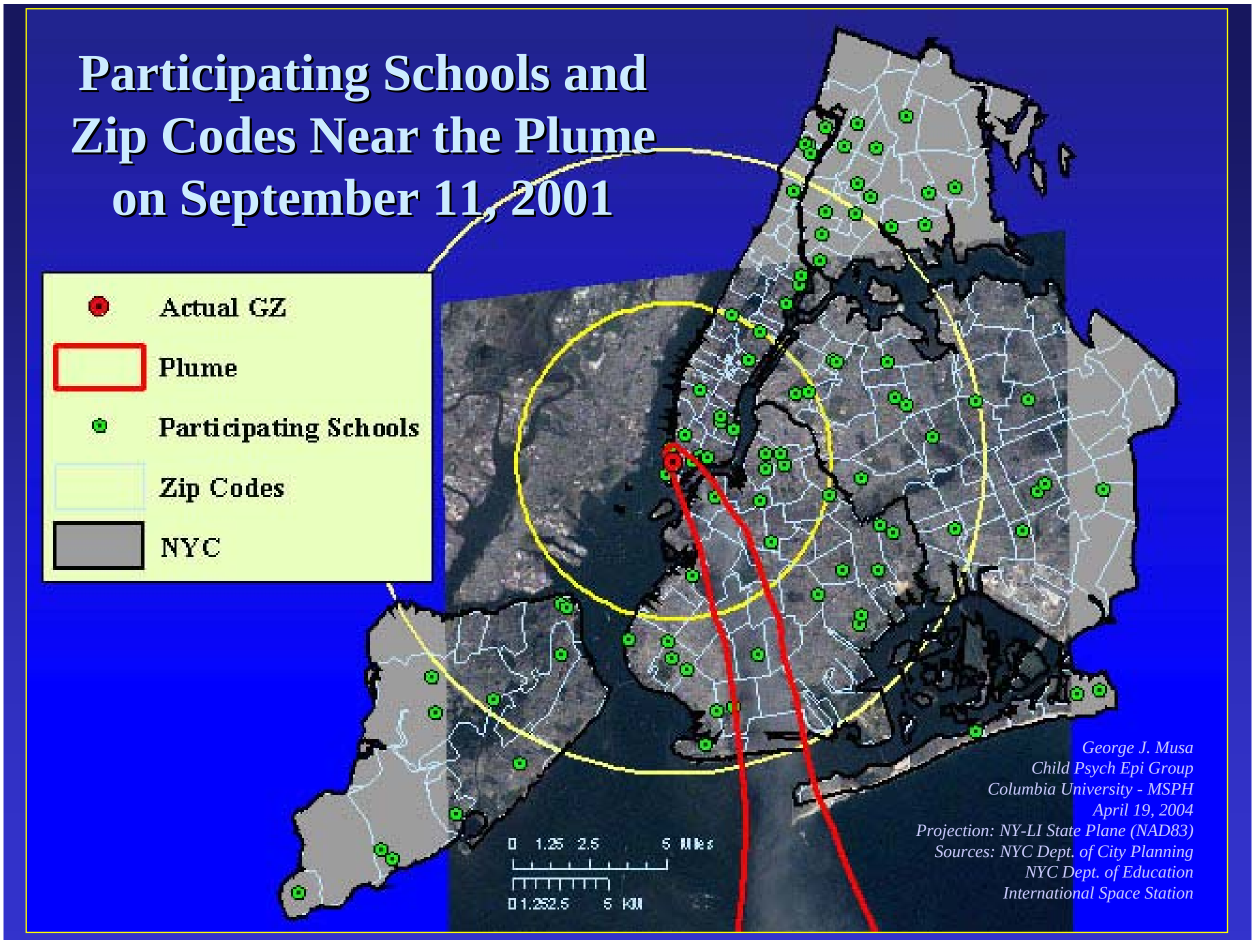


NYC Subway and
Bus Transportation
Surrounding NYC
Ground Zero
Participating Schools
Subways
Bus Routes
NYC
States
N
0 1.25 2.5 5 Miles
0 1.25 2.5 5 Kilometers
George J. Musa
Child Psych Epi Group
Columbia University - MSPH / NYSPI
December 30, 2005
Projection: NY-LI State Plane (NAD83)
Sources: NYC Dept. of City Planning
NYC Dept. of Education

Appendix II.


