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Elucidating Perceived and Actual Cancer Risk in Disadvantaged Neighborhoods Differentially Impacted by Environmental Hazards to Inform Future Public Health Interventions

LaShanta J. Rice
University of South Carolina - Columbia

ELUCIDATING PERCEIVED AND ACTUAL CANCER RISK IN DISADVANTAGED NEIGHBORHOODS DIFFERENTIALLY IMPACTED BY ENVIRONMENTAL HAZARDS TO INFORM FUTURE PUBLIC HEALTH INTERVENTIONS

by

LaShanta J. Rice

Bachelor of Arts
Talladega College, 2004

Master of Public Health
University of South Florida, 2008

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Accepted by:

Heather M. Brandt, Major Professor

Lucy Annang-Ingram, Committee Member

James W. Hardin, Committee Member

Sacoby M. Wilson, Committee Member

Lacy Ford, Vice Provost and Dean of Graduate Studies

DEDICATION

I dedicate this dissertation to my Lord and Savior, Jesus Christ. Father, I am so grateful for the thoughts and plans that you have for my life (Jeremiah 29:11), one of which was to endure this journey. It is because of you I am equipped to change lives as a public health professional. Thank you for leading me to and through this, and for guiding me every step of the way. For their sacrifice and unconditional love, I dedicate this dissertation to my parents; George and Erica Rice Jr. Thank you for always encouraging me to be my best and helping make my dream of being a doctor a reality. Without you praying with and for me throughout this process, obtaining a doctorate would not have come to fruition. I love you two dearly! God surely blessed me when he placed me in your care.

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ABSTRACT

In the United States, racial and ethnic minorities, economically disadvantaged and medically underserved groups bear a disproportionate amount of the cancer burden. Myriad social and environmental factors attribute to these disparities including disparate exposures to environmental pollutants, which account for two percent of all cancer deaths nationally. There is empirical evidence demonstrating risk perceptions and cancer worry are shaped by race/ethnicity and social and environmental experiences. Cancer risk perceptions among Non-Whites, especially Blacks compared to Whites is lower for various reasons. Low perceived cancer risk may explain persistent cancer disparities, since protective health behaviors are higher among persons who perceive their risk of cancer is higher. In addition to findings of lower perceived cancer risk, studies have shown that Blacks compared to Whites perceive their environmental health risks such as exposures to air and water pollution and other unhealthy environmental conditions are high even when they do not reside in an area with known issues.

A paucity of research has explored the interplay between these factors among Blacks in metropolitan areas with disparate environmental conditions and cancer outcomes. This study explored perceived and actual cancer risk using an environmental health survey and geospatial methods in Metropolitan Charleston, South Carolina. The survey was used to document perceptions of cancer risk, neighborhood

environmental health risks, and risk- reducing health behaviors. In addition, it evaluated the association between low perceived cancer risk and health behaviors among Blacks. Geospatial methods were used to analyze and map environmental cancer risk from 1996-2005, identify cancer clusters and hotspots, and to determine if cancer risk and outcomes vary spatially by racial and socioeconomic characteristics.

Descriptive statistics, bivariate and multivariate analyses were performed in SAS 9.3. Total cancer risk from the National-Scale Air Toxics Assessment for 1996 to 2005 was georeferenced and analyzed in ArcGIS 10.2. Cancer clusters and hot spots were identified using Anselin's Local Moran's I and Getis-Ord Gi* statistic. Correlations were performed in SPSS 22.0.

Survey respondents (N=405) were 100% Black, 81% female (n=323), 19% male (n=75), and ranged from 18 to 87 years of age. Low perceived cancer risk (absolute risk) was associated with daily alcohol consumption and having had a colon cancer screening female, and older age (24-65, $p<.05$). Worry about cancer was significantly associated with being a current smoker, fair diet, non-alcohol consumption, and colon cancer screening tests ($p<.05$). The Spearman's rho test revealed a statistically significant relationship between cancer risk and five-year incidence ($p=.043$). No significant relationship was observed between cancer risk and five-year mortality. However, incidence and mortality were significantly correlated with one another ($p<.001$). We detected a positive association ($p < .001$) between cancer risk and % Black and %poverty and a negative association with %income. Our findings suggest that perceived cancer risk is an important indicator of health behaviors among Blacks. Direct or indirect experiences with cancer and/or the environment, as well as awareness of family history of cancer are viable explanations of cancer risk perceptions. We believe our findings have implications for reducing place-based environmental cancer disparities and developing policies to reduce environmental and cancer burden in underserved and economically disadvantaged groups. Geographic variability in cancer risk may partially explain cancer disparities between groups.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

"The connection between health and the dwelling of the population is one of the most important that exists."
Cited in Lowry, S, BMJ, 1991, 303, 838-840

Since 1950, cancer has been the second leading cause of death, behind heart disease in the United States (U.S.) (Hoyert & Xu, 2012). An estimated 13 million Americans are currently living with cancer (Howlader et al., 2013). Approximately 1.67 million new cases and 585,720 deaths are projected to occur in 2014 (Howlader et al., 2013). Cancer risk increases with age and predominately occurs in middle aged or older adults (Siegel, Jiemin, Zhaohui & Jemal, 2014). The likelihood of cancer occurring among men in their lifetime is lower than that of women (Siegel et al., 2014). Cancer rates in South Carolina (SC) account for about 1.7% of all cancer deaths in the U.S. (Siegel et al., 2014); however, more than 192,000 new cases and 81,000 deaths occurred across the state from 1996-2005 (Hurley et al., 2009) making cancer the leading cause of death statewide (National Center for Health Statistics [NCHS], 2010; South Carolina Department of Health and Environmental Control [DHEC], 2013). There is no single cause of cancer so the development of the disease has been linked to several factors. The risk factors for cancer are multifaceted including genetics, tobacco use, poor diet, physical inactivity, sun exposure, and radiation exposure (National Cancer Institute [NCI], 2014).

while steadily declining, has not affected all groups equally (U.S. Cancer Statistics Working Group, 2013).Reducing cancer outcomes and adverse health associated with the disease is a national health concern in the U.S. (United Stated Department of Health and Human Services [DHHS] 2014). Achieving the aforementioned objective is possible if disparities in cancer are addressed. Improving health by eliminating health disparities has been an overarching goal of *Healthy People* since the third iteration of the national health benchmarks was established (National Center for Health Statistics [NCHS], 2001; DHHS, 2014), and the central focus of the Centers for Disease Control and Prevention (CDC) *2011 Health Disparities and Inequalities Report* (CDC, 2011). Each report provides valuable information on the health challenges facing the nation and points to solutions for continuing to examine and intervening on health disparities. Disparities in cancer are especially concerning because they demonstrate a major divide in a leading health indicator in the U.S. Gauging the underlying cause of cancer disparities is complex; however, doing so could inform policies, health decision-making and the development of interventions designed to improve health gaps between and within populations (CDC, 2011).

African Americans/Blacks, in particular men, have higher cancer incidence and mortality rates than any other racial and ethnic group (Edwards et al., 2014). For all cancers combined, in SC, 10-year age adjusted incidence and mortality rates were higher among Blacks than whites (Hurley et al., 2009). Disproportionate outcomes among Blacks are driven by higher rates in common cancers such as prostate and breast cancer (Edwards et al., 2014). As with the causes of cancer, root causes of differences in cancer are complex. The majority of cancer cases and deaths, however, have been linked to environmental factors including exposures to carcinogenic agents (NCI, 2014; Siegel et al., 2014). The distribution of risks from and exposure to hazardous environmental conditions is unequally bore by racial and ethnic minorities and economically disadvantaged populations (Apelberg, White, & Buckley, 2005; Wilson, Hutson, & Mujahid, 2009; Bullard, Mohai, Saha, & Wright, 2007; Payne-Sturges & Gee, 2006; Perlin, Wong, & Sexton, 2001; Perlin, Sexton, & Wong, 1999; Mohai & Saha, 2007; Mohai, Lantz, Morenoff, House & Mero, 2009). Mohai et al. (2009) observed social inequalities in the distribution of industrial facilities where Blacks reside. Blacks were approximately 3 times as likely as whites in both metropolitan and suburban areas across the U.S. to live near industrial facilities. Bullard et al. (2007) found higher percentages of people of color and rates of poverty in neighborhoods with hazardous waste facilities located within 1, 3, and 5 miles. Of the total population in the areas assessed, 48% were minority, 23% Hispanic, and 21% Black.

Although several factors account for racial and socioeconomic differences in residential environments, for this dissertation research residential segregation is considered the primary malefactor of environmental health disparities. For decades, housing discrimination prevented Blacks from moving into affluent and/or white areas confining them to neighborhoods with more minorities, housing with lower value, as well as with lower median household incomes (Fix & Struyk, 1993; Roberts & Toffolon-Weiss, 2001). Over time, residential segregation has limited educational and employment opportunities and economic resources and increased poverty along with the number of commercial facilities in residential environments (Bullard & Wright, 1987; Yinger, 2001; Ahmed, Mohammed, & Williams, 2007; White, Haas, & Williams, 2012). Living in segregated neighborhoods drives adverse health including cancer risk (Rice et al., 2014). Lifetime cancer risk is higher in areas where fewer residents own their home, households have no personal transportation, and at least two people reside in the home (Rice et al., 2014). Residential segregation and the nation's history of discrimination may also explain why minorities, especially Blacks perception of risk from environmental hazardous is higher than whites (Flynn, Slovic, & Mertz, 1994; Savage, 1993; Finucance et al., 2000; Marshall, 2004). Vulnerability to hazards, lack of control of hazard use, sociopolitical factors, and perceived benefits have been cited as reasons for differences in environmental health risk perceptions between racial and ethnic groups (Flynn et al., 1994; Fincuane, Slovic, Mertz, Lynn & Satterfield, 2000). Since the environment shapes risk perceptions, it also affects health behaviors.

Commers and colleagues (2007) introduced a model linking environmental conditions and health. In the second pathway, perceptions are posited to mediate the environments influence on health behaviors. Commers' (2007) model is the foundation of the conceptual framework for this stud, given the link between health behaviors and cancer. Although this association is well established, Americans (including Blacks) regularly engage in unhealthy behaviors (DHHS, 2008). Health behaviors are modifiable but there is a common misperception that reducing personal cancer risk cannot be controlled (Niederdeppe & Levy, 2007; American Cancer Society [ACS], 2006). Harboring fatalistic beliefs could be influencing health behaviors for some groups (Niederdeppe & Levy, 2007). Cancer fatalism among Blacks, though mixed, has been studied considerably. Some studies have found no association between fatalistic views and health behaviors (Niederdeppe & Levy, 2007; Sheppard et al., 2010), while others report more cancer fatalism (Powe, 1995; Powe, 1996; Powe, 1997; Powe, Daniels & Finnie, 2005; Underwood 1997; Wolff et al., 2003). Risk perceptions have been examined as a predictor of risk-reducing practices in several studies (Weinstein, 2000; Klein & Stefanek, 2007; Dillard et al., 2012; Kowalkowski et al., 2012). Knowing that Blacks are overburdened in areas with environmental hazards (Bullard et al., 2007), disproportionately burdened by cancer (Edwards et al., 2013), and that they ascribe to the belief that their risk of developing cancer is low (Orom et al., 2010) and preventing cancer cannot be controlled warrants an assessment of the relationship between all of these factors. Only one study to date has explored Blacks' perceived cancer risk and environmental health risks simultaneously (Gerbi, Habtemariam, Tameru, Nganwa & Robnett, 2011). All other studies have assessed environmental risk perceptions (Flynn et al., 1994; Fincuane et al., 2000; Marshall, 2005) and cancer risk perceptions between racial and ethnic groups (Orom et al., 2010; Kim et al., 2008; Lucas-Wright et al., 2014) separately.

To reduce the national cancer burden, public health prevention efforts must take into consideration the complexities that foster racial and ethnic cancer disparities. Compared to whites, Blacks bare an unequal burden of cancer and the reasons behind these disparities will need to be a critical area of investigation if national cancer objectives are to be achieved. Most public health interventions focus on changing individual health, but few studies explore underlying psychosocial and overlapping environmental factors that may be driving cancer disparities for some groups. Since risk perceptions play a major role in health decision-making and both perceptions and health behaviors occur within the context of the environment, elucidating the relationship between perceptions of cancer risk and environmental health risk may provide insight into the screening and preventive behaviors exhibited by Blacks in communities with environmental justice issues. Additionally, using geospatial methods to identify areas with higher cancer risk and locate areas with more socioeconomic vulnerability may inform ways to prevent and/or control cancer in high risk areas as well as inform polices and public health interventions that address disparities.

To determine perceived and actual cancer risk in environmental justice communities across Metropolitan Charleston, perceptions of Blacks were evaluated and actual cancer risk and social vulnerabilities were explored using geospatial methods to inform opportunities for public health intervention.

The specific aims of the study were:

Specific Aim 1: Evaluate the relationship between perceived cancer risk, perceived environmental health risks, and health behaviors

Research Question (RQ) 1: What is the relationship between socioeconomic status (SES), perceived environmental health risks, and/or health behaviors and perceived cancer risk?

Research Question (RQ) 2: Does perceived cancer risk vary by SES (education, and income) gender, and/or age?

Specific Aim 2: Use geospatial methods to explore actual cancer risk and socioeconomic vulnerability to environmental hazards

Research Question (RQ) 3: Has cancer risk increased, decreased, or remained steady from 1996 to 2005 in Metropolitan Charleston?

Research Question (RQ) 4: Are there spatial variations in cancer risk, incidence, and mortality by sociodemographic factors (% Black, % poverty, and % income)?

The next chapter will provide an in-depth discussion of cancer in the United States and South Carolina; outline the public health significance of cancer, as well as cancer-related health disparities. Also, the chapter will identify previous research examining environmental health disparities among racial and ethnic minorities and the role of risk perceptions in health behaviors among Blacks.

CHAPTER 2

BACKGROUND AND SIGNIFICANCE

This chapter provides an overview of cancer as a global health challenge and national public health concern since President Nixon's declaration of "War on Cancer." The latest state and metropolitan level cancer data are provided for the study area to place the study in context and offer an overview of the state of cancer, particularly emphasizing the disproportionate rate of disease. Key risk factors that are explored via this dissertation research are also discussed. A review of the fundamental causes of disproportionate cancer outcomes and risks associated with environmental exposures in racially and ethnically diverse communities are discussed. Then, a brief overview of environmental health inequalities in diverse communities is provided. Also, there is a discussion of the relationship between risk perceptions and health behaviors, cancer, and environmental risk perceptions and this section is concluded by discussing gaps in the literature and why this dissertation research makes a contribution to efforts to reduce cancer and environmental health disparities.

2.1 Cancer

2.1.1 Global Public Health Concern

Globally, in 2012, cancer claimed the lives of approximately 8.2 million people (Ferlay et al., 2013). An estimated 32.6 million people were said to be living with cancer and 14.1 million new cases were diagnosed (Bray, Ren, Masuyer & Ferlay, 2013). According to the World Health Organization [WHO] (2014), cancers, particularly those associated with the lung (trachea and bronchus), account for 1.6 million deaths (2.9%) making it the fifth leading cause of death worldwide. An increase in life expectancy has been cited as a reason for continued trends in cancer (WHO, 2014b) due to the fact that cancer risk increases with age (Howlander et al., 2012; NCI, 2008). As the population continues to age globally, deaths from cancer the NCI (2008) projects cancer deaths could exceed 13.2 million by 2030 or reach 24 million by 2035 (NCI, 2008; Ferlay et al., 2013). Xu, Kochanek, Murphy, & Tejada-Vera (2010) postulate such an increase in cancer burden could lead to the disease becoming the leading cause of globally.

Cancer trends in the U.S. are reflective of global trends, in that, this disease is among the leading causes of death and has ranked second to heart disease since 1935 (Hoyert & Xu, 2012). In 2011, cancer accounted for 22.9% of all U.S. deaths (Hoyert & Xu, 2012). In 2012, approximately 1.6 million new cases of cancer and 577,190 deaths were projected to occur (Howlader et al., 2012; Siegel, Naishadham, & Jemal, 2012). Projected outcomes have slightly increased to approximately 1.7 million new cases and 585,720 deaths this year (Howlader et al., 2013). An estimated13 million Americans are living with cancer (Howlader et al, 2013). Ford and colleagues (2012) assert these trends are due to individuals engaging in health protective behaviors including not smoking, exercising, and proper foo consumption. Despite improvements in chronic disease research efforts, the lifetime risk of being diagnosed with any type of cancer is about 41% and the lifetime risk of death from cancer is 21% for all racial and ethnic groups (NCI, 2013a; NCI 2103b; Howlander et al., 2013). Analogous to the global population, Americans are beginning to live longer. The median age for Americans is 40 years of age (Howden & Meyer, 2011) and in 2010, 26% of Americans were 45-64 years of age, which differs from population trends for this age group in 2000. Several factors influence the likelihood of developing, the most notable being age. Lifetime cancer risk increases with age and predominately occurs in adults middle aged or older (Siegel, Jiemin, Zou, & Jemal, 2014). Most cancers (77%) occur in adults greater than 55 years of age (Siegel et al., 2014).

In 2008, the National Center for Health Statistics (NCHS) reported that cancer has led to the loss of 15.5 years of productivity among Americans as a result of dying prematurely. In addition to devastating the lives of many Americans, cancer has become a substantial economic burden on the nation. Mariotto, Yabroff, Shao, Feuer, & Brown (2011) project that the increased aging of the U.S. population will lead to the national expenditure for cancer care to exceed $150 billion. Rising costs in cancer care, necessitates a better understanding of factors that are increasing risk of cancer among vulnerable populations such as the uninsured, elderly, economically disadvantaged, and/or racial and ethnic minorities.

2.1.2 Overview of Cancer in South Carolina

South Carolina offered an ideal setting for conducting this dissertation research due to the fact that Charleston has documented environmental justice challenges and talks of expanding the Port of Charleston into an environmental justice community continue (Ball, 2006). In addition, the Port of Charleston produces methyl bromide, a toxic chemical used to fumigate farms and disinfect in buildings, wood and cargo ships (Clemson Cooperative Extension, 2011). Methyl bromide has been linked to cancer risk (Cockburn et al., 2012) and cancer mortality rates in South Carolina have exceeded U.S. rates since 2000 (NCI, 2013). Thus, Metropolitan Charleston South Carolina is an appropriate geographic location in which to examine environmental health and cancer-related disparities.

In 2011, cancer was the leading cause of death in South Carolina (SC) with 9,510 reported deaths (South Carolina Community Assessment Network [SCAN], 2013). Although cancer rates only account for 1.67% of all cancer deaths in the U.S. (ACS, 2012), in 2009, more than 25,000 South Carolinians were diagnosed with cancer (SCAN, 2012) and greater than 9,500 died from the disease (SCAN, 2012). Racially diverse groups in South Carolina exhibit more cancer burden than their white counterparts. For example, cancer mortality rates among Blacks were consistently higher for every county in SC from 1996-2005 (Hurley et al., 2009). Of the five leading incident cancer sites in South Carolina, Black men had the highest incidence and mortality rate for three cancers from 1996-2005 (Hurley et al., 2009). In addition, while the 5-year survival rate for cancer was 61.5% for the state from 1996-2005, rates for both Black men and women remained lower than Whites during the same time period (Hurley et al., 2009).

The highest incidence rate from all cancers from 2006-2010 in South Carolina was observed in Dorchester County, one of three counties in the Charleston Metropolitan Statistical Area (MSA) (NCI, 2014a). Five-year incidence rates in Berkeley (522.8 per

100,000), Charleston (541.3 per 100,000), and Dorchester Counties (556.6 per 100,000) exceeded both state level rates (457.8 per 100,000) and national rates (453.7 per 100,000) for all cancer sites (DHEC, 2013; NCI, 2014a). Death rates in Charleston MSA followed a similar pattern in Charleston County where the annual rate was slightly higher at 189.6 per 100,000 than the state rate of 187.6 per 100,000 and national rates of 176.4 per 100,000 (DHEC, 2013; NCI, 2014a). Annual death rates in Berkeley County were slightly higher than the national rate at 176.6, but Dorchester County deaths rates were lower than state and national rates for 2006-2010 (DHEC, 2013; NCI, 2014b).

2.1.3 State of Cancer: Progress and Remaining Challenges

Since the 'War on Cancer,' declines in cancer incidence and mortality rates have resulted from improvements in prevention, detection, and treatment efforts (Edwards et al., 2014; Gail et al., 2007; Engels et al, 2008; Smith, Cokkinides, & Eyre, 2009; Johnson et al., 2008; Nomura et al., 2010). Some examples of these advances have occurred in the prediction of cancer risk in vulnerable populations. In 2007, Gail et al. developed a risk assessment tool to predict the likelihood of Blacks developing breast cancer. Engels et al. (2008) found that persons infected with human immunodeficiency virus (HIV) have an excess risk of cancer and higher risk of developing specific types of cancers due to having a suppressed immune system. Other studies have demonstrated that declines in cervical cancer are the result of practically universal Pap test screening practices and identification of potential cancer challenges during exams (American College of Obstetrics and Gynecology [ACOG], 2009; Moyer, 2012; Saslow et al., 2012).

Though varied, declines in cancer deaths rates have also been noted by gender.

Cancer death rates among men declined from 2000 to 2009 and 2005 to 2009, for ten of the most common cancers (Jemal et al., 2013). Additionally, incidence rates among women decreased for 15 out of 18 of the most common cancers; however, the incidence rates of both men and women for the top 17 cancers remained stable (Jemal et al., 2013). National causes of death by gender reflect nation-wide leading causes of death trends; in spite of this, when stratified by race/ethnicity outcomes vary (Heron, 2012). Among minorities, with the exception of Blacks, cancer is the top cause of death in women (Heron, 2012). For men, on the other hand, cancer only accounts for more deaths than heart disease for Asian/Pacific Islander men (Heron, 2012). Differences in cancer rates not only vary by gender, but they also vary by race and ethnicity, geographic location, sociodemographic factors such as income, education, and age. To address cancer warrants an understanding of the underlying factors that contribute to the disproportionate rate of cancer in certain groups. This dissertation research did so by exploring behavioral and environmental factors associated with the development of cancer.

2.2 Health Disparities

The majority of the burden in health and disease is systematically and adversely bore by socioeconomically and environmentally disadvantaged groups (U.S. Department of Health and Human Services [DHHS], 2010). A term used to explain population differences in the presence of disease and outcomes is "health disparities." There are many working definitions of health disparities. The *Healthy People 2020* definition of a health disparity is "a particular type of health difference that is closely linked with social, economic, and/or environmental disadvantage" (DHHS, 2010). These differences are further explained according to racial/ethnic, religious, socioeconomic, geographic, and historical acts of discrimination or exclusion" (DHHS, 2010). The Centers for Disease Control and Prevention [CDC] (2013a) uses health disparities and health inequalities interchangeably defining them as "gaps in health outcomes or determinants between segments of the population." Reducing health disparities has been an overarching goal nationally since the inception of *Healthy People 2000*. Despite continued efforts to bridge health gaps between and within groups, racial and ethnic disparities persistent for many health conditions including cancer.

2.2.1 Cancer Health Disparities

Even with established declines in overall cancer incidence and mortality rates, disparities in cancer are a topic of great concern because all groups are not equitably benefitting from progress that has been made in cancer research (Centers for Disease Control and Prevention [CDC], 2013b). Several studies have demonstrated that racial and ethnic minorities and persons of lower socioeconomic status are differentially burdened by cancer (i.e., have higher risk and lower survival rates) (Ward et al., 2004; (Howlander et al., 2012). White women, for instance, have an incidence rate of 418.2, which exceeds rates for all other racial/ethnic groups (Howlander et al., 2012). However, Black women are dying from cancer at a faster rate (174.6 per 100,000 vs.150.8 per 100,000) followed by white women, American Indian/Alaska Natives, Hispanics, and Asian/Pacific Islander (Howlander et al., 2012). In addition, Black men's overall cancer incidence rates exceeded those of women and other racial and ethnic groups from 2005 to 2009

(Jemal et al., 2013). National reports have demonstrated that while incidence rates steadily declined for Whites between 1975 and 2009, Blacks had the highest age-adjusted incidence rate for all cancer sites and consistently higher mortality rates than all other racial/ethnic groups from 2004-2008 (NCI, 2012; NCHS, 2011). Similar outcomes were also reported for cancer survival among Blacks (Altekruse et al., 2010).

2.2.2 Causes of Cancer Health Disparities

To reduce cancer health disparities requisites identifying factors that fundamentally cause them. It is important to acknowledge that cancer, like many other chronic diseases, occurs within the context of human circumstance (Freeman, 2006). Hence, the causes of cancer are largely unknown and often attributed to the interplay of myriad external (behavioral, social and environmental) and internal (genetic, mutations and hormonal) factors that manifest over time (NCI, 2012; Phelan, Link, & Tehranifar, 2010). According to Williams (1999), variability in health outcomes among groups in the U.S. is predicted by race and ethnicity. Freeman & Chu (2005) asserts health disparities are fundamentally characterized by culture, low socioeconomic status, and the effect of social injustice. Along the same lines, Williams & Jackson (2005) assert that racial disparities are best understood in the context of macrosocial group experiences, which perpetuate risks and cause discrepancies in access to resources. In the case of Blacks and other minority groups, residential segregation (Hayanga, Zeliadt, & Backhus, 2013; Morello-Frosch & Jesdale, 2006), social inequities (Ward et al., 2004), inadequate health to care access (Institute on Medicine, 1999; Ward et al., 2004), and disproportionate exposures to hazardous environmental conditions (Collins et al., 2011; Williams &

Jackson, 2005; Bullard, Mohai, Saha & Wright, 2007; Bullard, 1990: Adeola, 1994; Morello-Frosch & Jesdale, 2006) have been attributed as reasons for differences in cancer among Blacks. These social and environmental factors have been commonly referred to as the "fundamental cause of health disparities" (Williams & Collins, 2006).

2.3 Residential Environments

The World Health Organization [WHO] (2006) reports environmental factors (natural and man-made agents) cause approximately 25% of deaths and disease worldwide. Disease occurs within an environmental context and people constantly interact with their environment, which can either promote quality of life or perpetuate health disparities (DHHS, 2014). To put this dissertation research in context, the definition used for environment comprises all things external to an individual ranging from social factors to exposures to hazardous substances in the air, water, soil, and food (WHO, 2006). Unhealthy environments act as a breeding ground for adverse health (Williams & Jackson, 2005). Researchers have demonstrated that social and environmental factors, especially neighborhoods can enhance wellbeing or reinforce health disparities (Williams & Jackson, 2005, Marmot, 2005; Wilkinson & Marmot, 2003; Li, Wen & Henry, 2014; Clarke et al., 2013). Williams & Jackson examined the literature on racial differences in health and identified racial disparities in SES, education, income, health practices, and residential segregation. Pickett and Pearl (2001) linked socioeconomic factors in disadvantaged residential environments to diseases such as cancer. Clarke et al. (2013) showed that cumulative disadvantage in residential environments more than socioeconomic factors (i.e., wealth or ethnicity) shape health over time. Socioeconomic factors are important in explaining disparities, but they do not negate the fact that racial and ethnic groups are differentially impacted.

The racial makeup of a neighborhood is an indicator of health outcomes and living conditions in the U.S. due to historical patterns of racial residential segregation (Williams & Collins, 2001; Li Wen, & Henry, 2014). According to Woods and colleagues (2014), discriminatory practices in "housing policies in the U.S. established an inequitable generational trajectory." There are contrasting views about the health effects of racial residential segregation and health outcomes (Kramer & Hogue, 2009). Williams & Collins (2001) proposed that racial residential segregation is the foundation upon which Black-white disparities in health were established. Under this epistemology, laws preventing Blacks from moving into affluent and/or white neighborhoods shapes concentrated economic disadvantage, less desirable neighborhood conditions, and created barriers to quality health care (Williams & Collins, 2001; Feagin & Bennefield, 2014). In a systematic review of the literature on racial residential segregation, Kramer & Hogue (2009) identified numerous studies that reported an association between residential segregation and health outcomes. The majority of the literature reportedly health damaging effects from racial residential segregation. Divergent views about residential segregation having protective effects have also been postulated in recent years (Pickett & Wilkinson, 2008; Becares et al., 2012). Both studies ascribe to the belief that racial residential segregation or "ethnic group density" creates a health protective environment by fostering opportunities of social cohesion, more health-promoting resources, and reducing discrimination and stress (Pickett & Wilkinson, 2008; Becares et al., 2012). No matter the viewpoint adopted, the fact is that Black-white disparities can have a profound effect (negative or positive) on the health of group being separated. For the purposes of this work, the underlying assumption is that for Blacks in Charleston MSA racial residential segregation maybe having a deleterious effect rather than promoting better health.

2.3.2 Environmental Justice

Regardless of race, color, national origin, or income, all people should have the same degree of protection from environmental and health hazards and equal access to making environmental decisions or what is known as environmental justice (U.S. Environmental Protection Agency [EPA], (2014). Achieving environmental justice is possible by creating equitable, healthy, and sustainable communities where vulnerable populations live, work, and play; however, a racial divide exists in the enforcement of regulatory laws on environmental exposures (Bullard et al., 2007). This is generally referred to as environmental racism. Bullard (1993) defines environmental racism as an "environmental policy, practice, or directive reinforced by government, legal, economic, political, and military institutions that differentially affects or disadvantages (whether intended or unintended) individuals, groups, or communities based on race or color" (Bullard, 1993).

For some individuals, groups, and geographic areas are more vulnerable to elevated health risks due to unhealthy environmental conditions. Barriers to achieving environmental justice surfaced in 2002 when the South Carolina Ports Authority proposed the expansion of the Port Charleston into a predominately Black community in the City of North Charleston (U.S. Corps of Engineers, 2006). As required by the

National Environmental Protection Act (NEPA), an environmental impact assessment was conducted to assess the population residing in the proposed expansion area. The assessment revealed 22 communities met EPA criteria of an environmental population (Ball, 2006). As a result of the environmental impact assessment, community and university research efforts were performed to combat environmental inequities in North Charleston, South Carolina (Wilson, Rice, Fraser-Rahim, 2011; Wilson et al., 2012a; Wilson et al., 2012b; Wilson et al., 2013; Burwell-Naney et al., 2013; Rice et al., 2014). This dissertation research is one such project conducted to further explore some of the issues brought up by the impact assessment.

Similar to other ethnic minorities and economically disadvantaged populations, Blacks in North Charleston are overrepresented in areas that are burdened by unhealthy environmental conditions (Wilson et al., 2012). Examples of unhealthy environmental conditions include exposures to high levels of criteria air pollutants (Payne-Sturges & Gee, 2006) and facilities that emit carcinogens (Apelburg, Buckley, & White, 2005) and disproportionate disease (Wilson, Hutson, & Mujahid, 2009; Bullard et al., 2007; Payne-Sturges & Gee, 2006; Perlin, Wong & Sexton, 2001; Perlin, Sexton, & Wong, 1999; Mohai & Saha, 2007). These conditions can lead to cancer or exacerbate other health conditions (Morello-Frosch & Jesdale, 2006; Morello-Frosch & Lopez, 2006; Payne-Sturges & Gee, 2006).

Research has demonstrated racial/ethnic health disparities are perpetuated by disparate encounters in high risk settings including exposure to negative social factors (e.g., poverty, racism, segregation, violence, isolation and stress), environmental disamenities (e.g., noise, air pollution, water pollution, poor infrastructure, noxious land uses) and adverse health risks (Morello-Frosch & Jesdale, 2006; Wilson, 2009; Payne-Sturges & Gee, 2006).

2.3.3 Environmental Cancer Risk

Environment factors have been linked to the development of numerous cancers (Tomatis et al., 1990) and are said to account for about two-thirds of all cancer cases (DHHS, 2003). Some risk factors in the environment that are known to increase cancer risk are modifiable including smoking and tobacco use, bacterial or viral infections, exposure to radiation, and a suppressed immune system (National Cancer Institute [NCI], 2014). Tobacco use as well as smoking causes a variety of cancers (NCI, 2014). Cigarette smoking increases risk of cancers of the bladder, stomach, pancreas, lung, and kidney (NCI, 2014). Other risk factors that have not been shown to directly cause cancer, but that may affect cancer are poor diet, alcohol consumption, physical inactivity, obesity, and exposure to environmental hazards (NCI, 2014). Air pollution is an example of an environmental pollutant that exacerbates cancer as well as other health conditions (NCI, 2014; Vineis & Husgafvel-Pursiainen, 2005; Brunekreef & Holgate, 2002; Boffetta & Nyberg, 2003). Across the U.S., patterns of exposure to air quality are disproportionately higher in residential areas with more non-whites (Clark, Millet & Marsahll, 2014) and counties and/or other areas where racial and ethnic minorities, economically disadvantaged persons, and residents reside compared to non-Hispanic Whites (Miranda, Edwards, Keating & Paul, 2011; Bell & Ebisu, 2012). Differences in environmental exposures are not only influenced by sociodemographic and economic factors, they also are influenced by geography.

2.4 Geographic Information Systems

Where people live, work, and play fundamentally determines their health (Dummer, 2008). Elucidating the relationship between contextual factors and health can be challenging. Using concepts and techniques from geography, interactions between people and their environments can be explored using a methodology that uses both a multilevel approach and takes space and place into consideration (Dahlgren & Whitehead, 1991; Green, Richard, & Potvin, 1996). This can be achieved using geographic information systems (GIS). GIS is a mapping tool that gathers, stores and analyzes spatial data (Cromley & McLafferty, 2003; ESRI, 2014). In addition to managing data, GIS is used to identify spatial relationships, patterns, and trends from multiple data sources.

2.4.1 GIS and Public Health

The origins of the use of GIS methodologies in public health go back span almost 175 when Robert Cowan used mapping to represent the relationship between overcrowding and fever in Glasgow, Scotland in 1840 (Nigeria Health and Mapping Summit, 2011). The most notable use of GIS to represent relationships in public health was John Snow's mapping of the cholera epidemic in London in 1854 (Snow, 1855).

Using mapping, Snow (1855) identified a spatial relationship between the distribution of cholera and the location of a contaminated well (Snow, 1855). Public health agencies and entities are using GIS for diverse purposes such as mapping health data, modeling population characteristics, documenting and tracking disease burden, detecting public health threats and informing policy, creating and promoting targeted health interventions and initiatives, (Wilkinson, Grundy, Landon & Stevenson, 2003, p. 179; Centers for Disease Control and Prevention [CDC], 2013; Dummer, 2008). Although GIS is widely used across disciplines, assessing correlations between exposures to environmental factors and health outcomes is a common practice in environmental health research (English et al., 1999; Jerrett et al., 2003; Jarup, 2004; Mather et al., 2004; McGeehin, Qualters & Niskar, 2004; Nuckols, Ward & Jarup, 2004). Several studies have explored the relationship between the distribution of cancer risks from exposures to hazardous air pollutants using National-Scale Air Toxics Assessment (NATA) data (Apelberg, White & Buckely, 2005; Linder, Marko & Sexton, 2008; Collins, Grineski, Chakraborty & McDonald; Gilbert & Chakraborty, 2011).

2.4.2 Spatial Analytics and Clustering

Generally, cancer data is mapped at the county level to ensure anonymity; however, Krieger et al. (2002) found that census tract measures perform equivalently to county level assessments. At the county level some important contextual features that influence health differences may be masked at a higher level (county) than compared to the census tract level. For example, social vulnerability in Charleston Metropolitan is low across the all three counties. We anticipate drilling down to the census tract level will reveal areas where cancer risk may be clustering, which could explain Black-white disparities in cancer for this area. A cancer cluster is when the observed number of cancer cases exceeds the expected number of cases in a particular group with a certain timeframe (CDC, 2013). Environmental epidemiologists traditionally use geographic analyses to investigate environmental health hazards. Spatial analytics are used to identify disease clustering (Sherman et al., 2014). All clustering, including clusters of disease, aggregate within space and time (Ord, 2010). Clustering exists when the values of the feature observed is adjacent to other features with similar values i.e., high next to high and low adjacent to low values (Mitchell, 2009). It is a type of spatial autocorrelation that measures the relative distribution of a feature with the underlying assumption of independence (Anselin, 1995; Lee & Wong, 2005). Spatial autocorrelation is measured by calculating a Local Indicator of Spatial Autocorrelation (LISA) statistic (Local Moran's Index (I) value for each feature. Moran's I are compared to the index values expected, which are represented by standardized z-scores (Anselin, 1995). Z-scores will indicate if the distribution of the attribute is random, clustered, or dispersed. The LISA technique has been previously used to explore environmental inequalities in air pollution (Zou, Peng, Wan, Mamady & Wilson, 2014) and water pollution exposures (Oyana & Margai (2010). Geographic cluster analyses assessing the directionality of risk from environmental expsoures have also been performed (Oyana & Lwebuga-Mukasa, 2004; Guajardo & Oyana 2009). Using spatial analytics for this study could foster opportunities to identify geographic areas where the population risk of developing cancer is higher than in other areas.

2.5 Risk Perceptions

Perceived risk or risk perception, which will be used interchangeably throughout this dissertation, is an intuitive estimation of risk (Slovic, 1987), and accounts for "people's beliefs, attitudes, judgments and feelings, as well as, the wider social or cultural values and dispositions that people adopt, towards hazards and their benefits"

(Pidgeon, Hood, Jones, Turner, & Gibson, 1992). Further, risk perceptions measure the likelihood of personal harm (Weinstein & Klein, 1995). Risk perceptions have been largely explored in association with threat appraisal from environmental hazards that pose a threat to health (Savage, 1993; Flynn et al., 1994) and health behaviors (Vernon, 1999).

2.5.1 Environmental Risk Perceptions

Recognition of place as a significant contributor of risk perceptions dates back to Van Liere and Dunlap's (1980) findings of greater concerns of risk from environmental problems amongst urban compared to rural residents. Since their findings, studies have explored perceptions of environmental health risks by race/ethnicity and gender (Flynn et al., 1994; Fincuane et al., 2000; Marshall, 2004), age (Van Liere, 1980), socioeconomic factors (Lemyre, 2006), and proximity to hazardous waste (Vaughan & Nordenstam, 1991; Mohai, Lantz, Morenoff, House, & Mero 2009; Mohai, Pellow, & Roberts, 2009). The challenge, however, is that literature on the associations between environmental health risks and sociodemographic factors were primarily conducted between the 1980s and early 21st century. The underlying assumption of this work is that perceptions of cancer risk and environmental health risks vary by sociocultural and personal experiences. Pepitone and Triandis (1988) equated differences in ethnic environmental risks perceptions to shared interpretations and life experiences. Vaughan and Nordenstam (1991) posited that risk perceptions differ by group due to individual sociocultural contextual experiences. They reiterate Peptione and Triadis' (1988) paradigm that perceived risk is varied, culturally derived, and ensconced within it is the tendency to emphasize or downplay certain beliefs and/or practices. Place becomes significant in this process because where people live and the environment in which they interact and share experiences begets a cohesive value system, which is the breeding ground for perceptions. Elliott et al. (1999) examined the relationship between community concerns about health and environmental pollution. Environmental exposures and health are mediated by perceptions (Elliott et al., 1999). Several studies have demonstrated differences in cancer risk by proximity to environmental hazards (Levanthal et al., 1999; Linder, Marko, & Sexton, 2008; Apelburg et al., 2005; Collins, 2011) and the impact of perceptions of risk on cancer (Orom et al., 2010; Honda & Neugut, 2004); however, a paucity of research has addressed the perceptions of communities that are disproportionately exposed to environmental hazards. Evaluating actual risk of cancer for underserved populations could "facilitate the control of cancer by encouraging preventive action and early detection and treatment for individuals at high risk" (Levanthal et al., 1999). There is literature to suggest that males and females differ in their perception of environmental risk (Shepard, Jepson, Watterson, & Evans, 2012; Finucane, Slovic, Mertz, Flynn, & Satterfield, 2000; Flynn, Slovic, & Mertz, 1994 Davidson & Freudenburg, 1996). Most of the literature was conducted in the 1990s and no studies queried Blacks residing in metropolitan areas overburdened by unhealthy environmental conditions. Furthermore, many of the studies on racial/ethnic environmental disparities could not explain why differences exist.

2.5.2 Perceived Cancer Risk

Several studies have operationalized perceived risk as an indicator of health behaviors associated with the management, prevention, and care of chronic and infectious diseases (Adriaanse et al., 2008; Brewer et al., 2007; Dillard et al., 2012; Weinstein et al., 2007; Orom et al., 2010; Orom et al., 2012). Perceived cancer risk is a derivative of threat appraisal which is based upon one's belief that a disease poses a threat to personal health (Vernon, 1999; Lucas-Wright et al., 2014). Cancer is a chronic disease most notably associated with risk perceptions. The anticipated threat or future occurrence of an [*health*] event also impacts risk perceptions. For instance, perceived risk has played a major role in decisions related to cancer prevention, detection, and management by influencing the probability of engaging in a behavior (Levanthal et al., 1999; Elliott, Cole, Krueger, Voorberg, & Wakefield, 1999; Moser, McCaul, Peters, Nelson, & Marcus, 2007; Orom et al., 2010). Blacks hold fatalistic beliefs about cancer (Powe & Finnie, 2003; Niederdeppe & Levy, 2007). These beliefs encourage the common misperception that reducing personal cancer risk cannot be controlled (Niederdeppe & Levy, 2007; ACS, 2006) and thus may be influencing health behaviors for some this group (Niederdeppe & Levy, 2007). Cancer fatalism among Blacks, though mixed, has been studied considerably. Some studies have found fatalistic views did not influence health behaviors among Blacks compared to whites (Niederdeppe & Levy, 2007), while others report more cancer fatalism for this group (Powe, 1995; Powe, 1996; Powe, 1997; Powe, Daniels & Finnie, 2005; Underwood 1997; Wolff et al., 2003). Cancer beliefs reinforce perceived cancer risk and both are factors that can impede or promote preventive health behaviors including decisions regarding such as cancer screenings (Slovic, Peters, Finucane & MacGregor, 2005).

Risk perceptions have been examined as a predictor of risk-reducing practices in several studies (Weinstein, 2000; Klein & Stefanek, 2007; Dillard et al., 2012; Kowalkowski et al., 2012) and therefore have been examined as a predictor of risk-reduction practices in several studies (Levanthal, Kelly, & Levanthal 1999; Weinstein, 2000; Klein & Stefanek, 2007; Dillard et al., 2012; Kowalkowski et al., 2012). Although there is no working definition of perceived cancer risk, for this dissertation research, it was defined as the belief of being susceptible to or the likelihood of developing cancer.

2.5.3 Perceived Risk and Health Behaviors

Perceived risk is a fundamental construct in Social Cognitive Theory (Bandura, 1994), the Health Belief Model (Rosenstock, 1974), the Theory of Reasoned Action (Fishbein and Ajzen, 1975), and the Theory of Planned Behavior (Ajzen, 1985), all of which are arguably the most employed theoretic models in health behavior research.When applied in health research, perceived risk is used synonymously with perceived vulnerability, probability, and likelihood (Joseph et al., 2009; Waters et al., 2010; Weinstein et al., 2000). Each of the aforementioned health behavior models emphasizes the influence of individual level characteristics on risk perceptions.

Risk perceptions have been cited as a motivator of health behaviors because it prompts people to be proactive rather than reactive (Janz & Becker, 1984; Levanthal et al., 1999; Turner, Hunt, DiBrezzo & Jones, 2004). Several studies have demonstrated an association between risk perceptions and health behaviors (Orom et al., 2010; Moser et al., 2007; Weinstein et al., 2007). Brewer et al. (2007) and Weinstein et al. (2007)

stressed the importance of using appropriate measures to assess risk perceptions associated with influenza vaccination. Brewer et al. (2007) conducted a meta- analysis to assess if risk perceptions are rightfully positioned as an indicator of health behavior. Despite variations in analyses and assessment measures, Brewer and colleagues (2007) concluded that risk perceptions are appropriately positioned theoretically and vary depending on the health behavior. Weinstein et al. (2007) examined beliefs on risk probability as a predictor of vaccination for influenza. Weinstein et al. (2007) not only demonstrated that risk perceptions serve as an important indicator of vaccination, but they found that feeling at risk was more indicative of health behavior than thinking (cognition) that one is at risk. Moser and colleagues (2007) examined the correlation between perceived susceptibility of cancer risk and self-protective actions. The purpose of their study was to determine if personal risk operated independently or in tandem with worry. Moser et al. (2007) found that cognitive risk and affective worry were predictive of screening decisions. To elucidate the role perceived risk plays in risk-reducing health behaviors; risk should be assessed using measures that capture participants' feelings, which influences perceptions. Questions on worry about developing cancer were incorporated into the environmental health survey to better gauge participants' health behavior decisions.

Risk perceptions not only vary by behavior, but they vary by race/ethnicity. Studies have demonstrated diverging perspectives of risk perceptions by race and ethnicity (Joseph et al., 2009; Salant & Gehlert, 2008; Shelton, Goldman, Emmons, Sorenson, & Allen, 2011). Orom et al. (2012) conducted a study to understand the importance of cultural relevance in perceived risk and screening practices. Orom et al.

(2012) found that perceived cancer risk increases the likelihood that an individual will engage in preventive behaviors such as screening for disease. In another study, Orom et al. (2010) found that Blacks had lower perceived risk of cancer than their White counterparts (Orom et al., 2010). A study by Kim et al. (2008) observed diverging findings with regard to Black women and perceived risk. In their study assessing the association between cancer risk perceptions and screening among diverse women, Kim et al. (2008) found Black's perceptions of risk for three cancers were analogous to White women's perceptions.

Wailoo (2011) and Salant and Gehlert (2008) highlight the diverging sociopolitical structure of communities, cultural differences, and changes in patterns of perceptions over time as reasons for differences in perceptions by race and ethnicity. Other studies have demonstrated that socioeconomic and sociopolitical environmental factors associated with daily concerns are overshadowing cancer risk and prevention efforts in diverse communities, which in turn influences perceived risk of cancer (Salant & Gehlert, 2008; Joseph et al., 2009; Shelton et al., 2011).

Akin to differing perceptions of risk is the association between social position and perceived cancer risk. Social position is widely determined by socioeconomic status. Socioeconomic status is the underlying cause of inequities in health (Williams & Jackson, 2005). Williams & Jackson (2005) equate these differences to America's history of residential segregation. As a result of segregation, Blacks' socioeconomic mobility is truncated (Williams & Jackson, 2005). Studies have shown that socioeconomically disadvantaged populations are more likely to reside in areas with more environmental hazard (Bullard et al., 2007). In addition, these populations are more likely than their white counterparts to perceive their personal risk of environmental exposures are higher and that they are more vulnerability than others (Finucane et al., 2000).

2.6 Gaps in the Literature

Studies on perceived risk span environmental health, cancer, psychology, and sociology literature; however, there is little interdisciplinary work being done to assess the impact of overlapping risks. Health reports have been published that emphasize the significance of environment in the development of cancer. Cancer agencies have found a link between environmental pollutants and cancer demonstrating 2% of all cancers are related to environmental exposures (Siegel et al., 2014). Furthermore, studies continue to assess the how cancer health disparities occur as a result of myriad factors interacting in the environment. Regardless, no studies, with the exception of Vaughan & Nordenstam (1991) have emphasized racial/ethnic differences in cancer and environmental exposures are grounds for assessing risk. This dissertation research assessed perceived cancer risk from the perspective that an overlap exists in risk from factors external (environmental conditions) and internal (perceived risk) to an individual may explain some of the disparities observed amongst the economically disadvantage population. Gauging community-level environmental perceptions may provide insight into why certain populations choose to engage or not engage in health-protective behaviors, provide clarity on differing perceptions, and determine the most important influencing factors.

Given disparities in cancer exist and persist by race/ethnicity, screening patterns and treatment, it is imperative that research on the correlation between risk perceptions and risk-reducing health behaviors among minorities be conducted. There have been no studies to date that have assessed the role perceptions plays in the risk reducing health behaviors of individuals in communities at high risk for cancer, environmentally hazardous conditions, and social vulnerability. This dissertation research served as a formative step to aid in developing strategies that target fundamental causes of disparities.

CHAPTER 3

RESEARCH DESIGN AND METHODS

This chapter provides an overview of the conceptual framework that guided the overall study, research design, data sources and methods used to address the specific aims of this study. Also, this chapter explains in detail the primary data collection procedures used to evaluate perceived cancer risk and the secondary sources of data used to explore actual cancer risk. Detailed descriptions of the tenets from each of the health behavior theories used to develop the study's conceptual framework are presented. Next, the research design that guided the methods for each specific aim as well as the methodological approach are outlined.

The specific aims of this study were to:

1. Evaluate the relationship between perceived cancer risk and perceived environmental health risks, and risk-reducing health behaviors (Manuscript 1) and

2. Use geospatial methods to explore actual cancer risk and socioeconomic vulnerability to environmental hazards (Manuscript 2).

A cross-sectional environmental health survey was administered to elucidate perceived cancer risk. The survey was administered in Charleston MSA (i.e. Berkeley, Charleston, and Dorchester Counties) by two methods: 1) paper-and-pen and 2) online Recruitment flyers were used to recruit respondents to complete the survey. The survey included 10 domains (sociodemographic characteristics, environmental health risk, perceived cancer risk, health-related self-efficacy, health assessment, family cancer history, health care access, risk-reducing health behaviors, social support, government priorities).

To explore actual cancer risk, an exploratory spatial analysis was conducted using secondary data from the U.S. Census Bureau, cancer risk rates from the Environmental Protection Agency's (EPA) National-Scale Air Toxics Assessment (NATA), cancer incidence and mortality rates from the South Carolina Central Cancer Registry (SCCCR), and social vulnerability variables from the Hazards and Vulnerability Research Institute (HVRI).

3.1 Conceptual Framework

The methodology for addressing each specific aim and corresponding research question was based on a conceptual framework comprising constructs from the Health Belief Model (Hochbaum, 1958) and Social Cognitive Theory (SCT) (Bandura, 1986) in health promotion and Commers, Gottlieb and Kok's (2006) framework of the pathway of environmental health etiology in environmental health. Concepts from the PEN-3 Model (Airhihenbuwa, 1992), a culturally relevant health theory and the hazards-of-place model of vulnerability (Cutter, 1996; Cutter, Mitchell, & Scott, 2000; Heinz Center for Science, Economics, and the Environment, 2002; Cutter, Boruff, & Shirley, 2003), a geospatial model of social vulnerability to environmental hazards are also included.

Hochbaum (1958) introduced the Health Belief Model (HBM), the most used health promotion theory in social science research (Glanz, Rimer, & Lewis, 2002;

NCI, 2003). The Health Belief Model presents a way to better understand health behavior and provides an explanation for an individual's approach to health. HBM asserts that individual perceptions (i.e., perceived seriousness, perceived susceptibility, perceived benefits, and perceived barriers) determine health behavior, which in turn affects one's ability to prevent disease. Accordingly, the model assumes that perceived susceptibility is the strongest indicator of behavior change because the greater one's perceived risk, the greater their likelihood of engaging in behaviors to decrease their risk. In the model, modifying factors such as age, gender, and race/ethnicity are depicted as mediators of the likelihood of performing a behavior. This dissertation assessed community level perceptions of cancer risk and modifying factors such as gender, age, socioeconomic status (SES), and past experiences to determine perceived threats of risk and the likelihood that residents will use preventive services.

The PEN-3 model is a conceptual model that emphasizes the importance of incorporating culture into the development, implementation, and evaluation of health promotion programs (Airhihenbuwa, 1992; Airhihenbuwa, 1995). The model incorporates tenets of health education and health behavior which are explored through three interrelated and interdependent dimensions with descriptors for the acronym PEN 1) health education (Person, Extended Family, Neighborhood), 2) health behavior (Perceptions, Enablers, and Nurturers), and 3) cultural influence of health behavior (Positive, Exotic, and Negative) (Airhihenbuwa, 1992; Airhihenbuwa, 1995). In the first dimension, Airhihenbuwa (1995) emphasizes development of prevention and health programs that incorporate health education in the context of an individual's personal role in the family, acknowledgement of the significance of an individual's environment, and accounting for neighborhood factors. The second dimension of the PEN-3 model was developed from the amalgamation of other health education models including the Health Belief Model. To this end, dimension two comprises perceptions which result from the confluence of cultural practices, attitudes, and beliefs that facilitate health behavior change. Enablers and nurturers, on the other hand, are factors occurring at diverse levels (i.e., cultural, societal, systematic) that influences beliefs and actions (Airhihenbuwa, 1995). The last dimension of the model tackles the cultural appropriateness of health behavior to include behaviors that empower, behaviors that are inherit in a population or group, and health beliefs and actions that translate into behaviors that are detrimental. In the conceptual framework for this dissertation, the PEN-3 model serves as a broad framework to incorporate the relevancy of culture in perceptions of cancer risk and environmental health risks. Given each element of the three dimensional model operates contextually and interdependently, the PEN-3 model is embedded in the environmental component of the conceptual framework to reinforce the notion that group diversity in perceived risk is best understood within the context of sociocultural experiences, which shape individual risk perceptions (Vaughan & Nordenstam, 1991).

Commers et al.'s (2006) four-pathway framework encompasses "triadic reciprocity" between the individual, their behavior, and the environment (i.e., the association between perceived environmental health risks and human health through environmental influences). This dissertation focused on Pathway 2, which emphasizes environmental conditions influence on behavior with the mediation of perceptions and/or conscious awareness (Commers et al., 2006).

Akin to Commers et al.'s (2006) framework, Social Cognitive Theory conceptualizes the interplay between behavior, cognitive factors (perceptions), and environmental experiences (Bandura, 1986). The underlying assumption of Social Cognitive Theory is that the dynamic between perceptions and behavior, perceptions and environment, and environment and behavior is an interminable interaction influenced by past experiences (Bandura, 1986). A mechanism by which this triadic relationship operates is personal agency or self-efficacy. Self-efficacy characterizes an individual's belief in their ability to achieve a goal or execute an action to produce given attainments (Bandura, 1977; Bandura, 1997). According to Lorsbach & Jinks (1999), self-efficacy is a judgment of confidence associated with engaging in a task. Self-efficacy was incorporated into the conceptual framework; however, it was not measured on the environmental health survey. Furthermore, cancer risk perceptions were measured as a factor that shapes health related self-efficacy.

The Hazards-of-Place Model of Vulnerability is an exploratory model developed for the purpose of elucidating diverse elements that contribute to vulnerability of places (Cutter, 1996). Elements in the model include risk, mitigation, hazard potential, geographic context (elevation and proximity), and social fabric (experience, perception, built environment), biophysical vulnerability, social vulnerability, and place vulnerability. Each element is contextually arranged according to its influence on other elements in the model. In the model, risk functions as a measure of the probability of a hazard event occurring. In conjunction with risk, mitigation, which is a measure thought to curtail risks or reduce its impact, produces a hazard potential. Hazard potential is then moderated or enhanced by proximity to hazards and neighborhood experiences with hazards, perceptions of hazards, and the built environmental context of hazards. Embedded within the social fabric component of the model is the community's reaction to, recovery from, and adaptation to a hazard. Cutter (2003) purports the anticipated outcome is associated with socioeconomic factors. The Hazards-of-Place Model of Vulnerability culminates with the production of place vulnerability from biophysical and social vulnerability. The primary components of the Hazards of Place Model that were incorporated in the conceptual framework were risk, hazard potential, geographic context, social fabric, social and place vulnerability. Proximity to environmental hazards was used to emphasize the contextual factors that influence individual perceptions of risk. Perceived environmental risk and cancer risk were assessed by the hazard potential of the community (using cancer risk by environmental exposures to carcinogenic compounds), which estimated social vulnerability. Social vulnerability was operationalized according to Cutter's (1996) definition, which states that social vulnerability is embedded in historical, cultural and socioeconomic processes that foster vulnerabilities. Based on Cutter's (1996) definitions, social vulnerability was incorporated as a mechanism of the environment that indirectly affects perceived cancer risk and risk-reducing health behaviors. Place vulnerability was also incorporated to emphasize the role of *place* (e.g., geographic location of certain communities) in perceptions of cancer risk and environmental health risks.