NYC Ground Elevation
Schools
WTC
Elevation (ft)
Value
High : 408.82
Low : -5.13
N
0 1 2 4 Miles
0 1 2 4 Kilometers
WTC Towers sat below sea level

Appendix III.



10. References

American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*. 4th ed. Washington, DC: Author, 1994.

Anselin, L. (1999). *Spatial Econometrics.* Online Internet: http://www.csiss.org/learning_resources/content/papers/baltchap.pdfAnselin, L. (2002). “Under the hood: Issues in the specification and interpretation of spatial regression models.” *Agricultural Economics*, 27: 247-67.

Barrett, F.A. (2000). Finke’s 1792 Map of Human Diseases: the First World Disease Map? *Social Science & Medicine*, 50(7-8): 915-921.

Blanchard, E.B., Kuhn, E., Rowell, D.L., Hickling, E.J., Wittrock, D., Rogers, R.L., Johnson, M.R., Steckler, D.C. (2004). Studies of the vicarious traumatization of college students by the September 11th attacks: Effects of proximity, exposure and connectedness. *Behaviour Research and Therapy*, 42 (2): 191-205.

Blanchard, E.B., Rowell, D., Kuhna, E., Rogers, R., Wittrock, D. (2005). Posttraumatic stress and depressive symptoms in a college population one year after the September 11 attacks: the effect of proximity. *Behaviour Research and Therapy*. 43 (1): 143-50.

Bokszczanin, A. (2007). PTSD symptoms in children and adolescents 28 months after a flood: Age and gender differences. *Journal of Traumatic Stress*. 20: 347–51.

Byrne, J., & Sampson, R.J. (1986). Key Issues in the Social Ecology of Crime in *The Social Ecology of Crime*, James Byrne and Robert J. Sampson (Eds.). New York: Springer-Verlag. pp. 1-22.

Calderoni, M.E., Alderman,E.M., Silver,E.J., Bauman, L.J. (2004). The Mental Health Impact of 9/11 on Inner-City High School Students 20 Miles North of Ground Zero. *J of Adolescent Health.* 39(1): 57-65

Corburn, J., Osleeb, J., and Porter, M. (2006). Urban Asthma and the Neighbourhood Environment. *Health and Place* **12**(2): 167 – 179 (2006).

Cohen, P., Slomkowski, C., & Robins, L. N. (Eds.). (1999). *Historical and geographical influences on psychopathology*. Mahwah, NJ: Erlbaum.

Davis, L. & Siegel, L.J. (2000). Posttraumatic Stress Disorder in Children and Adolescents: A Review and Analysis. *Clinical Child and Family Psychology Review,* 3(3): 135-54.

de los Rios-Urban, M. & Chasan, R. (2005). Uses of Viewshed Analysis Models in Planning and Neighborhood Preservation. *Proceedings from the 2005 ESRI User Conference. http://gis.esri.com/library/userconf/proc05/abstracts/a2090.html*

DiMaggio, C., Galea, S., Emch, M. (2010). Spatial Proximity and the Risk of Psychopathology after a Terrorist Attack. *Psychiatry Research*. 176: 55-61.

Dohrenwend, B. P., I. Levav, P. E. Shrout, S. Schwartz, G. Naveh, B. G. Link, A. E. Skodol & A. Stueve (1992) Socioeconomic status and psychiatric disorders: the causation-selection issue. *Science,* 255**,** 946-952.

Duncan, C., Jones, K. & Moon, G. (1993). Do Places Matter? A Multi-level Analysis of Regional Variations in Health-Related Behavior in Britain. *Soc. Sci. Med.* 34(6): 725-33.

Dunlap, D.W., (2001). Hey, New York. Nice Map. Care to Give It a Try?; The City in Exquisite Detail, Soon to Be Online. *The New York Times*, February 15, 2001, Thursday, Metropolitan Desk Late Edition, Section B, Page 1, Column 2.

Faris, R.E.L, & Dunham, H.W. (1939) *Mental Disorders in Urban Areas: An Ecological Study of Schizophrenia and Other Psychoses*. Chicago: Chicago University Press.

Florax, R.J.G.M. & Nijkamp, P. (2004). “Misspecification in Linear Spatial Regression Models.” Online Internet: http://www.tinbergen.nl/discussionpapers/03081.pdf

Fotheringham, A.S., Brunsdon, C. & Charlton, M. (2002). *Geographically Weighted Regression: The Analysis of Spatially Varying Relationships.* Wiley, Chichester, Hoboken, NJ.