Using tenets from each of the aforementioned models, a conceptual model/framework for this dissertation research was developed. The model explores the correlation between cancer risk perceptions, environment, and health behaviors among residents in areas with known environmental justice issues (Aim 1). The conceptual framework is illustrated in Figure 3.1, which depicts a triadic relationship between the environment, cancer risk time and social fabric are represented in the social environment; place vulnerability is an example of the built environment, the hazard potential functions through both the social and natural environment, while geographic context focuses on the natural aspects of the environment. Incorporating the Hazards-of-Place Model emphasizes the fact that a range of factors produce social vulnerability and thus cancer risk as vulnerability occurs within a spatial context.

The state or condition of an individual's environment influences their perceptions of risk for cancer because disease does not occur in a vacuum, it occurs in the context of human circumstance. With that said, the environment is depicted as having a direct effect on cancer risk perceptions and risk-reducing health behaviors. Self-efficacy has been introduced as a factor that moderates the association between the environment and risk-reducing health behaviors. Cancer risk perceptions has been incorporated as a mediating factor between environment and risk-reducing health behaviors suggesting that engaging in health behaviors (e.g. cancer screenings) are mediated by personal beliefs that one is at risk of developing disease. Gender, age, and socioeconomic status are incorporated in the conceptual framework as factors that confound cancer risk perceptions. The conceptual model frames cancer risk perceptions as a positive or negative influence on health-related self-efficacy (belief in one's ability to take care of their own health). The role of self-efficacy was not explored in this dissertation research.

All of the interrelated relationships depicted in the conceptual framework are believed to function within an "exposome." The exposome is a concept complementary to

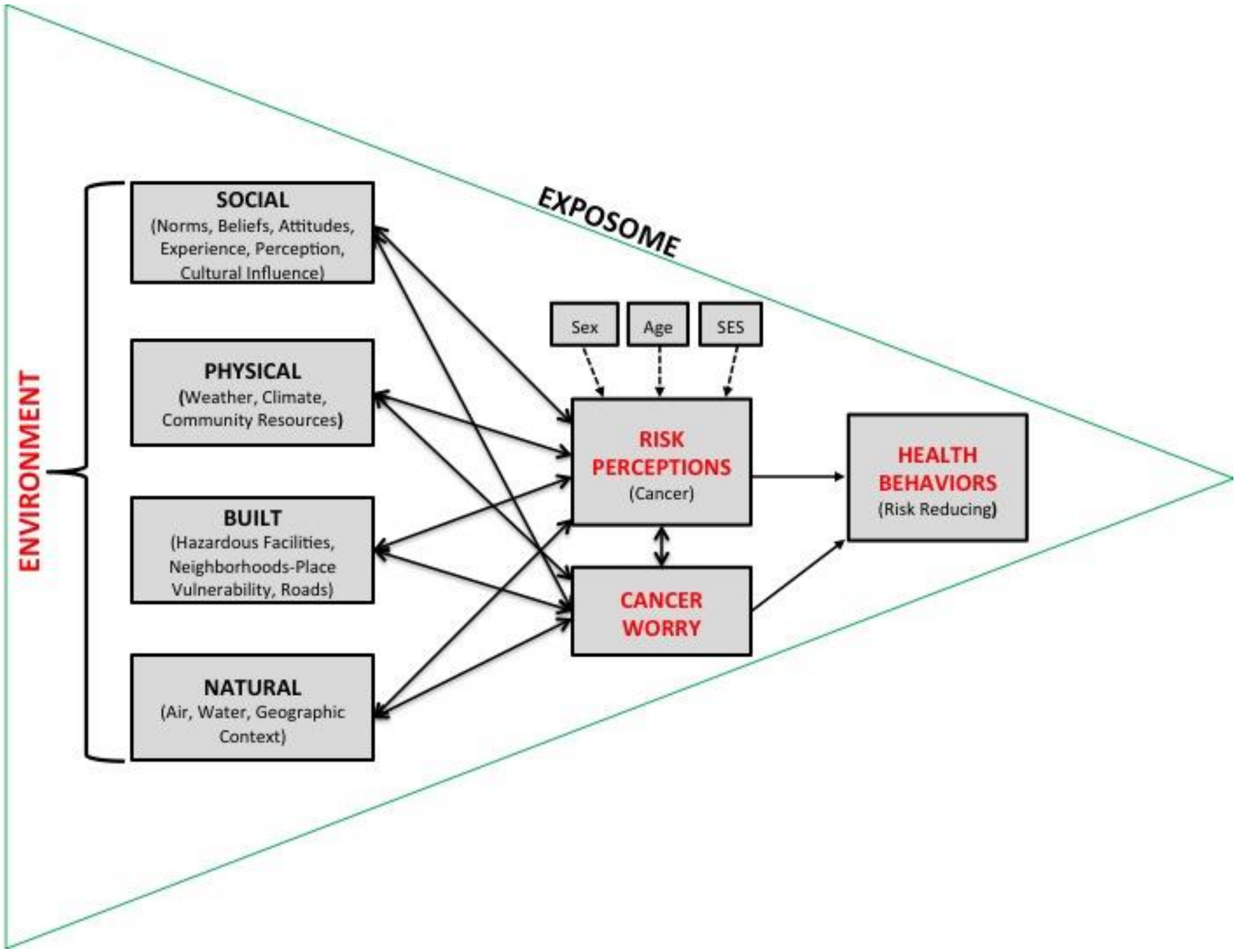

Figure 3.1 Conceptual Framework

the human genome (Wild, 2005). It describes all of an individual's exposures over the life course, how such exposures relate to one another and impact health (Wild, 2005). Understanding how exposures from our environment influence our risk perceptions, interact with contextual factors, and then translate into detrimental or beneficial health behaviors is the underlying premise of this conceptual framework. In addition, the triadic shape of the model deigned for this research is reminiscent of the Health Impact Pyramid (Frieden, 2005), in that it describes a public health concern at the individual level for the purpose of making a greater impact by informing interventions that can reduce health disparities at every level.

3.2 SPECIFIC AIM 1

Assessing perceived cancer risk comprised primary data collection including administration of a community environmental health survey.

Sampling

Sample. The survey was distributed to a convenience sample of Black adults (aged 18 and older) Charleston Metropolitan Statistical Area (MSA) (Charleston-North Charleston-Summerville) which includes Berkley, Charleston, and Dorchester Counties, South Carolina. To participate, respondents had to self-identify as Black, be age 18 years or older, and have resided in Charleston MSA for at least one year.

Study Setting. The study was conducted in the Charleston MSA with particular emphasis on North Charleston. This area was selected based on the fact that most Blacks in the Charleston MSA reside in the city of North Charleston. Of the metropolitan areas in South Carolina, Charleston MSA is the 4th largest with a population total of

122,689.and it ranks 79th largest in the U.S. (South Carolina Department of Commerce, 2011; U. S. Census Bureau, 2014e). The racial and ethnic composition is 67.4% White, 26.8% Blacks, 5.4% Hispanic/Latino, 1.6% Asians, 4.2% Other (U.S. Census Bureau, 2014a).

The city of North Charleston's demographic population total is 101,989, of which 47.2% self-identified as Black or Black. Non-Hispanic White represent 41.6% of the population followed by persons of Hispanic/Latino origin (10.9%), Asian (1.9%), 0.5 % American Indian and Alaskan Native, and 0.2% Native Hawaiian and Other Pacific Islander (U.S. Census Bureau, 2012). Additional demographic features pertaining to the study setting are provided in Table 3.1.

The Charleston MSA was a unique setting for this study because one of its three counties has the highest five-year incidence rates for all cancer types in SC (NCI, 2014a). In addition, Blacks are overrepresented in an area with environmental conditions that exacerbate cancer. In 2002, the proposed expansion of the Port of Charleston prompted an environmental impact assessment of the neighborhoods identified as potential expansion locations (Ball, 2006). An environmental justice analysis revealed that the expansion would have a disproportionately high and adverse impact on minority and low-income populations (Ball, 2006). The assessment identified twenty-two communities with vulnerability to environmental justice issues.

Sample size calculation. A priori power analysis was conducted to determine the sample size of the sample. Assuming a 95% level of confidence, population size of 53,851, and maximum acceptable difference of 5% from the true proportion (of at most 15%) the minimum sample size estimated was 382 respondents. Sample size calculations were performed using PASS 13 software (NCSS LLC, Kaysville, UT, USA) and the National Statistical Service sample size calculator (Australian Bureau of Statistics, 2014). The sample size was determined using the total population in the Charleston Metropolitan Statistical Area (MSA) from 2010 of 664,607 (U.S. Census Bureau, 2014). The population size of Blacks in the Charleston MSA is 185,263 (U.S. Census Bureau, 2012a). However, more Blacks live in the city of North Charleston (U.S. Census Bureau, 2014b). In 2012, the population estimate in North Charleston was 101,989. Blacks represent 47.2% of that population. Hence, the population size used to determine the sample of the survey was 53,851. The final sample size of 405 allows suitable power even under approximately 5.7% missing; only income had more missing data (Table 4.2).

Measures

Instrumentation. The survey instrument was designed using a combination of existing items from the National Survey of Public Perceptions of Environmental Health Risks (PEW), Health Information National Trends Survey (HINTS), and the Behavioral Risk Factor Surveillance System (BRFSS) survey. The survey instrument is in Appendix B. There are a total of 59 items on the survey. Some survey items were adapted from previous studies identified in the literature review and new items were developed based on the study area as needed (PSRA, 2000; NCI, 2012; CDC, 2011). The conceptual framework developed for this dissertation research guided survey items. The survey includes 10 domains; however, for this dissertation research, the primary domains of interest are: sociodemographic characteristics, environmental health risks, perceived cancer risk, risk-reducing health behaviors, self-efficacy, and social support.

Table 3.1 Descriptive Characteristics of Setting

	Total Population	Percent Black	Education Level (25+ with HS and Bachelor's degree)	Median Household Income	Percent persons below poverty	Cancer Incidence (rate)	Cancer Mortality (rate)
U.S.	313,914,040	13.1%	85.4% 28.2%	$52,762	14.3%	459.0	173.1
SC	4,723,723	28.1%	83.6% 24.4%	$44,587	17.0%	428.7	179.4
Charleston MSA	630,100	28.8%	87.8% 29.3%	$49.828	9.4%	439.9	179.5
North Charleston	99,727	47.2%	80.0% 17.1%	$39,182	22.4%	-	-

These content domains were selected based on their usage in the literature, applicability to the aims and research questions of this dissertation research, and consensus from CCRAB and the Environmental Health Core research staff. Table 3.2 provides an overview of each domain incorporated in the conceptual framework for this dissertation research, with items of interest for Manuscript 1 denoted. Following the table is a detailed descriptor of each domain on the survey

Sociodemographic characteristic. A total of 16 sociodemographic items are included on the survey. These items specifically obtained information on respondents' gender, age, occupation status, race, ethnicity, education level, combined annual household income, home ownership, length of time in community, and number of adult children residing in the household. Education and income were combined to create a composite socioeconomic status (SES) variable (low, medium, and high). To inform future public health interventions, items on different modes of accessing the Internet were also included.

Environmental health risks. Environmental health risks were assessed using 10 items. The items obtained information on respondents' perception of the role the environment plays in causing disease and the perceived seriousness of exposure to unhealthy environmental conditions such as air pollution, water pollution, soil.contamination, and toxic waste. Three of the items assessed respondents' personal experience with environmental pollution, respondents' family history of exposure to unhealthy environmental conditions, and perceived susceptibility to cancer based on environmental exposures. All items were adapted from the PEW survey (PSRA, 2000).

Perceived cancer risk. Perceived risk for cancer was measured using three cancer belief items from the 2012 HINTS (NCI, 2012) and one newly developed item. The items assessed respondents' belief of the likelihood of developing cancer in their lifetime, the extent to which respondents' worry about developing cancer in general, as well as specific cancers, and determine the basis of their beliefs about cancer.

Risk reducing health behaviors. Fourteen items was used to assess respondents' lifestyle behaviors and screening practices. Items were adapted from the 2011 BRFSS survey and the 2012 HINTS to assess Dart Wolin, & Colditz's (2012) eight ways to prevent cancer (CDC, 2011; NCI, 2012). The items will assess respondents' current lifestyle practices and past screening behaviors. Five items on screening behaviors assessed gender-specific and gender-neutral cancer screening practices.

Health-related self-efficacy. One item was used to assess respondents' health self-efficacy. The item was obtained from the 2012 HINTS (NCI, 2012) item, which assessed respondents' confidence in taking care of their own health.

Social support. Three social support items was used to assess respondents' social support. Social support items were adapted from the Ludden Social Network Scale, Multidimensional Scale of Perceived Social Support, and Piedmont Health Survey (Zimet, Dahlem, Zimet & Farley, 1988; Ellison & George, 1994; Pfeifer & Waelty Scale; 1995).

Health assessment. Two items were used to assess respondents' health, one of which was used in the 2012 HINTS (NCI, 2012) to assess perceived health status. The second item was adapted from the 2012 HINTS item on cancer diagnoses. The purpose of this item was to determine respondents' disease status (i.e., if the participant had ever been diagnosed with any type of cancer or other chronic disease).

Family cancer history. Three survey items will assess respondents' risk based on family history of cancer. The items ask about family members diagnosed with cancer, the respondents' perceived susceptibility to cancer based on their immediate relative's cancer status, and which specific relative had ever been diagnosed. Two items were adapted from the 2012 HINTS (NCI, 2012) and one item was newly developed.

Health care access. Health care access was measured using two items. Respondents were asked to indicate the type of health care coverage they have as well as the facilities they use when seeking medical care. One item was adapted from the 2012 HINTS (NCI, 2012) and the other item was created using a combination of the 2011 BRFSS survey and 2012 HINTS items on health care coverage (CDC, 2011; NCI, 2012).

Health information. One health information item from the PEW survey (PSRA, 2000) was used to assess respondents' interest in obtaining more information on the state of the environment in their community and what can be done to protect respondents and their family from environmental health problems. These items were adapted to also assess respondents' interest in obtaining any information at all on both topics.

Government priorities. Two items from the PEW survey (PSRA, 2000) was included to assess respondents' perception of the importance of more research on environmentally-related health effects and the extent to which the local government is giving enough attention to reducing illnesses that have been linked to environmental hazards.

The Principal Investigator (PI) and research staff recruited a non-probability sample of 424 Black adults who met the inclusion criteria. To be eligible to participate by completing the environmental health survey, respondents had to: 1) self-identify as Black or Black, 2) be at least 18 years of age, 3) have resided in Charleston MSA (Berkeley, Charleston, or Dorchester County) for at least one year, and 4) be able to read, write, or comprehend English. Individuals that do not meet these inclusion criteria were excluded from participating.

Participant Recruitment. A combination of homogenous and convenience sampling was used to recruit respondents to participate in the study. Use of homogenous and convenience sampling are based on their useful in recruiting respondents that share similar characteristics and settings and that are conveniently available to participate (Collins, Onwuegbuzie, & Jiao, 2007). In this case, eligible respondents resided in the Charleston MSA for at least one year. Respondents were recruited at local health, community, and social events in the Charleston MSA with a focus on events in the North Charleston area due to the highest proportion of Blacks residing in North Charleston in the Charleston MSA. Events included the 2013 Black Expo Charleston, Annual Day of Neighborly Need, and Charleston Community Research to Action Board (CCRAB) meetings, the public library, North Charleston Delta Sigma Theta Chapter meetings, Improvement Council meetings, the Sister Summit and other appropriate events recommended by community partners. Examples of additional events used to recruit respondents were identified by the CCRAB and the City of North Charleston's Community Center Activities webpage: http://www.northcharleston.org/residents/departments/parks/comm_center_activities.aspx.

In addition, respondents were recruited by word-of-mouth, email invitations, and in-person with recruitment letters with a flyer on the backside. The recruitment letter and flyer are in Appendix A. The PI, CCRAB, and Environmental Health Core research staff used word-of-mouth recruitment to share the opportunity to participate with eligible individuals. Email invitations were sent to individuals in a database maintained by the CCRAB and Environmental Health Core staff. The content of the email communication resembled the recruitment letters and flyer. Recruitment letters with a flyer on the backside were distributed at events. The PI made a presentation about the study at a CCRAB meeting to help guide recruitment activities.

Data collection

Survey Administration. Data were collected using two methods of survey administration: 1) paper-and-pen and 2) online or web-based. The paper-and-pen survey was administered with an invitation letter attached. Respondents reviewed the recruitment letter and then agreed to complete the survey on-site or took the survey packet home, completed it, and mailed it back via a postage-paid envelope. Online surveys were generated in Qualtrics, an online system used to create and manage surveys (Qualtrics, 2009). The survey in Qualtrics was an exact replica of the paper-and-pen survey with a progress bar included and skips patterns embedded. To participate in the survey online, Qualtrics generated a customized web link for respondents to access and complete the survey. A single URL generated by Qualtrics was provided via recruitment letter and/or email as an option for eligible participants to complete. Respondents were introduced to the study via an invitation letter on the first page of the survey.

Table 3.2 Domains on the environmental health survey

Domain	**Scale**	**Number of scale item(s)**	**Conceptual framework items**
Sociodemographic characteristics		16 items adapted from HINTS and 1question developed by the PI (NCI, 2012)	Age, gender, socioeconomic status (SES)
Environmental health risks	Severity	10 item, adapted from PEW (PSRA, 2000) survey	Hazards-of-Place Model of Vulnerability
Perceived Cancer Risk	Worry Lifetime risk of cancer	3 items, adapted from HINTS (NCI, 2012)	Cancer risk perceptions
Risk-reducing health behaviors	Smoking, weight, exercise, diet, alcohol consumption, sun exposure, infections, and cancer screening	14 item, adapted from HINTS (Dart et al., 2012; NCI, 2012; CDC, 2011)	Risk-reducing health behaviors
Health-related self-efficacy		1 item from HINTS (NCI, 2012)	Self-efficacy
Social support		3 items adapted from the Ludden Social Network Scale, Multidimensional Scale of Perceived Social Support, and Piedmont Health Survey (Zimet, Dahlem, Zimet & Farley, 1988; Ellison & George, 1994; Pfeifer & Waelty Scale, 1995)	PEN3 Model

Next, the survey prompted respondents to choose whether to proceed, to end their participation or continue complete the survey. Upon completion of the survey, Qualtrics saved each response. Paper-and-pen survey data were collected and combined with online survey data in an Excel spreadsheet. The Excel file was saved on the study database. Paper-and- pen and online survey responses were combined into one excel file once all data has been collected.

Pilot testing. Research staff and members of the Environmental Health Core reviewed several iterations of the survey before a final version was pilot tested on five students and four staff members, including the committee chair and outside committee members. Following student and staff feedback, the survey was administered at the 2013 Black Expo in North Charleston on March 9, 2013. Based on feedback from respondents that completed the survey, minor revisions such as adding an additional response option were made.

Data Management. Prior to and after data entry, all paper-and-pen surveys were stored in a locked file cabinet and online surveys were stored in Qualtrics in a password-protected folder. These security measures were taken to ensure data confidentiality. Paper-and-pen survey data was entered manually into a Microsoft Excel database and verified by the PI and a research staff member.

Data Analysis. Crosstabulations was conducted on online surveys and then data was downloaded and exported as a Microsoft Excel file. Both Excel files were imported into Statistical Analysis System (SAS) 9.3. Descriptive and inferential statistics were conducted for paper-and-pen and online surveys separately and for the combined data to obtain participant characteristics for both modes of administration as well as for the entire study. To characterize the study sample, descriptive statistics including frequency distributions, measures of central tendency (mean, mode, and median), and measures of variability were conducted.

Two research questions were tested to evaluate perceived cancer risk. Below each research question and the analysis used to evaluate the question are provided.

Research Question 1 (RQ1): Is there a relationship between perceived cancer risk and socioeconomic status, perceived environmental health risks, and/or health behaviors?

An ordinal logistic regression was performed to determine the relationship between perceived cancer risk and SES, environmental health and health behaviors. The dependent variable, perceived cancer risk, was categorical; it was recoded and analyzed dichotomously as low, medium and high perceived cancer risk. The independent variables were socioeconomic status (SES), perceived environmental health risks, risk reducing behaviors (smoking, weight, exercise, diet, alcohol consumption, sun exposure, infections, and cancer screening). SES was measured by combining estimates of education and annual household income. Variables used to derive SES were categorical. Once derived, SES was analyzed as low, medium and high SES. Perceived environmental health risks, also categorical were analyzed as an ordinal variable. Risk reducing health behaviors was assessed using 9 items. Items were analyzed as a dichotomous or ordinal variable.

Research Question 2 (RQ2): Does perceived cancer risk vary by education, income, gender, and/or age?

Basic inferential statistics (i.e., chi-square tests) were used to explore determine the relationship between perceived cancer risk and each covariate including gender, age, SES, health insurance, disease status, and environment causing cancer. An ordinal logistic regression was performed to assess the relationship between perceived cancer risk and SES, perceived neighborhood environment health risks, and health behaviors.

3.3 SPECIFIC AIM 2

Retrieving cancer risk and outcomes data, decennial census data, and spatial data from four sources enabled the conduct of a secondary data analysis to explore actual cancer risk. A description of each source, how the source was used, and how the data were obtained is provided below.

Study Area

Setting. The setting for Specific Aim 1/Manuscript 1was also the setting for Specific Aim 2/Manuscript 2.

Data Sources and Collection

The measures for Aim #2 were cancer risk, cancer incidence, cancer mortality, % poverty, % income, and % Black population. With the exception of cancer incidence and cancer mortality, each of the aforementioned measures were selected based on their use in previous literature (Cutter et al., 2003; Apelberg et al., 2005; Morello-Frosch & Jesdale 2006; Linder et al., 2008; Collins et al., 2011). Cancer incidence and mortality rates are included to provide an accurate depiction of what is actually occurring rather than predicting what may occur. All measures were operationalized in the conceptual framework within the adapted Hazards-of-Place Model of Vulnerability.

National-Scale Air Toxics Assessment (NATA). NATA is a comprehensive tool created by the Environmental Protection Agency (EPA) to assess air toxics in the United States. NATA was created as a screening tool to determine pollutants that require immediate attention and to improve knowledge on risks associated with air toxics. NATA data provides general information on emission sources in an effort to project risk. In addition to cancer risk, NATA includes county and census tract level estimates of cancer risks, neurological risk, and respiratory risk. A total of four NATA assessments have been conducted triennially. The initial assessment was performed in1996 and the last assessment was performed in 2005. Findings from the assessment were published in 2011 (EPA, 2002). For this study, only total cancer risk estimates was retrieved from NATA, a free public database.

South Carolina Central Cancer Registry (SCCCR). Established in 1994, the South Carolina Central Cancer Registry (SCCCR) is a database of newly diagnosed cancer cases in South Carolina that is used to examine cancer concerns through cancer assessments (South Carolina Department of Health and Environmental Control [SCDHEC], 2012). SCCCR assesses trends on the frequency of cancer cases by geographic location, changes in diagnosis and treatment patterns, and survival rates. Cancer death rates are collected by the Division of Vital Records and published by the Division of Biostatistics and Division of Public Health Informatics within DHEC. The system used to query cancer incidence and mortality data is the South Carolina Community Assessment Network (SCAN) (SCDHEC, 2012). SCCCR and SCAN queries are free to the public; however, to acquire data and use it requires permission. To acquire cancer incidence data, a Research Data Request Application was completed and submitted to the SCCCR's Cancer Control Advisory Committee Surveillance Subcommittee (CCAC-SS). The application went through a formal review process, which included proof of IRB approval from the University of South Carolina (Pro00027670).

Once approved by the CCAC-SS (IRB.l3-024), SCCCR assisted the PI with data acquisition, dataset creation, and data analysis as needed. Cancer mortality data was also requested for the Department of Health and Environmental Control Vital Records office.

Social Vulnerability Index (SoVI®). The SoVI® is a metric tool created by the Hazards and Vulnerability Research Institute (HVRI) to assess social vulnerability to environmental hazards by country in the United States. The SoVI® includes a compilation of socioeconomic variables identified in social science research as factors that act as barriers to community preparedness, response, and recovery from hazards (HVRI, 2014). The primary data source for SoVI® is the U.S. Census Bureau five-year American Community Survey estimates. Other SoVI® data sources, also from the U.S. Census Bureau, include the 2007 one-year American Community Survey, Geographic Names and Information System (GNIS), and model-based Small Area Health Insurance Estimates (SAHIE). SoVI® data represents data collected over a four year period (2005-2009). The SoVI® data are displayed using geographical variations in social vulnerability and classified by standard deviation. Counties with standard deviations above 2 are areas with greater social vulnerability. SoVI® can be used to predict areas where resources are needed to effectively reduce pre-existing vulnerability and determine recovery from disasters. The SoVI® is housed at the USC HRVI. As a student, access to SoVI was free.

Measures

Cancer risk. Cancer risk (total), as defined by the EPA, is the probability of contracting cancer over the course of a lifetime (assumed to be 70 years for the purposes of NATA risk characterization). Total cancer risk data were based on the 2005 National Emissions Inventory, which comprises major stationary sources (e.g., large waste incinerators and factories); area and other sources (e.g., dry cleaners, small manufacturers); and both on-road and non-road mobile sources (e.g., cars, trucks, boats) (EPA, 2011). The EPA derived cancer risk estimates from concentrations of exposure and standard inhalation concentrations (EPA, 2011). Cancer risk estimates were obtained from the NATA database for 1996, 1999, 2002, and 2005 (USEPA, 2002). Although cancer risk by emission source and compound is available, this study focused on total cancer risk estimates (risk from all compounds) at the census tract level. Cancer risk is represented in the conceptual model as "perceived cancer risk."

Cancer incidence. Cancer incidence was measured by the number of new cases diagnosed during a specific time period (i.e. one year) (SCDHEC, 2013). Cancer incidence measures are obtained from hospital cancer registry cases, hospitals without registries, independent pathology laboratories, freestanding treatment centers, and physician offices. SCCCR staff collects all non-registry hospital data. Cancer incidence was based on cancer counts for the tri-county area. Incidence counts were collected by SCCCR, which was the primary data source for this measure. Only cancer cases diagnosed for each NATA assessment year and the most recent data (2010 were retrieved. Cancer incidence was not included in the conceptual framework. Incidence data served to depict cancer occurrence only.

Cancer mortality. Cancer mortality was measured by the number of deaths occurring during a specific time period (SCDHEC, 2013). Cancer mortality measures are obtained from hospital cancer registry cases, hospitals without registries, independent pathology laboratories, freestanding treatment centers, and physician offices. SCCCR staff collects all non-registry hospital data. Cancer mortality was based on cancer counts for the tri-county area. Mortality counts were collected by SCCCR, which was the primary data source for this measure. Cancer deaths reported for all four NATA years and 2010 (most recent data) were used. Cancer mortality was not included in the conceptual framework. Mortality data served to depict recent cancer deaths only. Cancer incidence and cancer mortality data were acquired were requested from the SCCCR. A brief summary of this study was provided to Dr. Deborah Hurley, the Assistant Director of SCCCR. Approval to use cancer data was provided by the Cancer Control Advisory Committee Surveillance Subcommittee (CCAC-SS) (IRB.l3-024).

Percent poverty. The percent of poverty was measured using the U.S. Census Bureau's five-year American Community Survey (ACS) estimate of poverty for 2006-2010 standardized for SoVI®. The census definition of poverty "uses a set of money income thresholds that vary by family size and composition to determine who is in poverty. If a family's total income is less than the family's threshold, then that family and every individual it in is considered in poverty" (U.S. Census Bureau, 2014a). The percent of poverty by census tract was mapped using three levels-low, medium, and high.

Percent income. The percent of income was measured using the U.S. Census Bureau's five-year American Community Survey (ACS) estimate of poverty for 2006-2010 standardized for SoVI®. Income as measured by the U.S. Census is defined as gross income received on a regular basis (U.S Census Bureau, 2014b). The percent of income by census tract was mapped using three levels-low, medium, and high.

Percent Black. The percent Black population was measured using the U.S. Census Bureau's five-year American Community Survey (ACS) estimate of the Black population for 2006-2010 standardized for SoVI®. The percent Black population includes those individuals that self-identified as Black or Black on the ACS during the years assessed. The percent Black population by census tract was mapped using three levels denoting low, medium, and high percentage of Blacks.

Data Analysis

Two research questions were tested to evaluate actual cancer risk. Below each research question and the analysis used to evaluate the question are provided.

Research Question 4 (RQ4): Has cancer risk increased, decreased, or remained steady since 1996 in Metropolitan Charleston?

Cancer risk data for census tracts in Charleston MSA were linked by Federal Information Processing Standards (FIPS) codes with spatial data from the 1990 and 2000 U.S. decennial censuses. A choropleth map for each assessment year (1996, 1999, 2002, and 2005) was mapped using ArcGIS 10.2. Data were not normally distributed. Natural breaks of cancer risk were mapped on three levels-low, medium, and high. Significant clustering of cancer risk was explored using Global and Anselin Local Moran's I statistics. Positive spatial autocorrelation indicates similar values occur at adjacent locations; whereas negative autocorrelation implies that high values appear next to low values. The Moran's I statistic ranges from +1 (for positive spatial autocorrelation) to -1 (negative autocorrelation), and its expected value in the absence of autocorrelation approximates zero.

Research Question 5 (RQ5): Are there spatial variations in cancer risk, incidence, and mortality by % poverty, income, and Black population?

The last year of NATA (2005) and five-year cancer data (incidence and mortality) were joined in ArcGIS to geospatial data by census tract. Individual choropleth maps of cancer were created and then separate maps of % poverty, income, and Black population were created. Maps were saved as shapefiles and exported to Adobe Illustrator 17. Bivariate maps of cancer risk, incidence, and mortality by % poverty, income, and Black population were created. Correlation analyses between cancer risk and incidence and mortality separately and then cancer data and sociodemographic variables were performed in SPSS 22.0.

Data Management

Data were downloaded and saved to a database. After data were retrieved from all sources, one excel file was created and saved as a shape (.shp) file and linked in ArcGIS 10.2. A map of census tracts in South Carolina was downloaded from University of South Carolina's data server. Data in the zipped MS Access files were unzipped and downloaded on a study laptop. Then, Charleston MSA (Berkeley, Charleston, and Dorchester County) geospatial data were extracted and saved in an Excel file. Data were maintained in one geodatabase.

CHAPTER 4

RESULTS

This chapter presents the results of the overall assessment of perceived and actual cancer risk in the Charleston Metropolitan Statistical Area. The findings are presented for each specific aim and its corresponding research questions in the form of a peer-reviewed manuscript. Manuscript one focuses on Specific Aim 1, which was assessed by research questions 1 and 2. The first manuscript has been prepared for submission to the *Journal of Community Health.* The aforementioned manuscript is focused on perceived cancer risk, in particular documenting neighborhood perceptions of cancer and environmental health risks, and risk-reducing health behaviors with an emphasis on the association between low perceived cancer risk and health behaviors among Blacks. The second manuscript explores actual cancer risk from environmental exposures geographically and measures associations between cancer and racial and socioeconomic characteristics used to evaluate environmental justice. Manuscript two focuses on Specific Aim 2, which was assessed by research questions 3 and 4.

4.1 Exploring perceptions of cancer risk, neighborhood environmental risks, and health behaviors of Blacks [1]

1Rice, L. J., Brandt, H. M., Hardin, J. W., Ingram, L. A., & Wilson, S. M. To be submitted to *Journal of Community Health*

Abstract

Purpose Risk perceptions and cancer worry are shaped by race/ethnicity and social and environmental experiences, which in turn shape health decision-making. A paucity of studies, have explored the aforementioned relationship in metropolitan areas with disparate environmental conditions and cancer outcomes. The purpose of this study was to: 1) document perceptions of cancer risk, neighborhood environmental health risks, and risk-reduction health behaviors, and 2) determine the association between low perceived cancer risk and health behaviors among Blacks.

Methods A 59-item survey was administered to participants in Metropolitan Charleston, South Carolina (Berkeley, Charleston, and Dorchester Counties) from March 2013 to September 2013. A convenience sample of males and females was recruited at local venues (e.g., libraries, housing authority, and hair salons) and community events. Descriptive statistics, bivariate analyses (chi square), and logistic regressions were estimated using SAS 9.3 software.

Results Respondents (N=405) were 100% Black, 81% female (n=323), 19% male (n=75), and ranged from 18 to 87 years of age. Seven respondents did not report their gender. Low perceived cancer risk (absolute risk) was associated with non-alcohol consumption and colon cancer screening, sex, and older age (24-65, $p<.05$). Cancer worry was significantly associated with being a current smoker, fair diet, non-alcohol consumption, and colon cancer screening tests ($p<.05$).

Conclusions Perceived cancer risk is an important indicator of health behaviors among Blacks. Direct or indirect experiences with cancer and/or the environment and awareness of family history of cancer may explain cancer risk perceptions.

Keywords

Risk perception · cancer · environmental health · health behavior · community health·

Blacks·

Introduction

Despite national improvements in overall cancer incidence, mortality, and survival rates, compared to their white counterparts, Blacks have poorer survival outcomes and decline at a higher rate at every stage of diagnosis (Howlader et al., 2012; Siegel et al., 2014). Poorer cancer outcomes for Blacks are most often attributed to racial differences in prevention, and social, economic, and environmental factors (Siegel et al., 2014; Jemal & Siegel, 2011). In addition to shaping health behaviors, environmental factors, including environmental exposures, are associated with cancer incidence and mortality rates in the United States (Siegel et al., 2014; National Cancer Institute [NCI], 2010; Jemal & Siegel, 2011).

Two percent of all cancer deaths have been linked to exposures to environmental pollutants (Jemal & Siegel, 2011; Siegel et al., 2014) and studies have shown that minorities are inequitably exposed to pollutants due to their neighborhoods proximity to hazardous waste facilities (United Church of Christ [UCC], 1987; Bullard, 2000; Morello-Frosch, Pastor, & Sadd, 2001; Houston, Li, & Wu, 2014; Bullard, 2000; Jemal & Siegel, 2011; Mohai, Pellow, & Roberts, 2009; Wilson, Rice, & Fraser-Rahim, 2012; Wilson et al., 2012; Burwell-Naney et al., 2013). There is empirical evidence demonstrating that race is strongly associated with the distribution of commercial and industrial facilities across the United States (Perlin, Wong & Sexton, 2001; Bullard, Mohai, Saha, & Wright, 2007; Mohai et al., 2009; Taylor, 2014). Socioeconomic status (SES) has also been associated with the locations of industrial facilities emitting pollution (UCC, 1987; Saha & Mohai, 2005).

A growing body of environmental justice literature concerning racial and ethnic minorities and socioeconomically disadvantaged groups has linked disparate environmental exposures to hazardous air pollutants (harmful chemicals that produce cancer or other adverse health outcomes) to cancer risk (Environmental Protection Agency [USEPA], 2012; Apelberg, Buckley, & White, 2005; Linder, S. H., Marko, D., & Sexton, 2008; Collins, Grineski, Chakraborty, & McDonald, 2011; Rice et al., 2014). Communities with a higher percentage of Blacks and groups characterized with low education and/or high poverty had a significantly higher cumulative risk of cancer from environmental pollution (Apelberg et al., 2005; Linder, et al., 2008). Researchers have also assessed perceived risk from the perspective of those at risk.
Perceived risk or risk perception is an intuitive estimation of risk (Slovic, 1987), and accounts for "people's beliefs, attitudes, judgments and feelings, as well as, the wider social or cultural values and dispositions that people adopt, towards hazards and their benefits" (Pidgeon, Hood, Jones, Turner, & Gibson, 1992).

Studies on risk perceptions associated with environmental hazards have largely explored technologies, reproductive health, and socioeconomic and racial differences in hazard exposures (Slovic, Malmfors, Mertz, Neil, & Purchase, 1997; Pidgeon et al., 1992; Flynn, Slovic, & Mertz, 1994; Shepherd, Jepson, Watterson, & Evans, 2011; Savage, 1993; Lindell, Hwang & Seong, 2008; Finucane, Slovic, Mertz, Flynn, & Satterfield, 2000; Bord & O'Connor, 1997; Marshall, 2010). Findings from these studies demonstrate differences in perceived environmental health risks by SES, sex, race/ethnicity, and hazard experiences (Shepherd et al., 2011; Lindell, & Hwang, 2008, Vaughn & Nordenstamp, 1991). For instance, compared to Whites, Blacks tend to perceive greater risk from environmental factors (Flynn et al., 1994; Finucane et al., 2000).

Risk perceptions vary by health threat and race/ethnicity. The threat of environmental risks from environmental health hazards, including indoor exposures, national disasters, stress, and chemical pollution are perceived higher among minorities (Flynn et al., 1994; Lindell et al., 2008; Brent, 2004). Non-whites beliefs about cancer risk are more similar, in that they are lower than whites (Hughes et al., 1996; Lumpkins et al. 2013; Orom, Kiviniemi, Underwood, Ross, Shavers, 2010; Honda, & Neugut, 2004; Kim et al., 2008). Low perceptions of risk among Blacks are of great concern because for most cancers this population has higher cancer mortality rates and lower screening rates compared to their white counterparts (Siegel et al., 2014). Perceived vulnerability to a health threat may influence engagement in health protective behaviors such as cancer screenings (Ajzen, 1985; Weinstein, 1989; McCaul, Branstetter, Schroeder, & Glasgow, 1996; Jacobsen et al., 2004). Furthermore, perceived risk is associated with health behaviors (Orom et al., 2010; Moser, McCaul, Peters, Nelson, & Marcus, 2007; Janz & Becker, 1984; Levanthal, Kelly, & Levanthal, 1999). Perceived risk (cognitive) and worry (affective) predict screening decisions (Moser et al., 2007). For instance, undergoing a cancer screening is more common among persons with higher perceived risk (Katapodi et al., 2004; McCaul et al. 1996). To elucidate the role that perceived risk plays in risk factors for cancer, perceived risk should be assessed using measures that capture feelings. Perceived risk operationalized as feelings is worry, which is why these concepts are correlated (Hay, Buckley, & Ostroff, 2005).

Studies have demonstrated an association between risk perceptions and environmental health risks and cancer risk separately, but a paucity of research has explored perceptions as a concurrent contributor of disparities among Blacks. No study to date has assessed the overlap in risks in communities disproportionately impacted by cancer and environmental injustices. The purpose of this study among Blacks was to document: 1) perceptions of cancer risk and cancer worry, perceived neighborhood environmental health risks, and risk-reducing health behaviors, and 2) determine the association between low perceived cancer risk and health behaviors.

Methods

Study Setting

The study was conducted in the Charleston Metropolitan Statistical Area (MSA) in South Carolina. This MSA includes Berkley, Charleston, and Dorchester Counties, and is the fourth largest MSA in South Carolina (South Carolina Department of Commerce, 2011; U.S. Census Bureau, 2012). The racial and ethnic composition in 2011 was 68.6% White, 25.4% Black/Black, 2.9% Hispanic/Latino, and 1.9% other (U.S. Census Bureau, 2012).

Participants and Procedures

Eligible individuals were males and females, who self-identified as Black or Black, were aged 18 years or older, resided in the Charleston MSA for at least one year, and could read, write, and comprehend English. Convenience sampling was used to recruit participants. Over a six-month period from March to September 2013, participants were recruited at local health, community, and social events in the Charleston MSA, and through word-of-mouth, email invitations, in- person recruitment, social media (Facebook), and a newspaper advertisement. The University of South Carolina Institutional Review Board reviewed and approved the study procedures (Pro00027670).

Instrument

A 59-item survey instrument was constructed using selected existing items from the National Survey of Public Perceptions of Environmental Health Risks (Princeton Survey Research Associates [PSRA], 2000), Health Information National Trends Survey (HINTS), and the Behavioral Risk Factor Surveillance System (BRFSS) survey (PSRA, 2000; NCI, 2012; Centers for Disease Control [CDC], 2012). The survey included six content domains: sociodemographic and descriptive characteristics, perceived cancer risk, perceived environmental health risks, risk- reducing health behaviors, health-related self-efficacy, and social support. This manuscript focused on the first four domains. Survey items were revised based on suggestions from the Charleston Community Research to Action Board as part of pilot testing.

The instrument was pilot-tested with 13 participants who met the inclusion criteria before the final version was administered. Eligible participants completed the survey in one of two formats: 1) paper-and- pen or 2) web-based. Paper-and-pen surveys were distributed at venues described previously for participants to complete in-person or to complete off-site and then return in a postage-paid envelope. Online surveys were generated in Qualtrics, an online system used to create and manage surveys (Qualtrics, 2009). A single URL generated by Qualtrics was offered as an option for eligible participants to complete if they did want to do so in-person.

Sample size and Power

Sample size. A priori power analysis was conducted to determine the sample size of the sample. Assuming a 95% level of confidence, population size of 53,851, and maximum acceptable difference of 5% from the true proportion (of at most 15%) the minimum sample size estimated was 382 respondents. Sample size calculations were performed using PASS 13 software (NCSS LLC, Kaysville, UT, USA) and the National Statistical Service sample size calculator (Australian Bureau of Statistics, 2014). The sample size was determined using the total population in the Charleston Metropolitan Statistical Area (MSA) from 2010 of 664,607 (U.S. Census Bureau, 2014a). The population size of Blacks in the Charleston MSA is 185,263 (U.S. Census Bureau, 2012). However, more Blacks live in the city of North Charleston (U.S. Census Bureau, 2014b). In 2012, the population estimate in North Charleston was 101,989. Blacks represent 47.2% of that population. Hence, the population size used to determine the sample of the survey was 53,851 (U.S. Census Bureau, 2012). The final sample size of 405 allows suitable power even under approximately 5.7% missing; only income had more missing data (see Table 4.2).

Measures

Dependent Variables. The dependent variables were perceived cancer risk and cancer worry.

Perceived cancer risk. Absolute cancer risk perceptions were measured using the construct perceived cancer risk, a single-item from the 2012 HINTS survey. The item was measured using ‘‘How likely do you think you are to get cancer in your lifetime?’’. Response options were on a 5-point scale ranging from 1 (very unlikely) to 5 (very likely). The responses were then recoded into three responses: 1 (low perceived cancer risk), 2 (medium perceived cancer risk), and 3 (high perceived cancer risk).

Cancer worry. Cancer worry was assessed using the single-item question: ‘‘How often do you worry about getting cancer?” (NCI, 2012). Response options were on a 5-point scale including the options not at all, slightly, somewhat, moderately, and extremely and then re-coded as a dichotomous variable into 1 (no worry) and 2 (worry). Response options suggestive of worry (i.e. slightly, somewhat, moderately, and extremely) were collapsed and used to indicate that the respondent had some level of worry. Response option “not at all” indicated no worry.

Independent Variables. The independent variables included sociodemographic and descriptive characteristics, perceived environmental health risks, and risk-reducing health behaviors.

Sociodemographic and descriptive characteristics. A total of 16 sociodemographic and descriptive characteristic items were included on the survey. The items included information on participants’ sex, age, occupation status, race and ethnicity, education level, combined annual household income, home ownership, and length of time in community, household zip codes, and items on access to the Internet. Education and income were combined to create a composite socioeconomic status (SES) variable (low, medium, and high). The composite variable level for low SES comprised individuals with less than a high school education and a combined annual income of less than $15,000. Medium SES was equivalent to at least a high school education and vocational or technical training plus an income of $15,000-$49,999. High SES comprised the highest levels of education ranging from some college to postgraduate education and an annual income of $75,000 or more.

Perceived environmental health risks. Twelve items were adapted from the PEW survey (PSRA, 2000) to measure perceived environmental health risks. Items were assessed on a 3-point or 4-point scale. A single environmental health risk variable was created using six items. The items' response options were summed to create a cumulative score ranging from 6 (low) to 24 (high). Participants' overall rating of their community was assessed with response options ranging from 1 (very poor) to 4 (very good). The threat of being exposed to air pollution, water pollution, soil contamination, and toxic waste was measured by the perceived severity of the threat. Response options ranged from 1 (not at all a health threat) to 4 (very serious health threat). Perception of the environment causing cancer was measured by asking "Do you think the environment plays a major role, minor role, or no role at all in causing cancers?" Response options ranged from 1 (don't know) to 4 (major role). Participants were also asked about personal and family exposures to environmental pollution using the item "Have you or a close family member ever lived in a community where air pollution, water pollution, soil contamination, and/or toxic waste were problems?" Existing environmental problems and their perceived harm to health were also measured. Response options for the latter two items were yes, no, and don't know.

Risk-reducing health behaviors. Fourteen items assessed participants' health behavior and screening practices. These items were adapted from the 2011 BRFSS survey and the 2012 HINTS to assess eight ways to prevent cancer (Dart, Wolin, & Colditz, 2012; CDC, 2012; NCI, 2012). Ten items were selected to measure health behaviors for this study. Smoking habits were assessed by asking "Right now, how often do you smoke cigarettes?" Response options were not at all, some days, and every day. Weight was assessed using the question, "Right now, do you consider yourself to be underweight, about the right weight, or overweight?" Exercise was measured by asking the number of days per week participants engaged in physical activity, which included brisk walking, bicycling, and/or swimming. Response ranged from none to 7 days per week. Alcohol consumption was also assessed according to the number of days per week beer, wine, and liquor was consumed. Overall diet was measured on a 5-point scale ranging from 1 (poor) to 5 (excellent).

Sunscreen use was assessed by asking "When you are outside for more than one hour on a warm, sunny day, how often do you wear sunscreen?" Response options were I do not go out on sunny days, never, rarely, sometimes, often, and always. Prevention of infections such as human papillomavirus (HPV) was measured by asking about ever receiving one of more doses of the vaccine. Due to low response rates among male respondents, this analysis was restricted to female adults (i.e. aged 18-26). Five items on cancer screening behaviors assessed sex-specific and sex-neutral cancer screening. These items asked about a specific cancer screening test and when, if ever, the last one took place. For example, mammography exams were measured using the following item: "A mammogram is an x-ray of each breast to look for breast cancer. When did you have your most recent mammogram, if ever?" Response options ranged from 1 (≤1 year ago), 2 (>1 year to ≤2 years ago), 3 (>2 year to ≤3 years ago), 4 (>3 year to ≤5 years ago), 5 (≥5 years ago), and 6 (never had a mammogram). Similar response options were used to determine Pap testing, prostate-specific antigen (PSA) exam, and colon cancer screening exams (colonoscopy, sigmoidoscopy, or fecal occult blood test).

Data Analysis

Seven hundred eighty-nine surveys were distributed to eligible participants. A total of 424 were collected with a response rate of 54% for paper surveys. The overall response rate for both administration modes is unknown because participants were recruited to complete online and paper surveys via email, word-of-mouth, social media (Facebook), flyers, and a newspaper article. Nineteen surveys were excluded from the final sample because they were either a duplicate survey, completed by a respondent on behalf of another without permission, less than half of the survey was completed, and/or the participant did not reach the end of the survey before it was submitted. The final sample size was 405.

Paper surveys were coded and manually entered into an Excel file. For quality control, all surveys were re-entered into another file for comparison and discovery of data entry errors. Responses from the online survey were downloaded and merged into the quality checked Excel file. All analyses were conducted in SAS version 9.3 (Cary, NC). To establish perceptions of cancer and neighborhood environmental health risk and health behaviors, descriptive statistics, including frequency distributions, measures of central tendency (mean) and measures of variability (standard deviation) were calculated.

Basic inferential statistics (i.e., a chi-square test) were conducted as a preliminary step to more rigorous data analysis. To achieve the second purpose of the study, ordered logistic regressions were estimated to assess the relationship between perceived cancer risk and cancer worry (separately modeled dependent variables) and covariates including SES, perceived neighborhood environment, and risk-reducing health behaviors. Similar analyses were performed to determine whether perceived cancer risk and cancer worry varied by sociodemographic factors (i.e. education, income, sex, and age group).

Results

Characteristics of Respondents

A total of 405 respondents completed the survey. Descriptive characteristics of participants are shown in Table 1. Respondents were 100% Blacks between the age of 18 and 87 (mean age=49), 19% male, and 81% female. Among respondents who reported perceived cancer risk, 37% (n=142) reported lower absolute risk for cancer meaning they believed the likelihood of developing cancer in their lifetime was low. When asked how worried they were about getting cancer, 71% (n=279) of respondents reported some level of worry.

Participants equated their perceived cancer risk and worry to past personal or family experiences and information they received from a medical or health provider. Approximately 18% (n=56) of respondents had no health insurance. Those that reported having health insurance primarily had private health insurance. About 7% (n=27) of respondents were unemployed and 23% (90) were retired. In general, 39% (n=154) reported that they were in very good health, and 43% (n=169) were very confident in their ability to take good care of their health; however, about 12% (n=49) felt their health was fair. The majority of respondents (77%, n=305) reported having a family member that had been diagnosed with cancer. A little over 17% (n=16) of respondents reported having been diagnosed with breast, cervical, colon, or prostate cancer. Of those that reported a disease diagnosis, 48% (n=45) had diabetes.

Participants perceived environmental health risk was based on the state of their community's physical environment. Approximately 47% (n=186) rated their community as a somewhat good place to live. Environmental problems such as air and water pollution, soil contamination, and toxic waste were not considered a current issue. Regardless, 81% (n=323) of respondents were highly concerned about living in a community with environmental problems because it could be harmful to their health. The environment was perceived to play a very important role in causing disease. Specifically, 69% (n=273) thought the environment played a major role in the development of cancers. Thirty-one percent of respondents reported previously residing in or having a family member that lived in a community where environmental problems were an issue. Being exposed to air pollution (78%, n=312), water pollution (83%, n=328), soil (72%, n=286), and toxic waste (84%, n=335) were predominately rated as a very serious health threat by respondents.

Only 16% (n=34) of female respondents reported having a mammography screening within two years, which is the recommended breast cancer screening guideline established by the U.S. Preventive Services Task Force (USPSTF). Less than 7% of women age 21 to 65 reported having a Pap test within the recommended 3 year guideline**.**

Seventy-nine percent (n=38) of male respondents underwent a prostate-specific antigen (PSA) exam less than a year ago, while 6% (n=3) reported never having the exam. Fourteen percent (n=28) of respondents reported that they had never undergone a colon cancer screening exam. Of those that had an exam, 33% were screened within the last year.

Bivariate Analysis

To further explore perceptions of cancer risk and worry, we examined frequencies and interpreted possible differences with chi square measures. We detected no statistically significant association between each dependent variable and sex, age, SES, health insurance, and role of environment in causing cancer (Table 2).

Multivariate Analysis

Of the risk variables examined in association with perceived cancer risk, alcohol consumption (p=0.0308) and colon cancer screening (p=0.0141) were statistically significant. After controlling for other variables in the model (environmental health and SES), non- alcohol consumption and colon cancer screening remained statistically significant. Having a colon cancer screening exam more than three but up to five years ago was associated with low perceptions of cancer risk meaning that individuals that underwent some form of colon cancer screening exam believed their lifetime cancer risk was low. Female respondents perceived their lifetime cancer as low compared to male respondents. Respondents aged 24-44 and 45-64 reported lower lifetime cancer risk than older adults (65+). When other variables (environmental health and SES) were controlled for in the model, we observed no association between perceived cancer risk with sex or with age. Table 3 includes the p-values, odds ratios, and confidence intervals for each significant variable in the full model and after controlling for other variables. We found an association between cancer worry and four covariates: being a smoker, having a fair diet, non-consumption of alcohol, and having had a colon cancer screening test more than one year yet less than two years ago. After controlling for other variables in the model, each of the four health behaviors remained statistically significantly associated with cancer worry (Table 3).

Discussion

A paucity of studies has examined perceived cancer risk among Blacks in environmental justice communities. This study documented Blacks' cancer and environmental health risk perceptions and risk factors associated with cancer as well as examined associations between perceptions and cancer worry and health behaviors. Several studies have demonstrated that Blacks have lower perceptions of cancer risk (Orom et al 2010; Honda & Neugut, 2012). Consistent with other studies, our findings of low perceptions of cancer risk among Blacks parallels those from other non-white groups (Orom et al., 2010; Honda and Neugut, 2012). Previous studies liken low perceptions to a lack of awareness of family history of cancer. We found, however, that Blacks were aware of their risk from family history of cancer. Seventy-six percent of participants knew whether or not a family member had ever been diagnosed with cancer. Respondents who reported a familial diagnosis of cancer also indicated which relative (i.e. parent, sibling, grandparent, or other relative) had been diagnosed. Awareness of one's family history of cancer has implications of risk perceptions whether or not family history of cancer is known.

Additional factors that influenced cancer risk perceptions in this population include past personal and family experiences, the belief that a family member having cancer increases likelihood of getting the disease, and belief that the environment plays a significant role in cancer development. Prior personal and/or family experience with cancer was a determinant of respondents' cancer risk perceptions. These findings correspond with cancer risk perceptions and environmental health risk literature on the differences in risk perceptions between whites and non-whites (Flynn et al 1994; Orom et al 2010; Finucane et al., 2000). Ethnic and cultural differences in the subjective meaning of an event can lead to lower perceived risk or the "downplaying of risk" for some groups (Douglas and Wildavsky 1982). Sharing similar life experiences produces similar ascribing of life occurrences (Pepitone & Triandis, 1988). Study participants self-identified as Black/Black signifying similarities in racial and cultural backgrounds and shared sociocultural life experiences that differ from the experiences of other groups. These experiences influence risk perceptions (Vaughn & Nordenstam, 1991).

Participants' cancer beliefs are associated with their perceptions and how they responded to risks. About 14% of participants felt that cultural beliefs shaped their cancer beliefs. Cultural beliefs and direct and indirect experiences foster ideals on *illness representation* or people's cancer risk perceptions and cancer beliefs (Levanthal et al., 1980; Rees, Fry, & Cull, 2001; Joseph et al., 2009**).**

Although more than half of participants believed a family member's cancer diagnosis influenced their chance of developing cancer, 31% did not ascribe to this belief and 16% were unsure of the association. The fact that so many participants were unaware of the link between cancer risk and family history of cancer suggests that information on the genetic/familial risks of cancer is not equitably reached all populations. Across the lifespan, when compared to whites, Blacks have had less access to preventive messages by the time they become adults (Office of Communications and Public Liaison, 2008; Orom et al. (2010).

Perceived cancer risk (i.e., absolute risk) and cancer worry are positively correlated (Zajac et al., 2006), so we anticipated observing an association between both variables theorizing that they would predict respondents' health behaviors. Being a non-drinker and undergoing a colon cancer screening were the only risk-reducing health behaviors associated with both variables. As a risk factor for cancer, the association between non-alcohol consumption and lower perceived cancer risk makes sense given perceived susceptibility of cancer prompts precautionary health behaviors (Robb, Miles, & Wardle, 2007). Research has shown that Blacks of lower SES, when compared to their non-minority constituents, have misplaced beliefs about risk factors for cancer (Scroggins & Bartley, 1999). Based on our findings, this may hold true regardless of SES especially since only 5% of respondents were classified as low SES. Another reason for these findings could be that respondents made an informed health decision not to engage in a potentially harmful behavior such as drinking alcohol or to engage in a protective health behavior i.e. undergo a cancer screening exam.