Galea, S., Ahern, J., Resnick, H., Kilpatrick, D., Bucuvalas, M., Gold, J., Vlahov, D. (2002a). Psychological Sequelae of the September 11 Terrorist Attacks in New York City. *N Engl J Med*. 346: 982-7.

Galea, S., Resnick, H., Ahern, J., Gold, J., Bucuvalas, M., Kilpatrick, D., Stuber, J., Vlahov, D. (2002b) Posttraumatic stress disorder in Manhattan, New York City, after the September 11th terrorist attacks. J. of Urban Health, 79 (3): 340-53.

Galea, S., Ahern, J., Rudenstine, S., Wallace, Z., Vlahov, D. (2005). Urban Built Environment and Depression: a Multilevel Analysis. *J Epidemiol Community Health*. 59: 822-827.

Galea, S., Ahern, J., Nandi, A., Tracy, M., Beard, J., Vlahov, D. (2007). Urban Neighborhood Poverty and the Incidence of Depression in a Population-Based Cohort Study. *Ann Epidemiol*. 17(3): 171-179.

Gilbert, E. W. (1958). Pioneer Maps of Health and Disease in England. *Geographical Journal*, 124 (2): 172-183.

Goenjian A.K., Molina L., Steinberg A.M., Fairbanks L.A., Alvarez M.L., Goenjian H.A., Pynoos, R.S. (2001). Posttraumatic stress and depressive reactions among Nicaraguan adolescents after hurricane Mitch. *Am J Psychiatry*; 158(5): 788 - 94.

Goldstein, H., Steele, F. (2007). Multilevel Modeling. Presented at the Royal Statistical Society, June 21-22. Powerpoint obtained online: http://www.cmm.bris.ac.uk/MLwiN/tech-support/workshops/materials/RSS%20June%**2007**.ppt

Gorman-Smith D. & Tolan P. (1998). The role of exposure to community violence and developmental problems among inner-city youth . *Dev. Psychopathol*. 10: 101-16.

Gorman-Smith D., Tolan P.H., Zeli, A., Huesmann, R. (1996). The Relation to Family Functioning to Violence among Inner-City Minority Youths. *J of Family Psychology.* 10: 115-29.

Groome, D. & Soureti, A. (2004). Post-traumatic Stress Disorder and Anxiety Symptoms in Children Exposed to the 1999 Greek Earthquake. *British Journal of Psychology*, 95: 387-97.

Haggett, P. (1992). Sauer's Origins and Dispersals': Its Implications for the Geography of Disease. *Transactions of the Institute of British Geographers,* 17 (4): 387-398.

Harvard., S., Deguen, S., Bodin, J., Louis, K., Laurent, D.B. (2008). A Small-Area Index of Socioeconomic Deprivation to Capture Health Inequalities in France. *Social Science & Medicine*. 67: 2007-2016.

Hoven CW. Testimony, U.S. Senate, Health, Education, Labor and Pensions Committee, Regarding the *Unmet Needs of New York City School Children as a Result of the September 11th Attack on the World Trade Center*, Chair, Hillary Rodham Clinton, June 10th, 2002.

Hoven, C.W., Duarte, C. S., Lucas, C. P, Mandell, D. J., Cohen, M., Rosen, C., Wu, P., Musa, G. J., & Gregorian, N. (2002): Effects of the World Trade Center Attack on NYC Public School Students - Initial Report to the New York City Board of Education. Columbia

University Mailman School of Public Health-New York State Psychiatric Institute and Applied Research and Consulting, LLC. New York City.

Hoven, C.W., Duarte, C.S., Lucas, C.P., Wu, P., Mandell, D.J., Goodwin, R.D., Cohen, M., Balaban, V., Woodruff, B.A., Bin, F., Musa, G.J., Mei, L., Cantor, P.A., Aber, J.L., Cohen, P. Susser, E. (2005) Psychopathology Among New York City Public School Children 6 Months After September 11. Archives of General Psychiatry, 62: 545-552.

Hoven, C.W., Duarte, C.S., Wu, P., Erickson, E., Musa, G., Mandell, D.J. (2004). Exposure to Trauma and Separation Anxiety in Children After the WTC Attack. *Applied Developmental Science;* 8 (4): 172 - 83.

Jackson, C.H., Richarson, S. & Best, N.G. (2008). *Social Science & Medicine*. 67: 1995-2006.