With overlapping health disparities in cancer and environmental risks in Metropolitan Charleston, we anticipated finding an association between perceived cancer risk and neighborhood environmental health risks. Although no association was detected between the aforementioned variables, Blacks' cancer and environmental health risk perceptions remained consistent with previous studies (Flynn et al., 1994; Finucane et al., 2000). High perceived environmental health risks among Blacks especially by sex have been well documented. Akin to other studies, Blacks in this sample expressed a high level of concern that living in a community with unhealthy environmental conditions could be harmful to their health. We observed no difference in overall environmental health risk ratings by sex. Male and female respondents reported high environmental health risks for all items. Both groups also perceived that being exposed to environmental conditions such as air and water pollution, soil contamination, and toxic waste was a serious threat to health.

Our results support those of Flynn et al. (1994) and Finucane et al. (2000), however, not those of Gerbi et al. (2011) who found a statistically significant difference between Black male and female perceptions of two environmental health risks (i.e., water quality issues and the association between water and cancer). This study was comparable to Gerbi et al. (2011), in that all respondents were Black, yet our sample included more than two times the number of respondents. In addition, this study inquired about four distinct environmental health risks, which the community and government previously identified as health threats. It is important to note that the majority of respondents did not live in environmental justice communities; however, they were very concerned that living in a community with environmental problems could be harmful to their health. These findings coincide with studies conducted by Flynn et al. (1994) and Finucane et al. (2000). Blacks may have higher environmental risk perceptions because they have less opportunity to "create, manage, control and benefit from many of the major technologies and activities" that whites have, and therefore they are more vulnerable to environmental risks as individuals and a community (Slovic, 1997).

Strengths and Limitations

Cancer disparities do not occur in a vacuum so it important to explore such a topic through an interdisciplinary lens is a more comprehensive approach. Detangling the complexities that contribute to cancer disparities is useful to identify opportunities to eliminate health gaps between and within groups. Using items from pre-existing surveys strengthened and helped to validate some of the associations observed in this study. However, the most important strength is that this work served as a formative step in developing strategies for cancer and environmental health disparities interventions and was conducted with members of the community. The results of this study add to the literature on the overlap in cancer and environmental health disparities especially work on risk perceptions. In addition, it is one of a few studies that have explored perceived cancer risk perceptions among Blacks alone.

Despite the strengths of the study, our findings should be interpreted within context meaning with regards to a group of Blacks in a metropolitan city with both cancer and environmental health disparities and not generalized to the entire Black population. Some limitations of this study include social desirability, non-response error and cross-sectional study design. Using self-report data provides an easy way to collect data and ensures anonymity, but it can lead to biases in the study. Participants were not required to answer all items on the survey, which aided in reducing response bias. Obtaining information on sensitive matters such as cancer and requesting information on prior experiences, events, or encounters at a particular point in time could produce recall bias. A cross-sectional study design limits the ability to determine causal inference, yet it provided a real-time, snapshot of this AA population. Another limitation is that our sample was highly educated and therefore may have been more knowledgeable well informed about the risk factors for cancer.

Conclusion

This study provided a snapshot of risk perceptions among Blacks in a metropolitan area with both environmental and cancer health disparities. From this analysis, we determined that environmental health conditions do not influence perceptions of cancer risk or health behaviors, but Blacks believe that the environment has an impact on health and plays a major role in the development of cancer. We cannot definitely say whether lower cancer risk perceptions among respondents are fostered by non-alcohol consumption and colon cancer screening behaviors, but these data demonstrate that there are segments of the Black population that are making informed health decisions.

These data also suggest that Blacks adults have higher perceptions of environmental health risks regardless to whether they live in a neighborhood with poor environmental quality. Furthermore, this study revealed that factors other than knowledge of a family member's cancer influence perceptions of cancer risk. Personal and community sociocultural, historical and environmental experiences impact Blacks' beliefs about risk and worry about developing cancer. Blacks in Metropolitan Charleston are generally knowledgeable about the contribution that the environment plays in cancer development. Hence, their direct or indirect experiences with cancer and/or the environment, as well as awareness of family history of cancer are viable explanations of their cancer risk perceptions. Examining perceived cancer risks in this population has long- term implications for controlling cancer through preventive action. Future studies should explore the mediating effect cancer risk perceptions have on the relationship between environmental health risks and health behaviors.

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Table 4.1. Descriptive Characteristics of Respondents (n=405)

Dependent variables	*f* (%)
Perceived cancer risk	382
Low	142 (37.2)
Medium	126 (33.0)
High	114 (29.8)
Worry	391
No worry	112 (28.6)
Worried	279 (71.4)
Independent variables	
Age Group	396
18-24	14 (3.5)
25-44	146 (36.9)
45-64	164 (41.4)
65+	72 (18.2)
Sex	398
Male	75 (18.8)
Female	323 (81.2)
Education	396
<HS	20 (5.1)
HS and other training	169 (42.7)
College or more	207 (52.3)
Income	333
$0-9,999	68 (20.4)
$20,000-49,999	151 (45.4)
$50,000+	114 (34.2)
SES	399
Low	23 (5.8)
Medium	169 (42.4)
High	207 (51.9)
Smoking	396
Non Smoker	349 (88.1)
Smoker	47 (11.9)
Physical Activity	399
No Exercise	83 (20.8)
Exercise	316 (79.2)
Diet	400
Poor	19 (4.8)
Fair	78 (19.5)
Good	193 (48.3)
Very good	91 (22.8)
Excellent	19 (4.8)
Weight	398
About the right weight	152 (39.2)
Underweight	11 (2.8)
Overweight	235 (59.1)

Alcohol Use	396
None Drinker	235 (59.3)
Drinker	161 (40.7)
Sunscreen Use	401
No sun exposure	18 (4.5)
No sunscreen	162 (40.4)
Rarely	79 (19.7)
Sometimes	61 (15.2)
Often	40 (10.0)
Always	41 (10.2)

Table 4.2 Bivariate chi square analysis of covariates by perceived cancer risk and cancer worry

Variable	**Perceived cancer risk**					**Cancer Worry**			
	Total N (%)	Low	Medium	High	*p*	Total N (%)	No Worry	Worried	*p*
Sex	378				0.3752	387			0.7468
Male	74 (19.6)	33(44.6)	22 (29.7)	19 (25.7)		73 (18.9)	20 (27.4)	53 (72.6)	
Female	304 (80.4)	109 (35.9)	102 (33.6)	93 (30.6)		314 (81.1)	92 (29.3)	222 (70.7)	
Age	377				0.8171	386			0.0860
18-24	13 (3.4)	5 (38.5)	5 (38.5)	3 (23.1)		13 (3.4)	3 (23.1)	10 (76.9)	
25-44	141 (37.4)	57 (40.4)	44 (31.2)	40 (28.4)		144 (37.3)	52 (36.1)	92 (63.9)	
45-64	158 (41.9)	61 (38.6)	51 (32.3)	46 (29.1)		161 (41.7)	37 (23.0)	124 (77.0)	
65+	65 (17.2)	19 (29.2)	23 (35.4)	23 (35.4)		68 (17.6)	20 (29.4)	48 (70.6)	
SES	377				0.7842	386			0.4724
Low	23 (6.1)	9 (39.1)	7 (30.4)	7 (30.4)		23 (6.0)	4 (17.4)	19 (82.6)	
Medium	157 (41.6)	59 (37.6)	47 (29.9)	51 (32.5)		162 (42.0)	48 (29.6)	114 (70.4)	
High	197 (52.3)	71 (36.0)	71 (36.0)	55 (27.9)		201 (52.1)	56 (27.9)	145 (72.1)	
Health Insurance	297				0.5123	306			0.5501
Yes	244 (82.2)	95 (38.9)	74 (30.3)	75 (30.7)		251 (82.0)	74 (29.5)	177 (70.5)	
No	53 (17.9)	20 (37.7)	20 (37.7)	13 (24.5)		55 (18.0)	14 (25.5)	41 (74.6)	
Environment Causing Cancer	376				0.7244	384			0.6069
Major role	257 (68.4)	95 (37.0)	81 (31.5)	81 (31.5)		264 (68.8)	72 (27.3)	192 (72.7)	
Minor role	76(20.2)	30 (39.5)	26 (34.2)	20 (26.3)		77 (20.1)	22 (28.6)	55 (71.4)	
No role	17 (4.5)	8 (47.1)	5 (29.4)	4 (23.5)		17 (4.4)	6 (35.3)	11 (64.7)	
Don't know	26 (6.91)	8 (30.8)	12 (46.2)	6 (23.1)		26 (6.8)	10 (38.5)	16 (61.5)	

Table 4.3. Multivariate analysis of perceived cancer risk and worry with associated independent variables

Variable	Low perceived cancer risk			Cancer Worry		
	OR	95% CI	*p*	OR	95% CI	*p*
Age						
18-24	0.462	0.11-1.95	0.2925	1.102	0.17-7.10	0.9187
24-44	0.45	0.24-0.85	0.0129*	1.559	0.76-3.21	0.2280
45-64	0.49	0.27-0.90	0.0213*	0.652	0.31-1.37	0.2582
65+ (*ref*)	-	-	-	-	-	-
Sex						
Female	2.02	1.17-3.47	0.0112*	0.845	0.44-1.61	0.6084
Male (*ref*)	-	-	-	-	-	-
Education						
Low	2.24	0.69-7.22	0.1786	0.184	0.02-1.60	0.1249
Medium	1.14	0.73-1.80	0.5624	1.138	0.66-1.96	0.6396
High (*ref*)	-	-	-	-	-	-
Income						
Low	0.862	0.45-1.64	0.6494	1.813	0.87-3.79	0.1139
Medium	0.898	0.56-1.45	0.6616	0.990	0.55-1.79	0.9728
High (*ref*)	-	-	-	-	-	-
[a]Colon cancer screening						
No colonoscopy (*ref*)	-	-	-	-	-	-
<1yr ago	1.11	0.67- 1.83	0.6897	0.859	0.48-1.53	0.6078
1-2 yrs ago	0.75	0.42- 1.35	0.3393	0.394	0.18-0.88	0.0226*
2-3 yrs ago	0.82	0.40- 1.69	0.5855	0.659	0.27-1.59	0.3526
3-5 yrs	0.42	0.21-0.83	0.0127*	0.632	0.27-1.51	0.3008
5+ yrs ago	1.48	0.53-4.16	0.4544	1.040	0.34-3.23	0.9453
Diet						
Poor	0.37	0.11-1.27	0.1143	0.748	0.19-2.92	0.6755
Fair	0.42	0.16-1.11	0.0790	0.29	0.1-0.92	0.0349*
Good	0.55	0.22-1.38	0.2001	0.499	0.18-1.41	0.1899

Very good	0.78	0.30-2.05	0.6166	0.752	0.26-2.20	0.6032
Excellent (*ref*)	-	-	-	-	-	-
HPV						
Yes	1.12	0.63-1.97	0.7053	0.945	0.49- 1.83	0.8668
No (*ref*)	-	-	-	-	-	-
Mammogram						
No mammogram	1.09	0.08-15.67	0.9474	0.273	0.01- 7.09	0.4345
<1yr ago	1.24	0.15-10.57	0.8442	0.729	0.06- 9.03	0.8059
1-2 yrs ago	2.36	0.26-21.55	0.4466	1.493	0.11- 19.51	0.7597
2-3 yrs ago	0.72	0.068-7.69	0.7852	0.424	0.02- 7.82	0.5643
3-5 yrs	0.80	0.07-9.27	0.8606	<0.001	<0.001- >999.99	0.9779
5+ yrs ago (*ref*)	-	-	-	-	-	-
Pap testing						
No mammogram	2.62	0.25-27.96	0.4260	6.302	0.47- 84.97	0.1654
<1yr ago	0.59	0.20-1.70	0.3279	0.771	0.24-2.44	0.6588
1-2 yrs ago	0.77	0.25-2.37	0.6534	0.454	0.13-1.59	0.2175
2-3 yrs ago	0.59	0.15-2.31	0.4517	0.636	0.14-2.87	0.5556
3-5 yrs	0.66	0.15-2.99	0.5927	1.004	0.19-5.36	0.9965
5+ years ago (*ref*)	-	-	-	-	-	-
PSA						
No PSA	>999.99	<0.001- >999.99	0.9610	0.419	<0.001- >999.99	0.9977
<1yr ago	>999.99	<0.001- >999.99	0.9633	>999.999	<0.001- >999.99	0.9662
1-2 yrs ago	>999.99	<0.001- >999.99	0.9628	0.452	<0.001- >999.99	0.9977
2-3 yrs ago (*ref*)	-	-	-	-	-	-
Alcohol consumption						
Non-drinker	1.53	1.04-2.25	0.0302*	2.19	1.34-3.58	0.0018*
Drinker (*ref*)	-	-	-	-	-	-

Smoking						
Non-smoker (*ref*)	-	-	-	-	-	-
Smoker	0.794	0.431-1.461	0.4583	0.34	0.14-0.85	0.0209*
Weight						
About Right						
Underweight	1.225	0.828-1.812	0.3097	1.12	0.70-1.78	0.6439
Overweight (*ref*)	1.099	0.349-3.460	0.8724	1.30	0.31-5.54	0.7195
Physical Activity	-	-	-	-	-	-
No Exercise (*ref*)				1.31	0.76-2.26	0.3357
Exercise	-	-	-	-	-	-
Sun Exposure	0.992	0.622-1.583	0.9740			
Not outside on sunny day						
Never	0.990	0.35-2.82	0.9842	1.410	0.45-4.44	0.5574
Rarely	0.679	0.35-1.33	0.2565	0.500	0.23-1.07	0.0739
Sometimes	0.875	0.42-1.83	0.7224	0.445	0.19-1.04	0.0626
Often	1.399	0.64-3.06	0.3999	0.472	0.19-1.16	0.1033
Always (*ref*)	0.489	0.21-1.16	0.1030	0.616	0.23-1.64	0.3305
Note: *p<.05	-	-	-	-	-	-

4.2 Examining place-based environmental cancer disparities by racial and sociodemographic factors[1]

1Rice, L. J., Emrich, C. T., Brandt, H. M., Annang Ingram, L., Hardin, J. W., & Wilson, S. M. To be submitted to *Health and Place Journal*.

ABSTRACT

The purpose of the study was to analyze and spatially represent environmental cancer risk from 1996-2005 to identify and cancer clusters and hotspots, and to determine if cancer risk and outcomes vary a spatially by racial and socioeconomic characteristics.

Cancer risk from the National-Scale Air Toxics Assessment (NATA) for 1996 to 2005 was georeferenced to census tracts and mapped. Cancer data were joined to environmental justice (percent Black, poverty, and income) variables using Federal Information Processing Standards (FIPS) codes from the Social Vulnerability Index from 2006-2010. Spatial patterns were calculated using both Global and Anselin's Local Moran's I. Correlations analyses were performed in SPSS 22.0.

The Spearman's rho test revealed a statistically significant relationship between cancer risk and five-year incidence (p=.043). No significant relationship was observed between cancer risk and five-year mortality. However, incidence and mortality were significantly correlated with one another (p<.001). Correlations between cancer risk and environmental justice variables were statistically significant (p < .001). A positive relationship between cancer risk and %Black (r=.324) and %poverty (r=.474) was detected. A negative linear association was detected between cancer risk and %income (r=-.542).

Our study provides insight into the geographic distribution of cancer and the need for studies to explore cancer risk across groups and the factors causing cancer risk clusters in Metropolitan Charleston. Findings from this research demonstrate that environmental cancer risk may partially explain cancer disparities in Charleston.

1. Introduction

Cancer is the leading cause of death in South Carolina (South Carolina Community Assessment Network [SCAN], 2013). State five-year death rates for 2006-2010 were 187.6 per 100,000, which exceeded national rates (176.4 per 100,000) during the same time period (National Cancer Institute [NCI], 2014b). Of the 46 counties in SC, ten had a death rate less than or equal to 176.4 per 1000,000, the national average. The remaining thirty-six counties had death rates ranging from 176.6-262.9 per 100,000. Five-year incidence rates in SC only slightly exceed the nation's average at 457.8 compared to 453.7 per 100,000 (NCI, 2014a).

Several factors increase the likelihood of developing cancer including tobacco use, smoking, physical inactivity, poor diet, and environmental factors (NCI, 2014c). Higher cancer outcomes in the state have been linked to disparate exposures to water contamination (Wagner et al., 2011), unequal distribution of noxious facilities (Wilson et al., 2012a; Wilson et al., 2012b; Burwell-Naney et al., 2013; Wilson et al., 2013), socioeconomic factors (Rice et al., 2014), and occupational exposures to asbestos (Elliott et al., 2012).

Two-thirds of all cancer cases and deaths are triggered by environmental factors such as exposure to hazardous pollutants at the neighborhood level (Siegel et al., 2014). Higher rates of cancer risk from hazardous air pollutants have been linked to disparate environmental exposures in communities of color (Apelberg et al., 2005; Linder et al., 2008; Collins et al., 2011; Gilbert & Chakraborty, 2011). Apelberg et al. (2005) found that census tracts with higher cancer risk characteristically had more socioeconomic disadvantage, fewer Non-Hispanic Whites and greater percentages of Blacks. In one of the first national assessments of toxic waste and race, the United Church of Christ [UCC] (1987) demonstrated that demographic characteristics of a community, particularly race and socioeconomic status, were indicators of hazardous waste facility location. Following UCC's report, several studies found more exposure to environmental hazards in poor Black and Hispanic communities (Bullard, 1994; Bullard et al.,2007; Chakraborty & Zandbergen, 2007). In South Carolina there was a shift in the pattern of the population from 1950 to 1990. Mitchell and colleagues (1999) revisited *Dumping in Dixie* (Bullard, 1994) and their findings demonstrated that Whites compared to Blacks and affluent versus economically disadvantaged persons predominated populated areas in close proximity to hazardous waste facilities between 1950s and 1970s. Specifically, proximity to Toxic Release Inventory (TRI) facilities was equitably distributed among low-income and minority populations (Mitchell et al., 1999). By 1990, however, both urban and rural area population demographics and income levels were inverted (Mitchell et al., 1999). A recent study by Wilson et al. (2012a) demonstrated disparities in the distribution of TRI facilities in Charleston by race/ethnicity and socioeconomic position at the block and census-tract level.

The aforementioned disparities have been linked to various diseases including cancer (Morello-Frosch, Pastor, & Sadd, 2001). Blacks in South Carolina experience adverse health outcomes for many cancers and other health conditions (Daguise et al., 2006; Adams et al., 2006; Drake et al., 2006; Herbert et al., 2009). Recent studies identified disparities in the distribution industrial facilities and environmental hazards including of diverse industrial facilities (e.g., underground storage tanks, Toxic Release

Inventory (TRI) facilities, and Superfund sites), particularly in the Charleston area (Wilson et al., 2012a; Burwell-Naney et al., 2013; Wilson et al., 2013; Rice et al., 2014).

The Charleston Metropolitan Statistical Area (MSA), is a highly industrialized area comprised of three counties (Charleston, Berkeley, and Dorchester). The Port of Charleston is one of the top ten busiest ports in the nation moving millions of containers annually (Piperato, 2014). In 2002, the port planned an expansion, which included the potential of overburdening economically underserved communities of color in the northern part of the MSA (Ball, 2006). An environmental impact assessment was conducted per the National Environmental Policy Act (ACT) in 2006 to determine the impact of the expansion in areas with potential environmental justice issues (Ball, 2006). Details of the impact assessment and proposed port expansion in Charleston are described in Wilson, Rice & Fraser-Rahim (2011). The aforementioned environmental health assessment identified 22 environmental justice communities. These predominately Black communities had a large percentage of people of color, individuals living below the federal poverty line, and low-income groups (i.e. > 50%) (Ball, 2006). In Charleston, Black males' rate of cancer likelihood of dying from the disease is higher than White males. In addition, Black men and women die 27% and 11%, respectively, more often than Non-Hispanic Whites (Siegel, Ma, Zou & Jemal, 2014). The Black population leads all racial/ethnic groups in mortality and in SC Blacks are twice as likely to die from cancer as Whites (Siegel, 2014).

Williams and Collins (2001) showed that racial residential segregation fosters socioeconomic inequalities in health at the neighborhood and community level. Dummer (2008) postulated it is the interaction between people and their environment that fundamentally determines their health. To gauge this relationship, health professionals are incorporating unconventional methods such as geographic information systems (GIS) to determine how space and place influence health. In recent years, governmental agencies including the National Cancer Institute have begun using geospatial tools such as exploratory spatial data analysis (ESDA) to identify patterns of cancer and health disparities, to display data and communicate local information to the public (NCI, 2014d). Numerous studies have identified a relationship between the distribution of cancer risk from air toxics with racial and socioeconomic characteristics (Apelberg, et al., 2005; Linder et al., 2008; Collins et al., 2011; Chakraborty, 2012; Rice et al., 2014). Chakraborty (2012) assessed spatial and social disparities in cancer risk exposures. He explored several demographic and socioeconomic variables (proportion of Black, Hispanic population, population over 65, and proportion of persons below poverty line, housing occupancy, and home ownership). He demonstrated that three factors: race, ethnicity, and home ownership predicted cancer risk in Metropolitan Tampa.

To determine whether similar trends exist in Metropolitan Charleston, this study utilized geospatial methods to assess trends in cancer risk using the Environmental Protection Agency's National-Scale Air Toxics Assessment (NATA). The purpose of the study was to map environmental cancer risk from 1996-2005, identify cancer clusters, and determine whether cancer risk and outcomes vary geographically by racial and socioeconomic characteristics.

2. Methods

2.1 Study area

The study was conducted in the Charleston Metropolitan Statistical Area, which is the second largest MSA in South Carolina and 79th largest in the U.S. (South Carolina Department of Commerce, 2011; U.S. Census Bureau, 2012a). The South Carolina Ports Authority (SCPA) is located in Charleston, SC. The Port of Charleston is the eighth busiest port in the U.S. (Piperato, 2014). In 2013, 1.55 million Twenty-Foot-Equivalent Units (TEUs) were moved by the port (Piperato, 2014). An expansion of the port was planned for 2012. One of the potential expansion sites included North Charleston (Ball, 2006).

The estimated total population in Charleston MSA is 664,607 (U.S. Census Bureau, 2014a). The racial and ethnic composition of the Charleston MSA in 2011 was 68.6% White, 25.4% Black, 2.9% Hispanic/Latino, 1.6% Asian, 0.2% American Indian/Alaska Native, and 0.1% Native Hawaiian/Pacific Islanders (U.S. Census Bureau, 2014a). The majority of Blacks in Charleston reside in the City of North Charleston, which has a population of 99,727, of which 47.2% were Black (U.S. Census Bureau, 2014b).

2.2 Data sources

This study involved analysis of secondary data. Twenty-seven demographic variables from the Social Vulnerability Index (SoVI®) derived from 2010 U.S. Decennial Census and American Community Survey for 2006-2010 data from the Hazards and Vulnerability Research Institute (HVRI) at the University of South Carolina were used (Hazards and Vulnerability Institute [HVRI], 2014). Total cancer risk data from the U.S. Environmental Protection Agency's (EPA) National-Scale Air Toxics Assessment (NATA) for 1996, 1999, 2002, and 2005(U.S. EPA, 2013) were used to map patterns of cancer risk across Metropolitan Charleston. Cancer incidence and mortality data were retrieved from the South Cancer Central Cancer Registry (South Carolina Community Assessment Network [SCAN], 2013) for corresponding years of SoVI® and NATA data.

2.3 Measures

2.3.1 Cancer risk. Total lifetime cancer risk estimates (risk from all pollutants) at the census tract level were retrieved from the EPA. Cancer risk, as defined by the EPA, is the probability of developing cancer over the course of a lifetime (assumed to be 70 years) (U.S. EPA, 2013). Total cancer risk comprises major stationary sources (e.g., large waste incinerators and factories); area and other sources (e.g., dry cleaners, small manufacturers); and both on-road and non-road mobile sources (e.g., cars, trucks, boats) (U.S. EPA, 2013). Cancer risk estimates are derived from concentrations of exposure and standard inhalation concentrations and represent the people per million (people/million) at risk of developing cancer (U.S. EPA, 2013). Cancer risk is estimated based on being exposed 24hour/7days a week exposure (U.S. EPA, 2013). Natural breaks in the data were used to classify cancer risk as low, medium, and high. Risk levels were defined classified using three categories: low, medium, high. The three levels were defined using standard deviations High cancer risk was defined according the highest category after data were reclassified using a standard deviation for the three levels.

2.3.2 Cancer incidence and cancer mortality. Cancer incidence is the number of new cases diagnosed during a specific time period (one year) (National Cancer Institute [NCI], 2013a). Cancer mortality is the number of deaths occurring during a specific time period (NCI, 2013b). The SCCCR has a case ascertainment rate of 95% of cancer cases in South Carolina.

2.3.3 Environmental justice. Federal regulations require actions to address environmental justice in minority populations and low-income populations (Clinton, 1994). Specifically, the National Environmental Policy Act (NEPA) requires an analysis of the environmental effects on human health, socioeconomic factors, and federal actions on minority and low-income communities (Clinton, 1994). Similar to NEPA's required environmental justice analysis performed by the South Carolina Department of Health and Environmental Control (SCDHEC) (Ball, 2006); three variables (percent poverty, percent Black, and percent low-income) were used to define environmental justice status in Metropolitan Charleston. The environmental justice threshold value for each variable by census tract was 50%.

The percent of persons living at or below the poverty line is represented by percent poverty from U.S. Census Bureau and standardized by for the SoVI® (HVRI, 2005; U.S. Census Bureau, 2014a). The census definition of poverty "uses a set of money income thresholds that vary by family size and composition to determine who is in poverty. If a family's total income is less than the family's threshold, then that family and every individual it in is considered in poverty" (U.S. Census Bureau, 2014c). Per capita income was used as proxy for the environmental justice variable percent low-income. Income data were retrieved from the U.S. Census Bureau and standardized for the SoVI® (HVRI, 2005; U.S Census Bureau, 2014d). Percent Black was measured using the 2010 U.S. Census Bureau Decennial Census estimates of the Black population standardized for SoVI® (HVRI, 2005). Each of the environmental justice variables were mapped by census tract using standard deviations classified as low, medium, and high.

2.4 Data analysis

All spatial data analyses were performed in ArcGIS 10.2 (ESRI). To indicate the extent of variability from the mean, data were classified using standard deviations. Bivariate associations were classified as low, medium, and high. To explore spatial relationships in the distribution of cancer risk at the census tract level, a Global Moran's Index (Moran's I) statistic was used to measure spatial autocorrelation (Moran, 1950) across metropolitan Charleston. Anselin Local Moran's I (Anselin, 1995) was used to identify and map spatial clusters and outliers of cancer risk at the census tract level. The Moran's I statistic ranges from -1.0 (negative spatial autocorrelation) to 1.0 (positive spatial autocorrelation). Values closer to 1 demonstrate spatial clustering. SPSS 22.0 was used to determine the relationship between each cancer variable (risk, incidence, and mortality) and variables used to define environmental justice populations i.e. poverty, income, and minority status. Percent Black was used as a proxy for minority status. Bivariate choropleth maps were used to represented the geographic associations between cancer data and environmental justice variables.

3. Results

3.1 Total cancer risk

Patterns of cancer risk varied across Metropolitan Charleston from 1996 to 2005. The lowest and highest risk levels were observed in 1996. High cancer risk in 1996 was >56.9 people per million (people/million).-. Low cancer risk (20.8-29 people/million) was greatest in 2002 (n-72 tracts). From 1996 to 1999 the number of census tracts with high cancer risk increased by 6% from 8 people/million to 15 people/million. In 2002, only 4% (n=5) of census tracts were identified as high risk (>42 people/million). Fewer low cancer risk census tracts were observed in the 2005. The number of high risk tracts increased by 12% (i.e. 5 people/million to 19 people/million) from 2002 to 2005.

The mean estimated risk score in 1996 was 41 people/million of equally exposed people. Risk levels in subsequent years decreased. Respectively, in 1999 and 2002, mean cancer risk was approximately 32 and 29 people/million. In 2005, however, cancer risk was lower than 1996 yet higher than 1999 and 2002 at 38people/million. In the first assessment year (1996), 62% of census tracts had a risk level ranging from 35-57 people/million, which was equivalent to medium risk for that year. Only 7 tracts in the first assessment year had high cancer risk levels (≥57 people/million). Patterns of cancer risk in 1999 were similar to patterns in 1996 in that approximately 46% (n=51) of the tracts had medium risk. The lowest level of risk for that year was 18 people/million. Figures 4.4 through 4.7 depict risk scores for each year NATA were performed.

All four maps display the estimated total cancer risk as low, medium, and high risk levels by NATA year. Overall, there was less variation in cancer risk in 1999, 2002, and 2005 compared to 1996. Risk levels in later years were as low as 17.8 people/million in 1999 to 26.3 people/million in 2005 and up to 54.4 people/million in 1999 to 66.3 people/million in 2002.

3.2 Spatial patterns of cancer

After assessing trends in cancer risk for each year, a Global Moran's I statistic was performed on the entire metropolitan area to identify patterns of spatial autocorrelation. For 1996, 1999, 2002, and 2005, total cancer risk across the metropolitan statistical area (MSA) was spatially clustered ($p<.001$). All z-scores were positive indicating a non-random distribution of cancer risk. There was less than a 1% chance that the spatial pattern observed in cancer risk in Charleston MSA was by chance. Values of cancer risk tended to cluster spatially meaning (high values clustered near other high values and low values clustered near other low values) across Charleston MSA. For each year assessed, Moran's I values were above 0 (0.27, 0.43, 0.33, and 0.28, respectively) indicating strong spatial autocorrelation for each year (Table 4.4). Based on these results, the null hypothesis that cancer risk is randomly distributed was rejected. In addition, z scores for each year fell outside the normal range (-1.96 and +1.96) suggesting the spatial pattern of risk exhibited was too unusual to be just random chance, which is also reflected in the small p-value ($p<.001$). For each census tract, spatial autocorrelation was also measured using the Anselin Local Moran's I. Local measures revealed high-high clustering in the southeastern part of the MSA for each NATA year.

3.3 Sociodemographic factors

The percent of Black population, poverty, and income were assessed to determine areas with high levels of environmental justice and simultaneously high cancer risk. The highest percent of Blacks in Metropolitan Charleston was observed along Interstate 526 in the central part of the metropolitan area. The percent of Blacks in each census tract ranged from <1 to 92% with a mean percent of 29. There were 27 census tracts where the percentage of Blacks exceeded 50% of the tract. Less than 20% of census tracts had high cancer risk and a simultaneously higher percentage of Blacks. The number of census tracts (n=9) with both a high percent of Blacks and high cancer incidence was equal to the number of tracts with low percent of Blacks and low cancer incidence was equivalent. Only three out of 156 tracts percentage of poverty was greater than or equal to 50%. Poverty when compared to percent income and percent Black had the most tracts (n=25) where high and low cancer risk overlapped with the corresponding level of risk. The number of census tracts with high cancer mortality counts and higher percentages of Black was twice as high as the number of tracts with low percent Black and low mortality count. Greater levels of poverty were observed inland near the cities of North Charleston and Charleston. The percent of high and low poverty census tracts and overlapping high and low cancer incidence and mortality counts were similar. A total of seven tracts had high poverty and high incidence and six tracts had low incidence and low poverty.

Per capita income was used to determine the level of income by census tract. Low-income tracts were those with an income level less than or equal to $24,506. A total of 85 tracts were identified as low income. Middle income levels appeared to cluster along the coast line in Mount Pleasant, Charleston and north of Interstate 526 going toward Summerville. Nine census tracts had higher income levels ($47,914-$85,585). High income and high cancer incidence had one tract more that the number of tracts with low income and low incidence counts.

A Spearman's rank-order correlation was run to determine the relationship between cancer risk, cancer incidence, and cancer mortality and individual environmental justice variable. There was a weak, positive correlation between cancer risk and percent Black. As cancer risk increased, percent Black increased. A moderate, positive correlation between cancer risk and percent poverty was observed demonstrating greater level of poverty in areas with higher cancer risk. In addition, a moderate, negative correlation between cancer risk and percent income was identified suggesting greater socioeconomic disadvantage where cancer risk is higher. Each of the aforementioned correlations was statistically significant ($p < .001$).

Bivariate maps of cancer risk from 2005 and five-year cancer incidence and cancer mortality counts in Charleston MSA by percent Black, poverty, and income are illustrated in Figures 4.12-4.19. Of the three environmental justice variables, 16.2% (n=19) of census tracts had both high cancer risk and a high percent Black population. An equal number of census tracts (n=18) had high cancer risk and low percent income or high percent poverty. When assessed with all three variables, cancer risk appeared to cluster south of the central part of Metropolitan Charleston (Figures 4.12-4.14). Census tracts with 16 or more cancer cases or deaths (cut off for SCDHEC) were mapped to identify areas with either high incidence or mortality and high percent Black, high percent poverty, and low percent income. From the bivariate analysis, the number of tracts of cancer incidence and mortality was relatively lower than cancer risk bivariate assessments. Less than one percent of tracts were identified as having high cancer incidence and high percent poverty (n=1). High risk tracts with low percent income (n=3) and high percent Black (n=5) represented less than 4% of the tracts. There were no high mortality, high poverty tracts, less than 2% were high mortality, low percent income, and 5% (n=6) were high mortality, high percent Black.

The correlation between lifetime cancer risk and incidence and mortality was also assessed. The correlation analysis revealed a statistically significant correlation between cancer risk and five-year incidence (p=.043). No significant relationship was observed between cancer risk and five-year mortality. However, incidence and mortality were significantly correlated with one another ($p<.001$). A statistically significant relationship ($p<.001$) between cancer risk and individual environmental justice variables (%Black, %poverty, and %income) was identified. The effect size of the relationship between cancer risk and environmental justice variables was small (Cohen, 1988). Ten percent of the variance in cancer risk was explain by the percent of Blacks (r=.324) in the census tract. Up to 29% of the variance in cancer risk could be explained by percent poverty (r=-.542) and 22% of the variance was accounted for by the percent of income (r=.474).

4. Discussion

In this study, we geographically assessed environmental cancer risk, explored potential clusters, and examined the relationship between cancer and the distribution of sociodemographic factors in Metropolitan Charleston. The majority of cancer risk from 1996-2005 in the metropolitan area followed the same pattern. Low, medium, and high risk census tracts were adjacent to tracts with similar corresponding scores for each assessment year (e.g., high-risk census tracts next to high-risk census tracts). The highest level of risk was observed in the initial year of the assessment, 1996. This may be due to changes in the number and type of air pollutants assessed each year or an increase in the number of census tracts from 1990 to 2000. The number of pollutants assessed by the EPA from 1996 to 1999 increased and so did the number of census tracts in the decennial census from 1990 to 2000 (U. S. EPA, 2013, U.S. Census Bureau, 2014). Both changes could have had an effect on the projected total cancer risk because creating new boundaries would either increase or decrease the number of people in old tracts.

Adding more pollutants to the NATA data likely decreased the overall total lifetime cancer risk by accounting for more chemicals than initially assessed. Although we did not observe a consistent pattern of cancer risk across the years, most of the variation in risk was observed in the first year. Risk trends in 1996 showed more variability with levels ranging from zero (no risk) to 107 people/million (high risk) in some tracts. Risk levels for all other years, on the other hand, displayed limited variability. Our findings make sense given that cancer incidence and mortality rates have been steadily declining since the 1990s (Edwards et al., 2014).

The geographic analysis identified clusters of cancer risk in Metropolitan Charleston from 1996 to 2005. The highest cancer risk was identified in the first assessment year. A year after the initial assessment, the SCDHEC reported clustering of pleural cancer in Charleston County, which is the largest of the three counties in the Charleston MSA. The causes of the cancers were unknown, however, occupational exposures at the local Naval Shipyard was offered as a plausible explanation. Data from the SC Central Cancer Registry revealed an increase in both cancer incidence and mortality rates in Charleston County in the years following the shipyard cancer clusters. Naval Shipyard census tracts are not only located in North Charleston, but risk levels of the tracts were mostly medium risk between 1996 and 1999.

A barrier to continuing the national trend of declining cancer rates is persistent disparities in cancer outcomes that have proven detrimental to the health of certain groups. Risk factors, including differential exposure to pollutants, account for tens of thousands of cancer deaths in the U.S. (Siegel et al., 2014). With less emphasis being placed on the environment's influence on cancer, more underserved groups including persons of color and economically disadvantaged groups bare most of the cancer burden. We used the latest year of NATA cancer risk with sociodemographic factors from 2006-2010. As the percentage of the Black population and poverty increased, cancer risk increased. These findings are consistent with prior studies that demonstrated cancer risk from ambient air toxics by census tract in metropolitan areas with more persons from racial/ethnic groups and with fewer socioeconomic us experience higher lifetime cancer risk from air toxics (Apelberg, et al., 2005; Collins et al., 2011; Linder et al., 2008; Rice et al., 2014).

We observed a positive association between percent Black population and cancer risk. Our findings indicated that Blacks and people with high poverty in Charleston MSA were more likely to be exposed to hazardous air pollutants and reside in a census tract with high cancer risk. Income was negatively associated with cancer risk and the percent of persons living in poverty was positively associated with cancer risk. These coincide with Bullard and colleagues (2007) findings that high poverty areas have less economic resources and therefore play host to facilities that emit harmful substances including NATA air pollutants. In this study, poverty explained the majority of cancer risk, which suggests that cancer risk goes beyond race and ethnicity; it is driven by greater socioeconomic circumstances. In other words, those who have less access to resources such as job opportunities and quality education have more risk. These findings support Siegel, Ward, Brawley and Jemal's (2011) report that poverty is a potent carcinogen contributing more to risk than tobacco and obesity issues.

As income level decreased, the number of people per million at risk for cancer risk increased. These findings align with other studies including Evans and Kantrowitz (2002) that demonstrated that socioeconomic resources determine health outcomes and environmental risk factors. Percent Black, poverty, and low-income are variables used to determine whether a neighborhood is an environmental justice community or not. In metropolitan Charleston, there are twenty-two such communities many of which are located in North Charleston (Ball, 2006). We observed cancer risk hot spots in and around this area for each year NATA was assessed.

5. Conclusion

In this study, we found evidence of place-based environmental cancer risk by race and socioeconomic position. As the percent of Blacks increased, the number of people at risk for cancer also increased. Our assessment provides insight into the geographic distribution of cancer and helped to identify census tracts with cancer risk clusters as well as statistically significant cancer risk hot spots. Also, we found evidence of an association between cancer risk from environmental pollutants and five-year cancer incidence suggesting environmental exposures are an important contributor of cancer risk in certain areas. Future studies should explore cancer risk across groups and the factors causing cancer risk clusters. We believe our findings have implications for reducing place-based environmental cancer disparities and developing policies to reduce environmental and cancer burden in underserved and economically disadvantaged groups.

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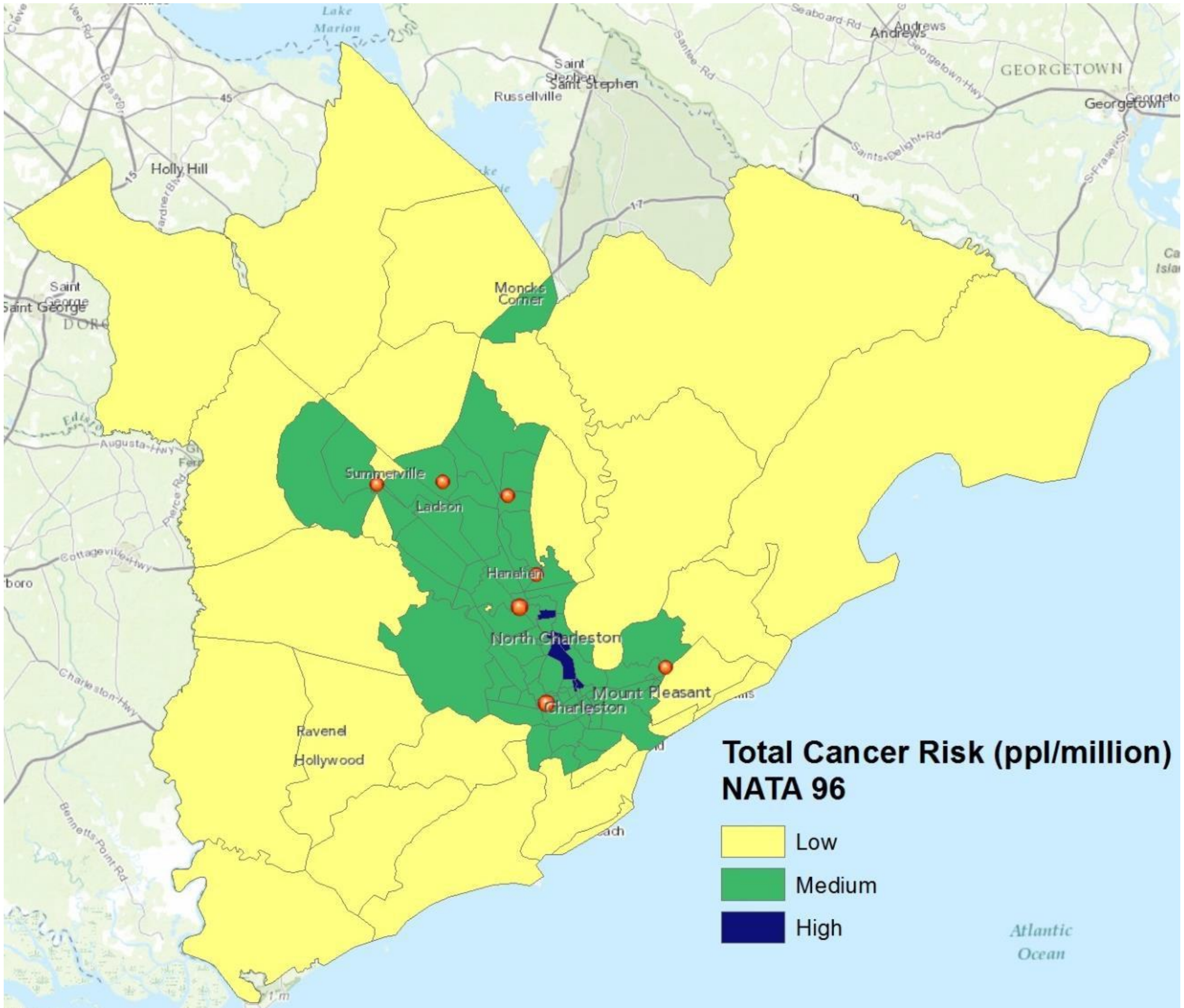

Figure 4.4 Total Cancer Risk in Metropolitan Charleston, 1996

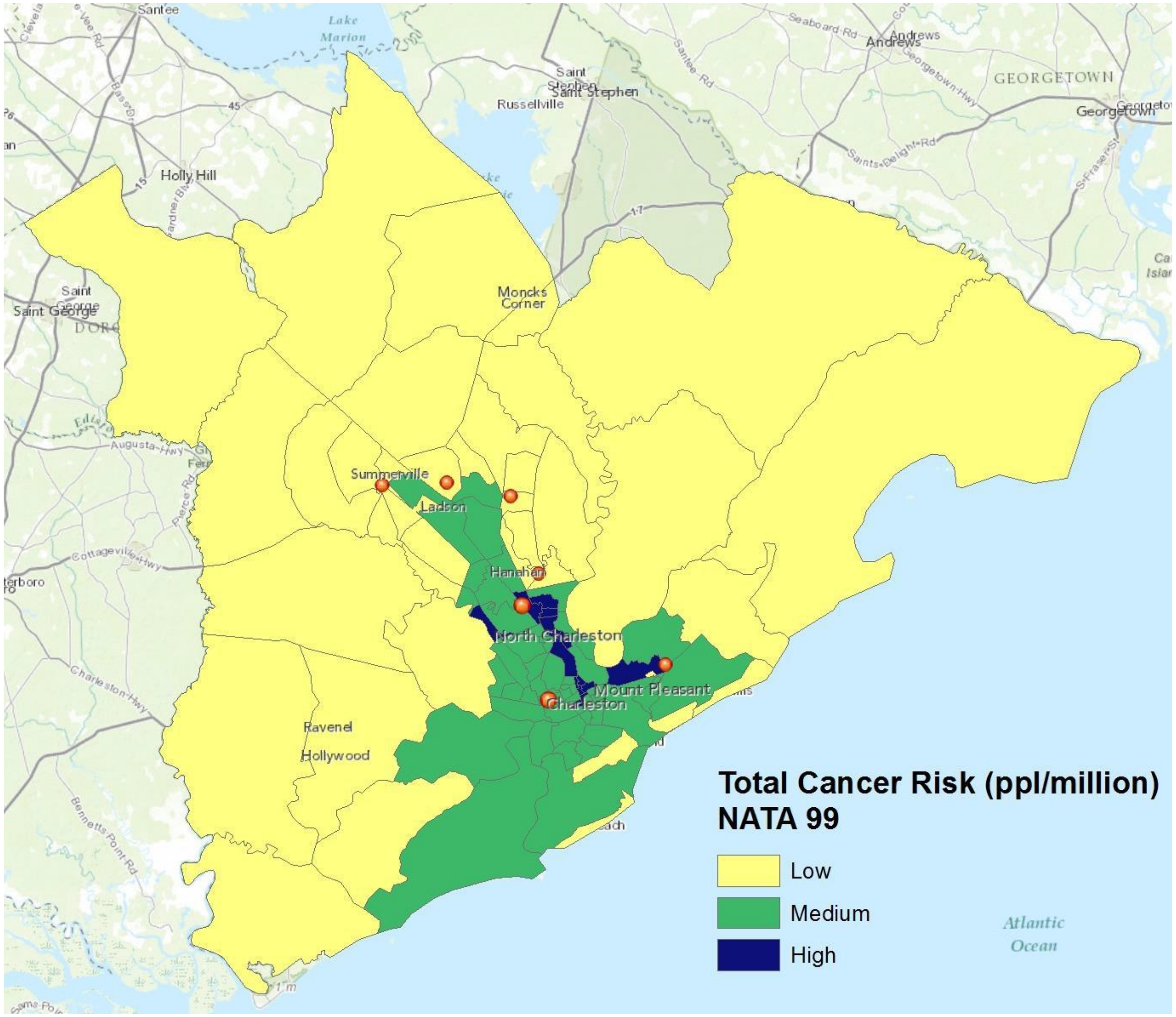

Figure 4.5 Total Cancer Risk in Metropolitan Charleston, 1999

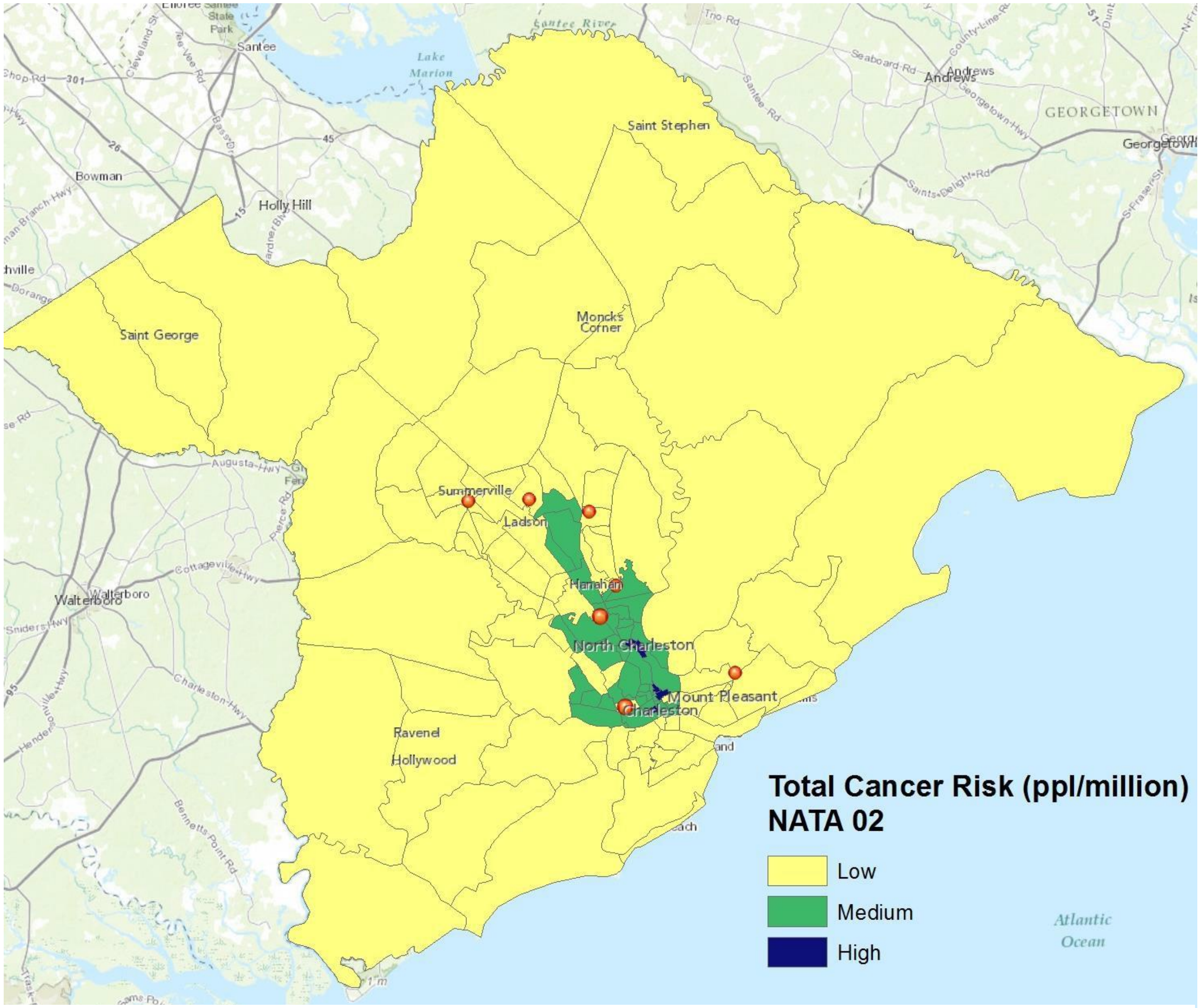

Figure 4.6 Total Cancer Risk in Metropolitan Charleston, 2002

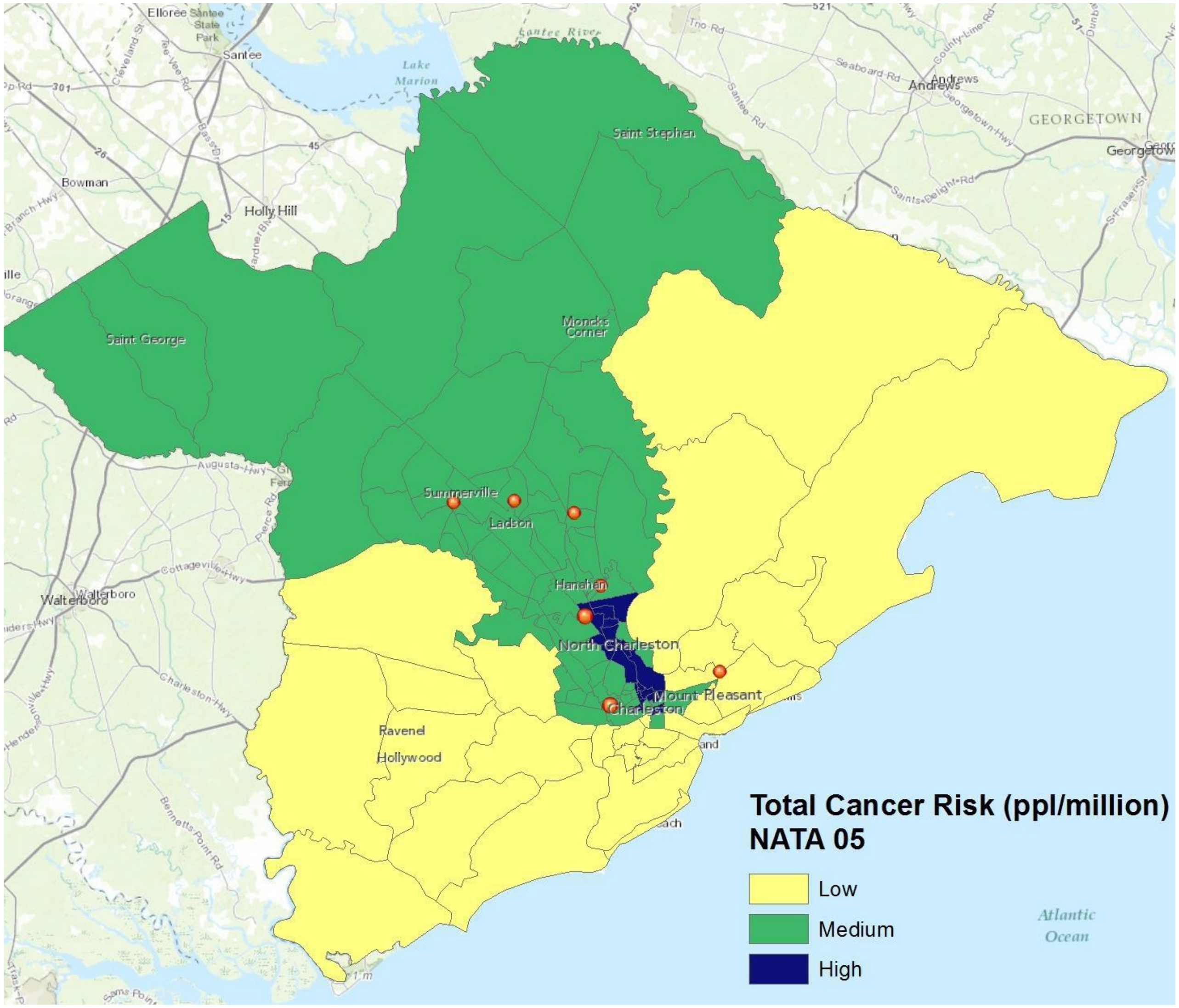

Figure 4.7 Total Cancer Risk in Metropolitan Charleston, 2005

Table 4.4. Spatial autocorrelation by NATA year

Year	Global Moran's I	*p*-value	z-score
1996	0.27	0.000000	16.02
1999	0.43	0.000000	24.37
2002	0.33	0.000000	19.28
2005	0.28	0.000000	16.50