Kar, N., Mohapatra, P. K., Nayak, K. C., Pattanaik, P., Swain, S. P., & Kar, H. C. (2007). Post-traumatic stress disorder in children and adolescents one year after a super-cyclone in Orissa, India: Exploring cross-cultural validity and vulnerability factors. *BMC Psychiatry*, 7.

Krieger, N., Williams, D.R., Moss, N.E. (1997). Measuring Social Class in US Public Health Research: Concepts, Methodologies, and Guidelines. *Annu Rev Public Health*. 18: 341-78.

Kriger, N., Chen, J.T., Waterman, P.D., Soobader, M-J, Subramanian, S.V., Carson, R. (2003). Choosing Area Based Socioeconomic Measures to Monitor Social Inequalities in Low Birth Weight and Childhood Lead Poisoning: The Public Health Disparities Geocoding Project (US). *J. Epidemiol Community Health.* 57: 186-99.

Liberti, J.C. & Rappaport, T.S. (1996). A Geometrically Based Model for Line-Of-Sight Multipath Radio Channels. *Proceedings from the Vehicular Technology Conference, 1996. 'Mobile Technology for the Human Race'., IEEE 46th:* 844-848. ttp://ieeexplore.ieee.org/xpl/freeabs_all.jsp?isnumber=10813&arnumber=501430&type=ref

Lucas C.P., Zhang H., Fisher P.W., Shaffer D., Regier D.A., Narrow W.E., Bourdon K., Dulcan M.K., Canino G., Rubio-Stipec M., Lahey B.B., Friman P. (2001). The DISC Predictive Scales (DPS): Efficiently screening for diagnoses. *J Am Acad Child Adolesc Psychiatry*; 40: 443 - 9.

Maantay, J.A., Maroko, A.R. & Herrmann, C. (2007). Mapping Population Distribution in the Urban Environment: The Cadastral-based Expert Dasymetric System (CEDS). *Cartography and Geographic Information Science*. 34 (2): 77-102.

May, J. M. (1950). Medical Geography: Its Methods and Objectives. *Geographical Review,* 40 (1): 9-41.

Meade, M. S. (1977). Medical Geography as Human Ecology: The Dimension of Population Movement. *Geographical Review*, 67 (4): 379-393.

Musa, G.J., Hoven, C.W., Duarte, C.S., Wu, P., Erickson, E.A., Fan, B., Balaban, B., Jeng, A., Sherpa, C. (2003). Distance from Traumatic Event and Posttraumatic Stress Disorder in Children. Paper presented at The 131st Annual Meeting of the American Public Health Association, San Francisco, California.

Neuner, F., Schauer, E., Catani, C., Ruf, M., & Elbert, T. (2006). Posttsunami stress: A study of posttraumatic stress disorder in children living in three severely affected regions in Sri Lanka. *Journal of Traumatic Stress*. 19: 339–47.

NYC Board of Education. Student Register (City Wide). Available at: http://www.nycenet.edu/dist_sch/dist/distreg.asp?dist=01&boro=&sch=$displayType=city. Accessed 2002.

Petrucci, A., Slavati, N., & Seghieri, C. (2003). The Application of Spatial Regression Model to the Analysis and Mapping of Poverty. *Environment and Natural Resources Series.* Online Internet. http://www.povertymap.net/publications/doc/Spatial%20Regression%20Analysis%20for%20Poverty%20Mapping%20FAO.pdf.

Pfefferbaum B., Seale T.W., McDonald N.B., Brandt E.N., Jr., Rainwater S.M., Maynard B.T., Meierhoffer, B. Miller, P.D. (2000). Posttraumatic stress two years after the Oklahoma City bombing in youths geographically distant from the explosion. *Psychiatry*; 63(4): 358 – 70.

Pfefferbaum, B., Seale, T.W., Brandt Jr., E.N., Pfefferbaum, R.L., Doughty, D.E., Rainwater, S.M. (2003) Media Exposure in Children One Hundred Miles From a Terrorist Bombing. *Annals of Clinical Psychiatry,* 15 (1): 1-8

Pfefferbaum; B., Nixon; S.J., Tivis, R.D.; Doughty; D.E., Pynoos, R.S., Gurwitch, R.H., Foy, D.W. (2001). Television Exposure in Children after a Terrorist Incident. *Psychiatry;* Fall 2001; 64 (3): 202-11.

Pynoos R.S., Frederick C., Nader K., Arroyo W., Steinberg A., Eth S. Nunez F., Fairbanks L. (1987) Life threat and posttraumatic stress in school-age children. *Arch Gen Psychiatry*; 44(12): 1057-1063

Pynoos R.S., Goenjian A.K., Tashjian M., Karakashian M., Manjikian R., Manoukian G., Steinberg, A.M., Faribanks, L.A. (1993). Post-traumatic stress reactions in children after the 1988 Armenian earthquake. *Br J Psychiatry*; 163: 239 - 47.

Ross, C. E. (2000) Neighborhood Disadvantage and Adult Depression. *Journal of Health and Social Behavior,* 41**,** 177-187.

Sahin, N. H., Batigun, A. D., & Yilmaz, B. (2007). Psychological symptoms of Turkish children and adolescents after the 1999 earthquake: Exposure, gender, location, and time duration. *Journal of Traumatic Stress*. 20: 335–345. Eds. Saltzman, W. R., Layne, C. M., Pynoos, R. S., Steinberg, A.

Sampson, R.J. (1985). Neighborhood and Crime: The Structural Determinants of Personal Victimization. *J of Research in Crime and Delinquency*. 22: 7-40.

Sampson, R.J. (1988). Local Friendship Ties and Community Attachment in Mass Society: A Multilevel Systemic Model. *Am Sociological Review*. 53:766-79.

Schlenger, W. E., J. M. Caddell, L. Ebert, B. K. Jordan, K. M. Rourke, D. Wilson, L. Thalji, J. M. Dennis, J. A. Fairbank & R. A. Kulka (2002) Psychological Reactions to Terrorist Attacks: Findings From the National Study of Americans' Reactions to September 11. *JAMA,* 288**:** 581-588.

Schuster, M.A., Stein, B.D., Jaycox, L.H., Collins, R.L., Marshall, G.N., Elliott, M.N., Zhou, A.J., Kanouse, D.E., Morrison, J.L., Berry, S.H. (2001). A National Survey of Stress Reactions after the September 11, 2001, Terrorist Attacks. *N Engl J Med*. 345 (20): 1507-12.

Shaffer D., Fisher P., Lucas C.P., Dulcan M.K., Schwab-Stone M.E.. (2000) NIMH Diagnostic Interview Schedule for Children Version IV (NIMH DISC-IV). *J Am Acad Child Adolesc Psychiatry*. 39:28-38.

Silver E., Mulvey E.P., Swanson J.W. (2002). Neighborhood structural characteristics and mental disorder: Faris and Dunham revisited. *Social Science and Medicine*. 55 (8): 1457-70.

Subramanian, S.V., Chen, J.T., Rehkopf, D.H., Waterman, P.D., Kriger, N. (2006). Comparing Individual- and Area-based Socioeconomic Measures for the Surveillance of Health Disparities: A Multilevel Analysis of Massachusetts Births, 1989-1991. *Am Jl of Epidemiology*. 164 (9): 823-34.

Thienkrua, W., Cardozo, B. L., Chakkraband, M. L., Guadamuz, T. E., Pengjuntr, W., Tantipiwatanaskul, P., et al. (2006). Symptoms of posttraumatic stress disorder and depression among children in tsunami-affected areas in southern Thailand. *JAMA*, 296: 549– 559.

USA Today (2004). Report: Final WTC death toll drops by three; could stand at 2,749. Accessed Online 2/22/2008. http://www.usatoday.com/news/sept11/2004-01-23-wtc-toll_x.htm

Weems, C. F., & Overstreet, S. (2008). Child and adolescent mental health research in the context of Hurricane Katrina: An ecological needs-based perspective and introduction to the special section. *Journal of Clinical Child and Adolescent Psychology*, 37: 487–94.

Weems, C. F., Watts, S. E., Marsee, M. A., Taylor, L. K., Costa, N. M., Cannon, M. F., et al. (2007). The psychosocial impact of Hurricane Katrina: Contextual differences in psychological symptoms, social support, and discrimination. *Behaviour Research and Therapy*, 45: 2295–2306.

Weissman, M.M. & Myers, J.K. (1978) Rates and risks of depressive symptoms in a United States urban community. *Acta Psychiatrica Scandinavica*. 57 (3) , 219–231

Wylie, M.P. & Holtzman, J. (2004). The Non-Line of Sight Problem in Mobile Location Estimation. *Proceedings from 23th Annual IEEE Conference on Computer Communications*, 827-31.