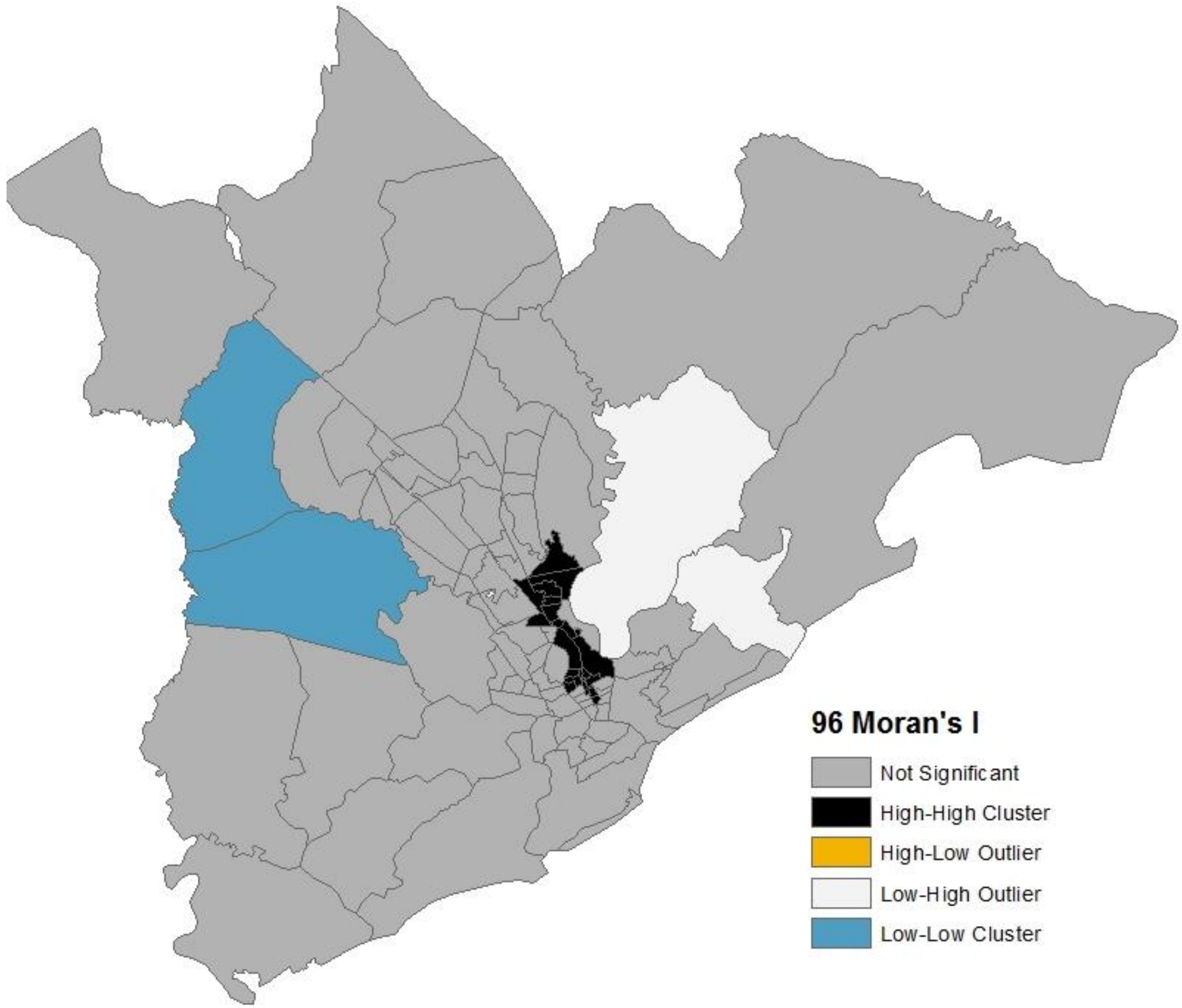

Figure 4.8 Total Cancer Risk in Metropolitan Charleston Local Moran’s I, 1996

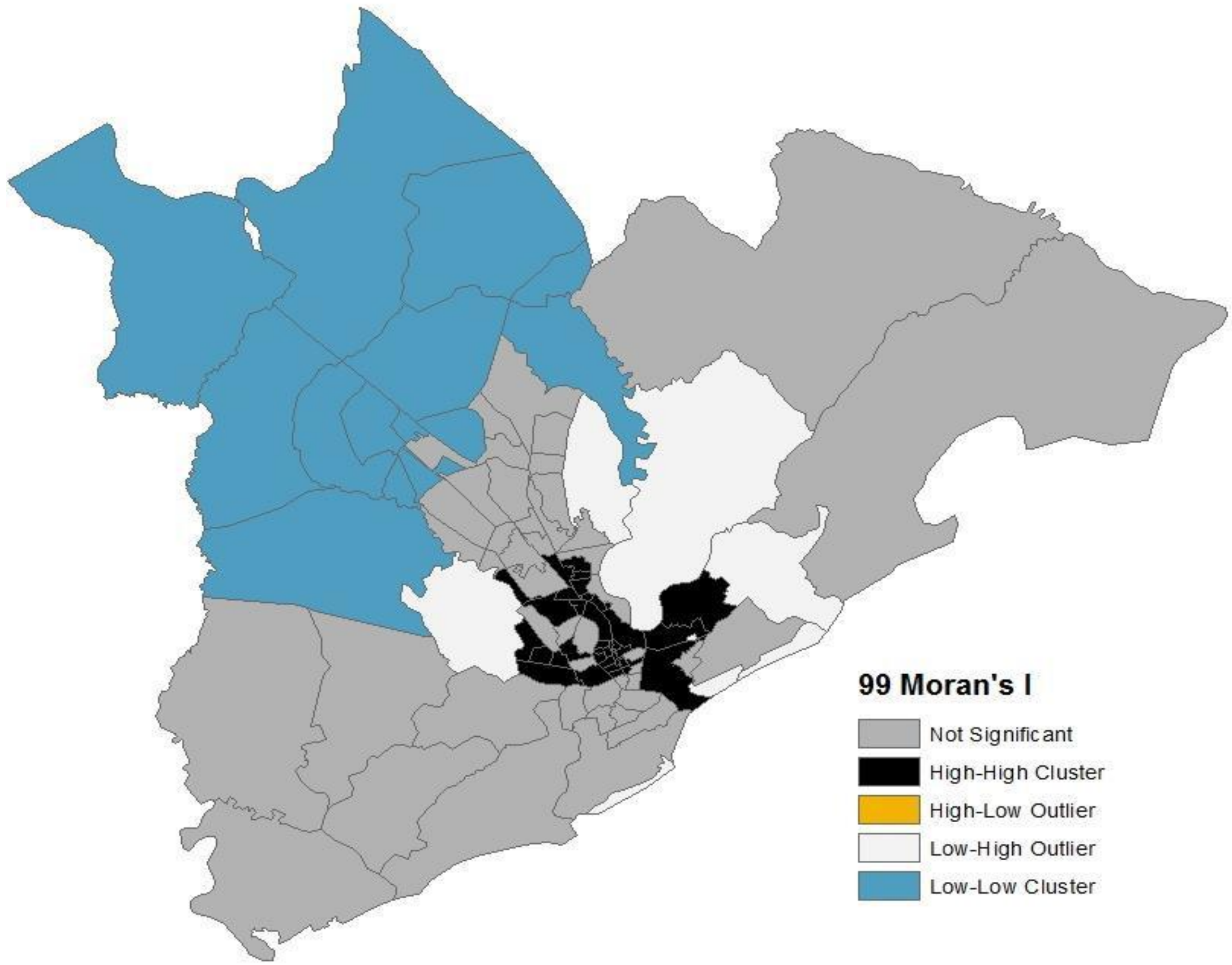

Figure 4.9 Total Cancer Risk in Metropolitan Charleston Local Moran's I, 1999

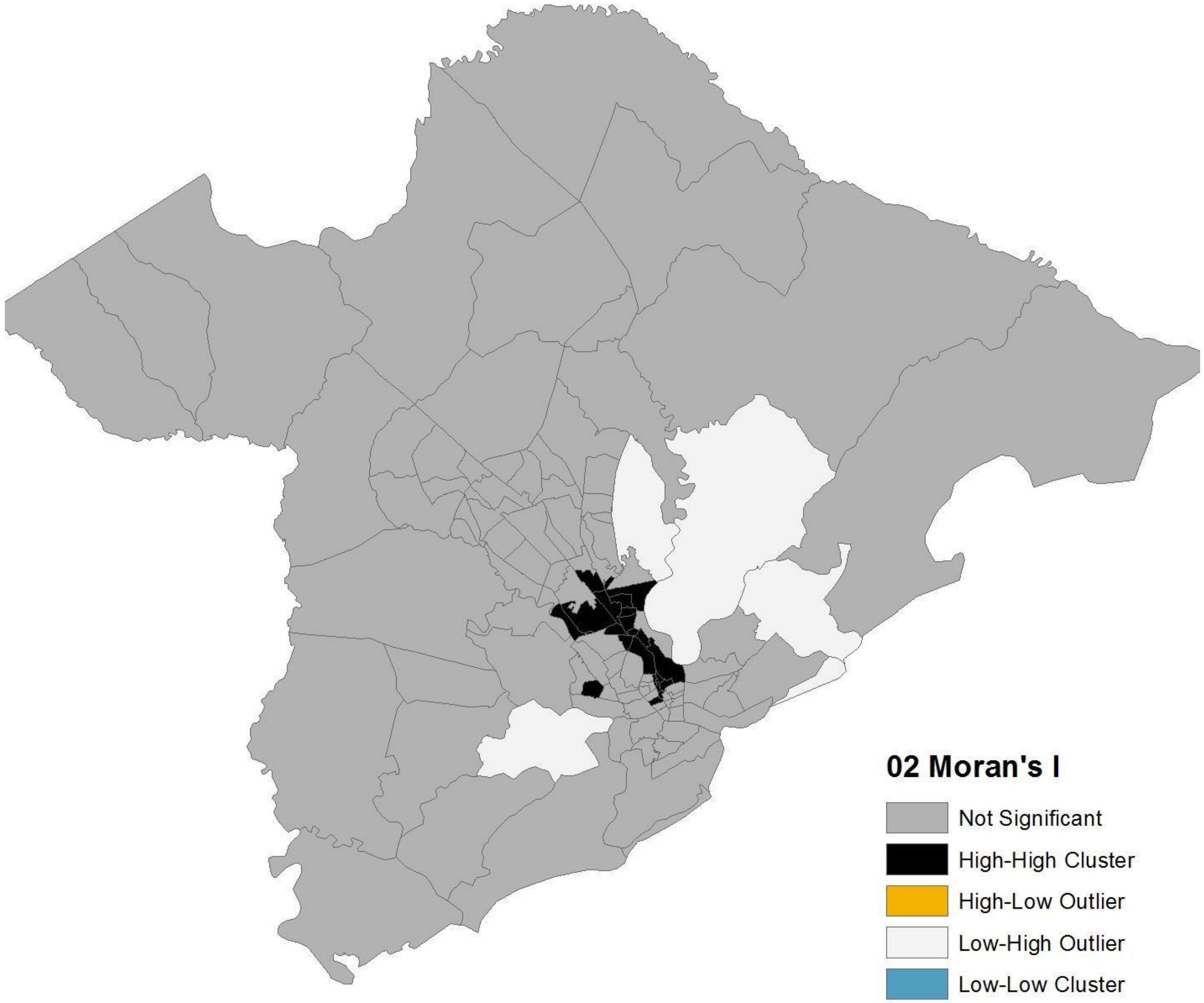

Figure 4.10 Total Cancer Risk in Metropolitan Charleston Local Moran’s I, 2002

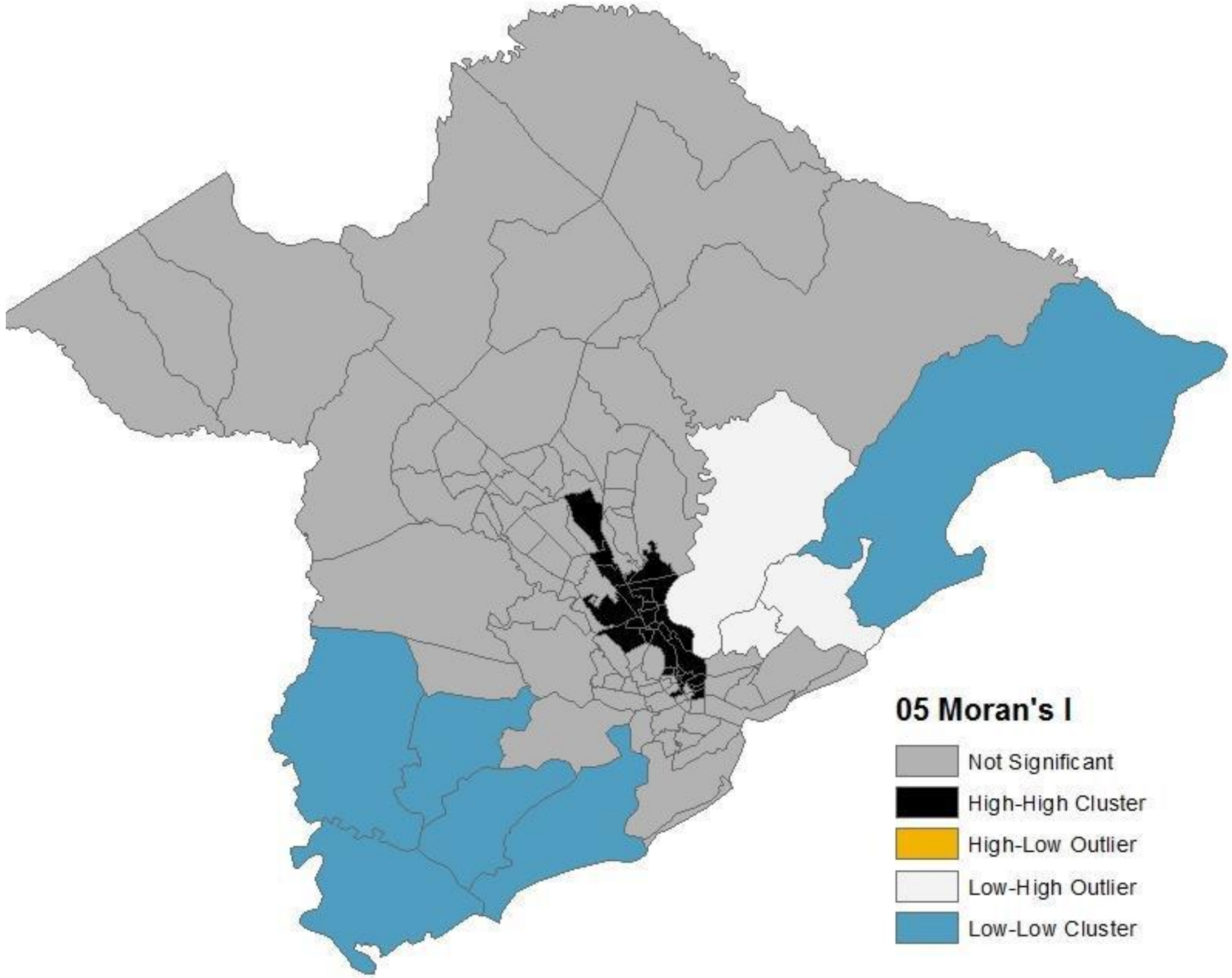

Figure 4.11 Total Cancer Risk in Metropolitan Charleston using Local Moran's I, 2005

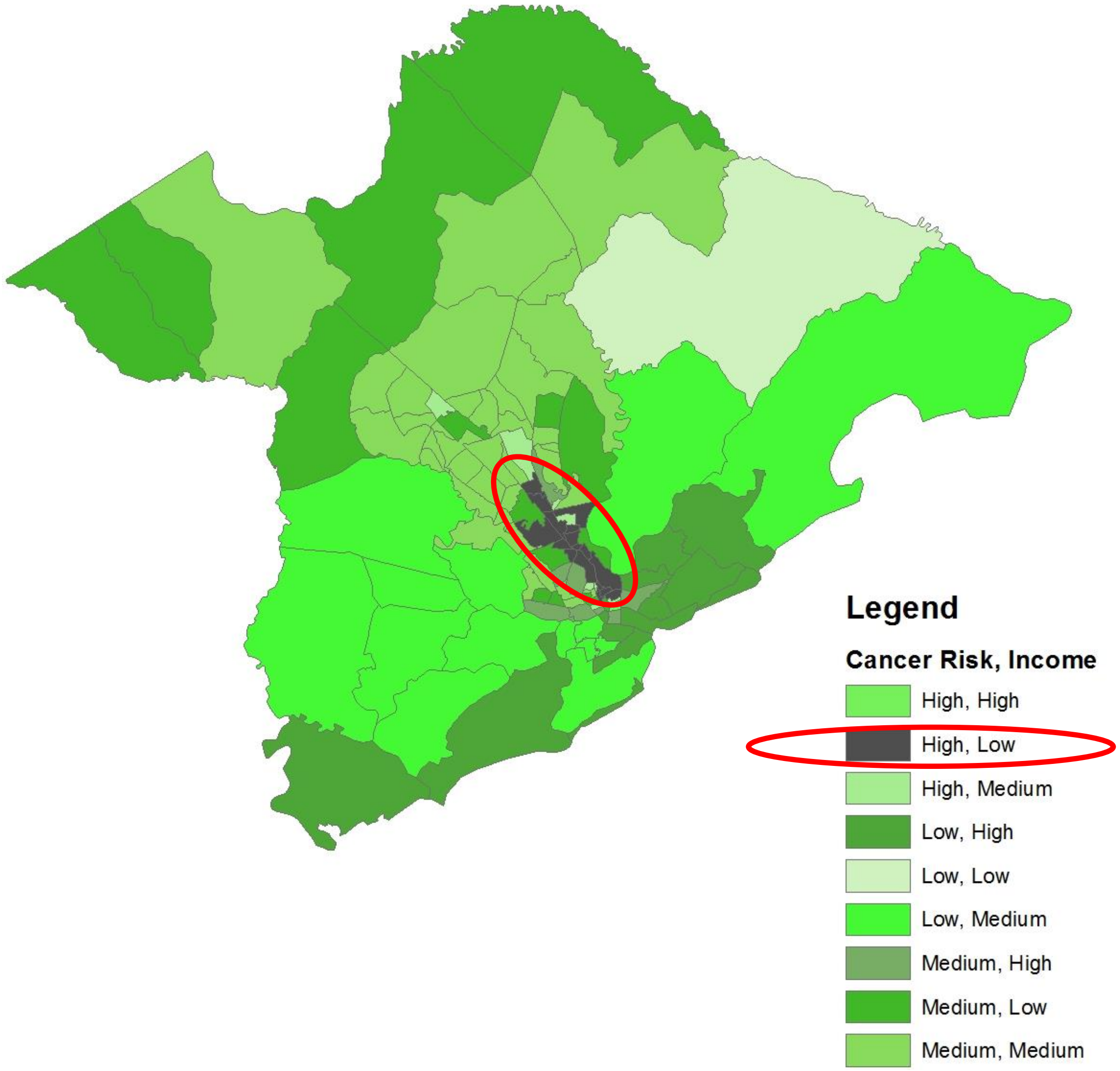

Figure 4.12 Total Cancer Risk in Charleston MSA by Percent Income

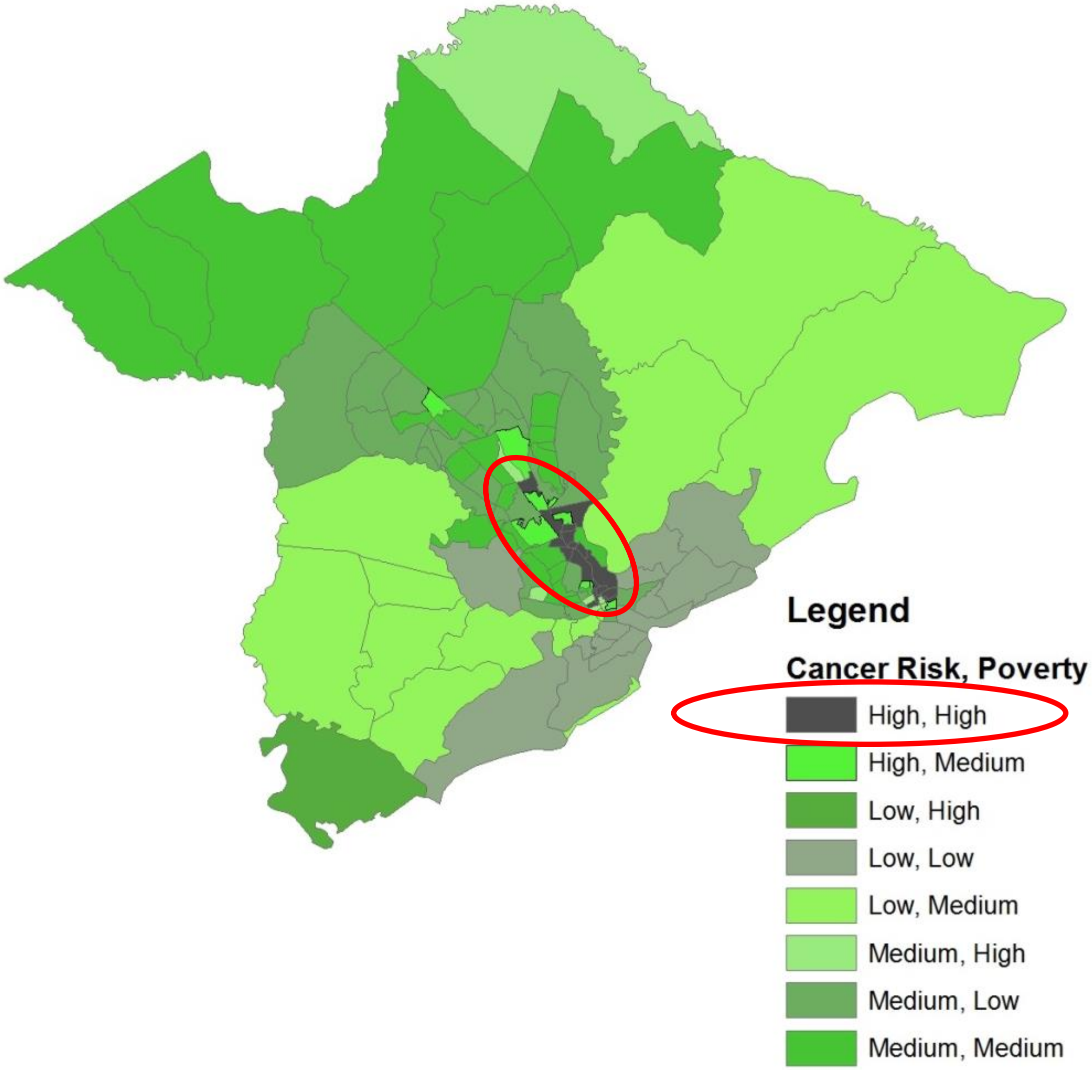

Figure 4.13 Total Cancer Risk in Charleston MSA by Percent Poverty

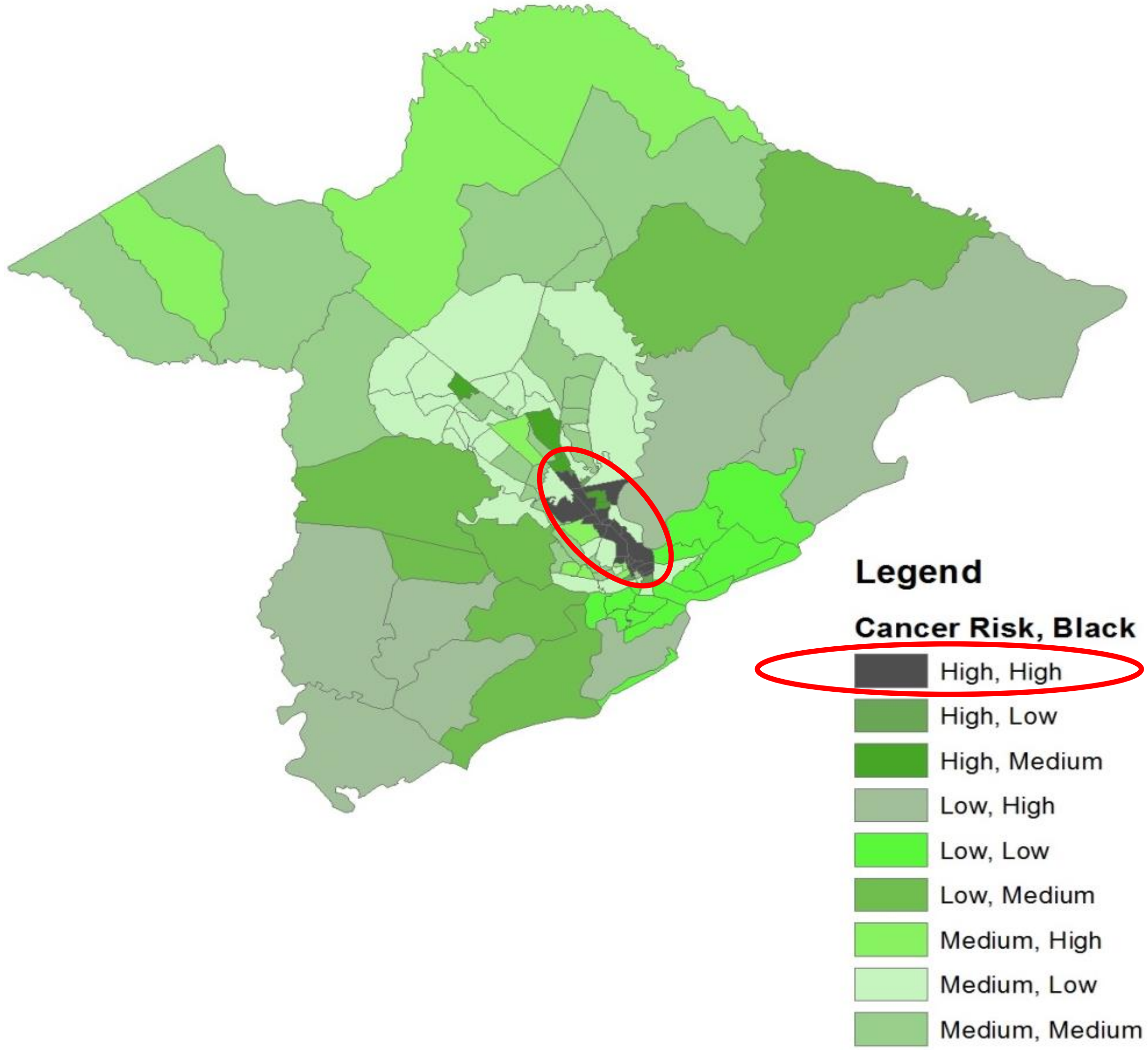

Figure 4.14 Total Cancer Risk in Charleston MSA by Percent Black

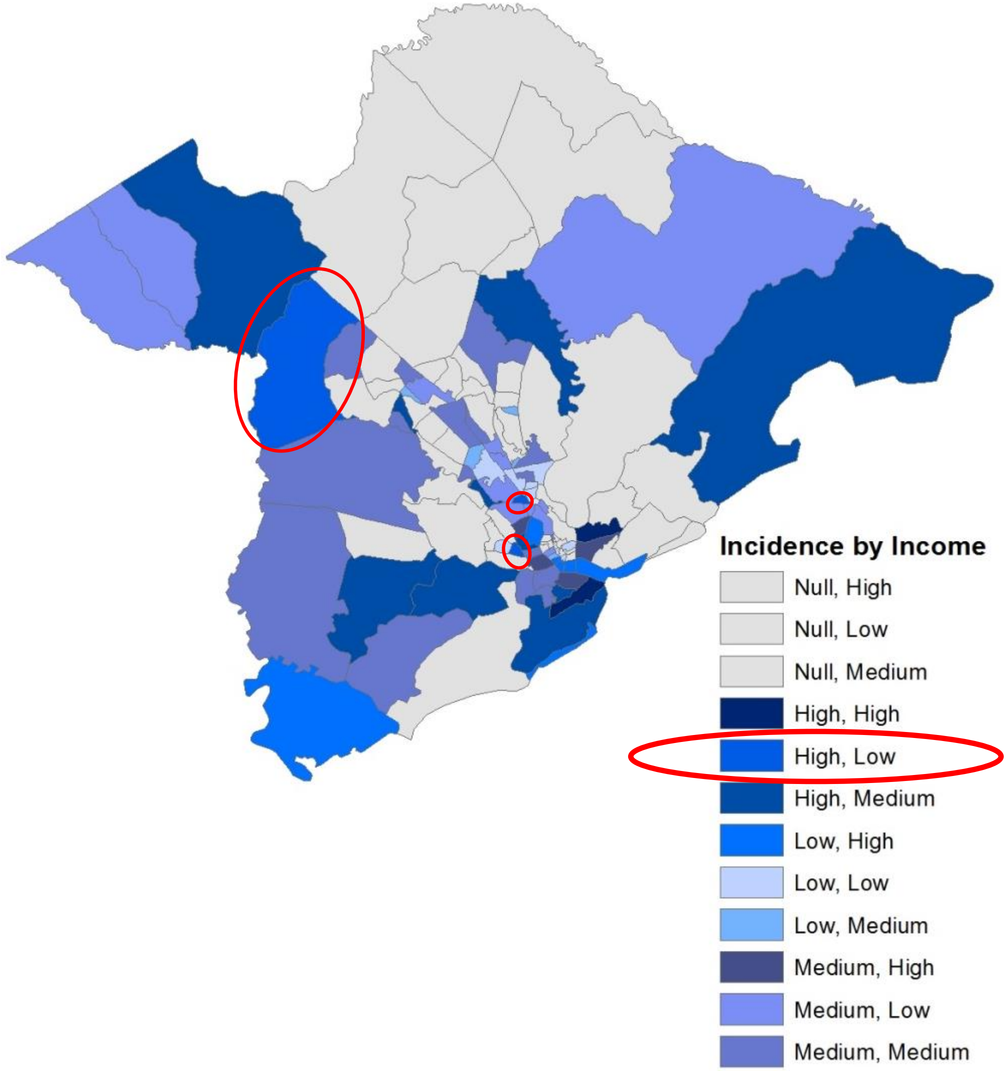

Figure 4.15 Total Cancer Incidence in Charleston MSA by Percent Income

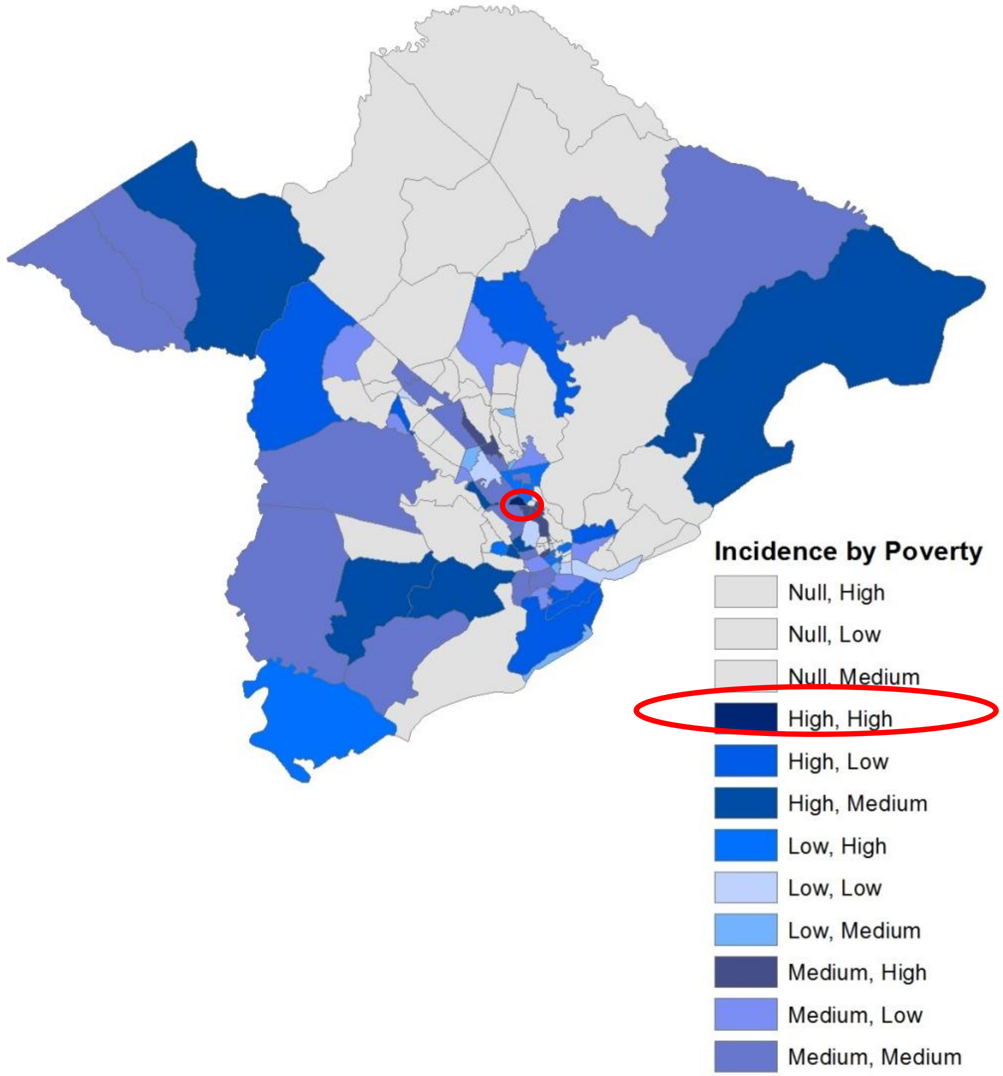

Figure 4.16 Total Cancer Incidence in Charleston MSA by Percent Poverty

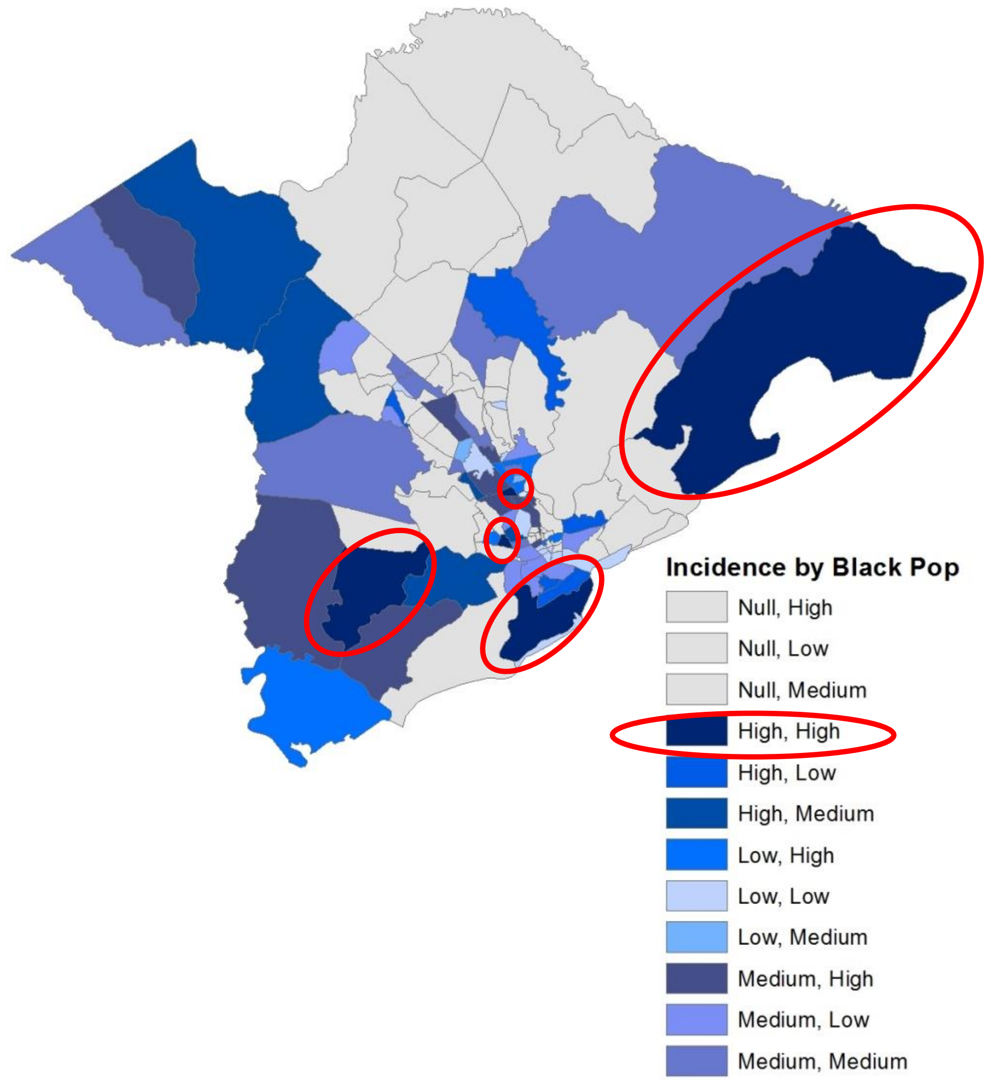

Figure 4.17 Total Cancer Incidence in Charleston MSA by Percent Black

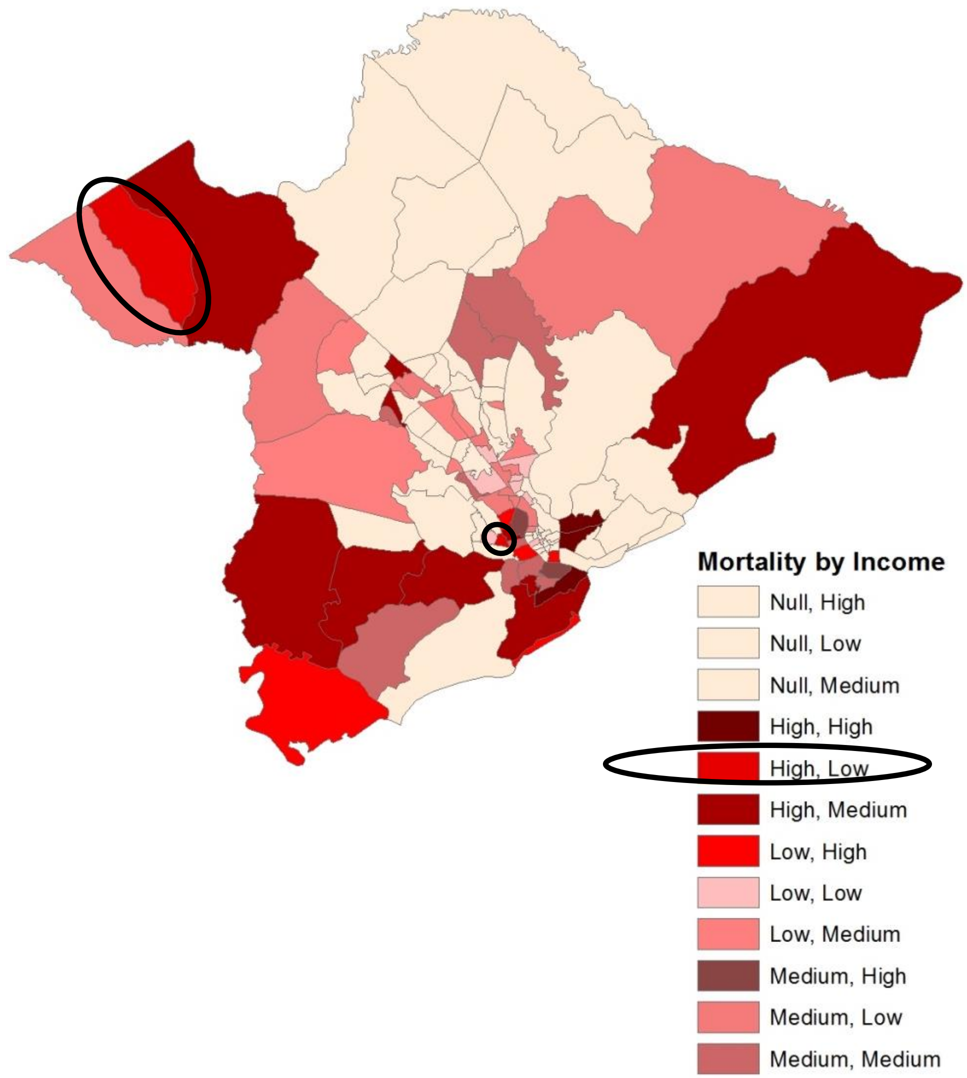

Figure 4.18 Total Cancer Mortality in Charleston MSA by Percent Income

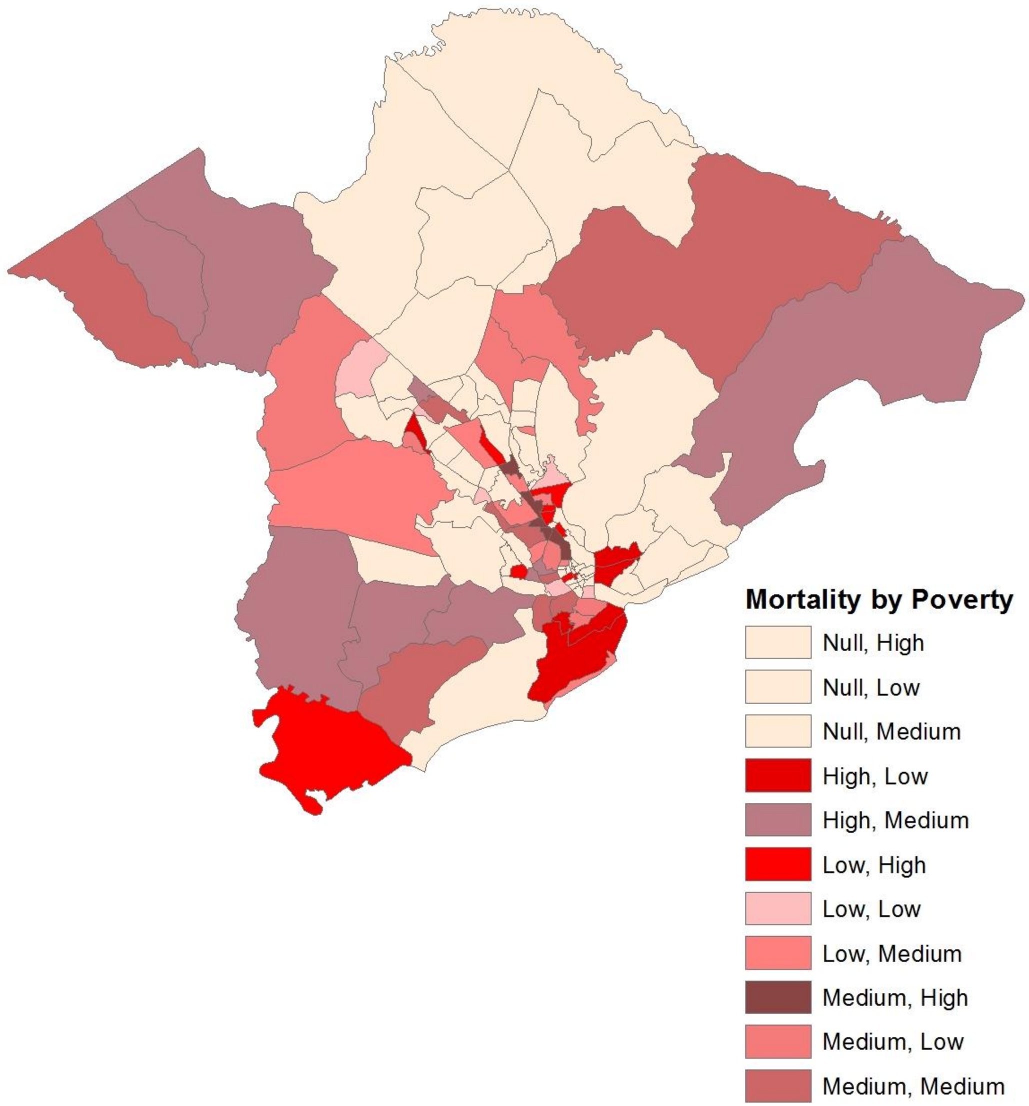

Figure 4.19 Total Cancer Mortality in Charleston MSA by Percent Poverty

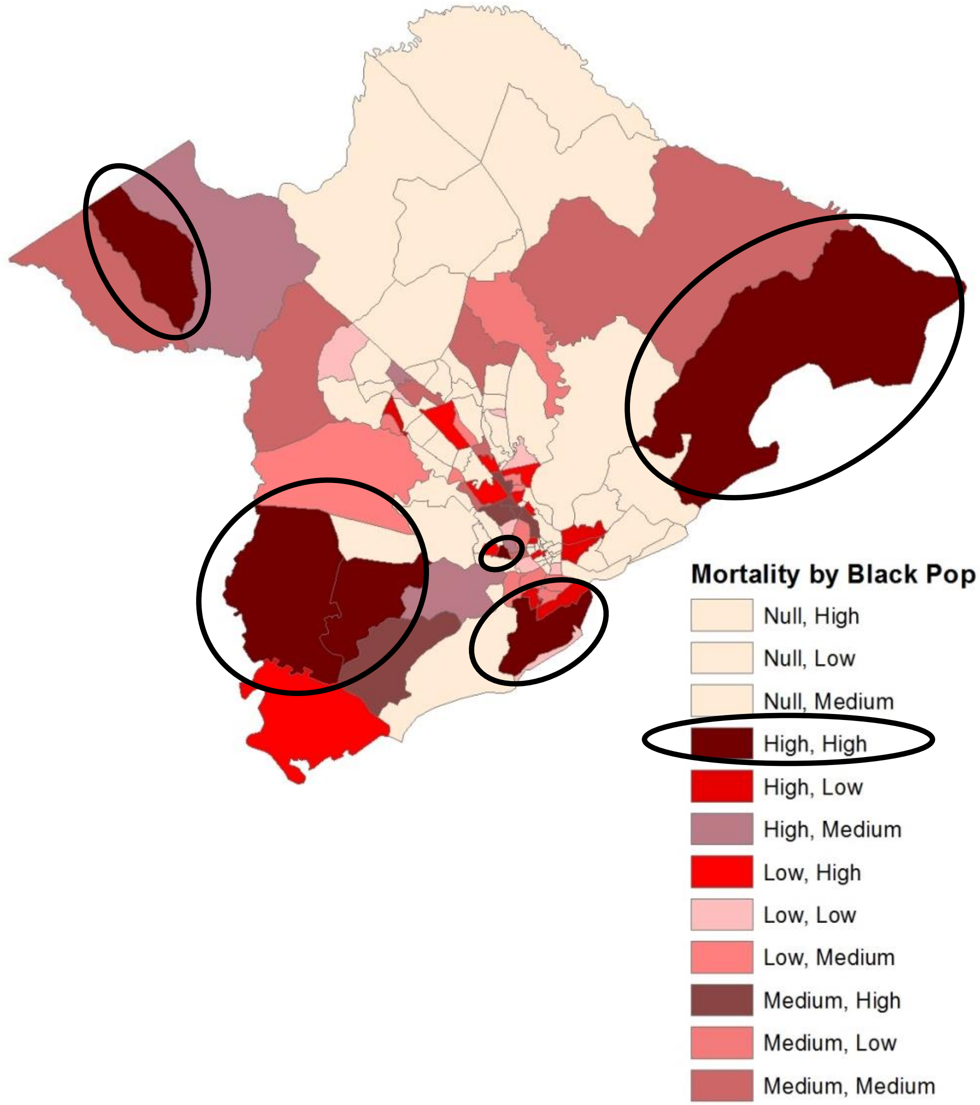

Figure 4.20 Total Cancer Mortality in Charleston MSA by Percent Black

Table 4.5. Spearman's rho correlation analysis between cancer variables and sociodemographic factors

Test	EJ Variables		Cancer Risk	Cancer Incidence	Cancer Mortality
Spearman's rho	%Black	Correlation Coefficient	.324**	.120	.172
		Sig. (2-tailed)	.000	.196	.064
		N	117	117	117
	%Income	Correlation Coefficient	-.542**	.024	-.030
		Sig. (2-tailed)	.000	.797	.749
		N	117	117	117
	%Poverty	Correlation Coefficient	.474**	.055	.058
		Sig. (2-tailed)	.000	.555	.533
		N	117	117	117

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

CHAPTER 5

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

This chapter provides an overview of the results from the two manuscripts presented in Chapter 4. This chapter also presents a summary of the findings and discussion of conclusions, limitations, and public health and policy implications of the overall study. The chapter concludes with a discussion of potential areas and possible directions for future research.

5.1 Summary of Study Findings

This dissertation included two specific aims to assess perceived and actual cancer risk in the Charleston MSA.

Specific Aim 1: Evaluate the relationship between perceived cancer risk, perceived environmental health risks, and health behaviors

RQ 1: What is the relationship between socioeconomic status (SES), perceived environmental health risks, and/or health behaviors and perceived cancer risk?

Findings for RQ 1 revealed no association between perceived cancer risk and community perceptions of environmental health risks or SES. These findings were unexpected given health behaviors occur within an environmental context (Stokols, 1992) and Gerbi et al. (2011) found a statistically significant association between awareness of environmental health risks and cancer risk perceptions among Blacks.

Although no association was detected; low perceived cancer risk and high environmental health risk were identified among Blacks in the Charleston MSA, which is consistent with previous studies (Flynn et al., 1994; Finucane et al., 2000; Marshall, 2006). A relationship between SES and respondents' perceptions of cancer risk was anticipated due to the fact that studies have demonstrated low education and low-income persons generally report lower perceptions of cancer risk for certain behaviors (Peretti-Watel et al., 2014). Unfortunately, findings from this study yielded little concordance with the literature. Non-alcohol consumption and undergoing a colon cancer screening exam were the only risk-reducing health behaviors significantly associated with both low perceived cancer risk and cancer worry.

RQ 2: Does perceived cancer risk vary by SES (education and income), sex, and/or age?

Findings from RQ2 revealed no significant association between perceived cancer risk or cancer worry and SES. A relationship between low perceived cancer risk and sex was observed. In particular, findings demonstrated when compared to males, females were more likely (OR=2.02, CI 1.173-3.469) to perceive their lifetime risk as low. These findings are parallel to extant literature that compared to females, males' absolute perception of cancer risk is typically lower than females (McQueen et al., 2008). No significant relationship was observed between cancer worry and sex or age. With regard to age, however, younger adults (25-44 and 45-64) were 45-49% less likely to report low perceived cancer than older adults (aged 65 or more) suggesting that age was a protective factor. These findings are supported by studies conducted by

Lipkus et al. (1999) and Hay et al. (2006), which demonstrated older adults have lower perceived cancer risk than younger adults due to not knowing their risk.

Specific Aim 2: Use geospatial methods to explore actual cancer risk and socioeconomic vulnerability to environmental hazards

RQ 3: Has cancer risk increased, decreased, or remained steady from 1996 to 2005 in Charleston MSA?

Results of the geospatial data analysis for RQ3 revealed no consistent pattern of cancer risk in Charleston MSA from 1996 to 2005. The lowest (0 people/million) and highest (107 people/million) cancer risk levels from exposure to hazardous air pollutants were observed in the initial assessment year (i.e. 1996). There was more variability in cancer risk in 1996 than in subsequent years (i.e. 1999, 2002, and 2005), which all demonstrated similar cancer risk patterns ranging between 15-65 people/million. Our findings make sense given that cancer incidence and mortality rates have been declining since the 1990s (Edwards et al., 2013). The Global Moran's I tool was used to measure spatial autocorrelation based on both cancer risk locations and values simultaneously. The analysis evaluated whether the pattern of cancer risk expressed was clustered, dispersed, or random. Values of cancer risk in the dataset tended to cluster spatially meaning (high values clustered near other high values and low values clustered near other low values) across the Charleston MSA. This is evident by each Moran's I value. Moran's I values typically fall between -1.0 and +1.0. For each year assessed, Moran's I was positive (0.27, 0.43, 0.33, and 0.28, respectively) demonstrating spatial autocorrelation. As a result, the null hypothesis under the Global Moran's I that cancer risk is randomly distributed was rejected.

Z scores associated with the analysis were outside the normal range (-1.96 and +1.96) suggesting the pattern observed were too unusual to have occurred by random chance, which is also reflected in the small p-value ($p<.001$). A Hot Spot Analysis was conducted for the same MSA. Findings from that analysis coincide with the spatial autocorrelation revealed significant clustering of low and high cancer risk.

RQ 4: Are there spatial variations in cancer risk, incidence, and mortality by sociodemographic factors (% Black, % poverty, and % income)?

Analyses for RQ 4 revealed a correlation between percent Black, percent poverty, and percent income and cancer risk. No significant correlations were observed between cancer incidence or cancer mortality and sociodemographic factors. Bivariate and correlation analyses both demonstrated that there were more Census tracts in the Charleston MSA with high levels of cancer risk and high levels of each sociodemographic factor than there were tracts with an overlap in high cancer incidence or cancer mortality and sociodemographic factors. Several studies have demonstrated elevated levels of cancer risk when exploring relationships with one of the sociodemographic factors used in this study (Apelberg, et al., 2005; Collins et al., 2011; Linder et al., 2008; Rice et al., 2014). For example, some of the findings from this study correlate with research by Apelberg and colleagues (2005) findings that Blacks and socioeconomically disadvantaged groups disproportionately experience excess cancer risk. Akin to this study, Linder et al., 2008 found that the intensity at which cancer risk occurred was related to social disadvantage including a strong association between cancer risk and poverty. Similarly, this study's findings align with research conducted by Collins et al. (2011), which showed a negative relationship between neighborhood socioeconomic variables. Neighborhoods with less income and with a poverty line greater than 35% were at higher risk than neighborhoods for more socioeconomic resources (Collins et al., 2011). The finding that percent poverty had the strongest correlation with cancer risk is congruent with Rice et al.'s (2014) finding that cancer risk levels are highest in Census tracts with more material deprivation, which is directly proportionate to economic resources. High poverty areas have fewer economic resources and therefore play host to facilities that emit harmful substances including air pollutants assessed for the NATA (Bullard, Mohai, & Saha, 2007). Income was negatively associated with cancer risk so as income level decreased the number of people/million at risk for cancer risk increased. These findings align with Evans and Kantrowitz (2002) study which demonstrated that socioeconomic resources determine health outcomes and environmental risk factors.

5.2 Limitations

This study is not without limitations. With respect to collecting primary data using survey methodology such as convenience sampling and self-identification of race limited how representative the sample was of all Blacks in Charleston MSA. Many of the respondents were highly educated, which suggests they may have been more knowledgeable about the risk factors associated with. According to the American Community Survey, educational attainment estimates from 2006 to 2010 among Black adults (males and females age 25 or old) in the Charleston MSA was primarily at the high school level (U.S. Census Bureau, 2014f). Hence, the sample having more education may have affected the respondents health behaviors, especially those related to screening recommendations. Using self-report data has its challenges, mainly introducing nature to biases, such as social desirability and recall bias. Some respondents may have overestimated their health behaviors or inaccurately reported past behaviors due to recall or social desirability bias. To prevent recall bias, a timeframe was incorporated into items cancer risk factors, but recalling information accurately can be a challenge especially since the majority of respondents were over age 45. A cross-sectional study design was used for the survey, but respondents were not required to answer all questions. Hence, this study was subject to non-response error which may have influenced the generalizability or the representativeness of the sample (Yoon & Horne, 2004). Using a cross-sectional study design limits the ability to determine causal inference (i.e. determine whether respondents' perceived cancer risk prompted them to respond to their health and thus behavior according to recommended guidelines or if respondents' behaved according to their environment which in turn prompted them to engage in risky or health-protective behaviors) (Levin, 2006). Despite having limitations in the study design, a preliminary snapshot of health behaviors associated with risk factors for cancer was observed in a population with excess cancer burden and environmental exposures. Since this study was exploratory in nature, no statistical interactions were conducted. The primary focus was on determining the relationships between factors, which were tested and discussed. Although conducting interactions between variables was beyond the scope of this study, performing such an analysis in the future has implications for future research. For this study, secondary data analysis was used to explore relationships between cancer and environmental disparities. A disadvantage to using secondary data is that their inabilities to fulfill every objective data were retrieved to assess (Greenstein, 2012). For this work, there was data pertinent to the dissertation that may not have been collected, may be missing, and/or may be incomplete because it was beyond the scope of the original study. Interruptions in the data such as those previously mentioned may lead to an underestimation or overestimation of the correlation between measures, thus biasing the results. Census data, in general, has its own limitations. Census data collection varies by data collected. For example, the Census is collected decennially and some housing (i.e. American Housing Survey) is collected biennially. In addition, American Community Survey data are collected annually; however, single-year and multi-year estimates are not produced for all population sizes, which can be a limitation (U.S. Census Bureau, 2009). Some statistics used in the Census are based on complete enumerations versus samples of the population. NATA data limitations vary by year (U.S. EPA, 2010a; U.S. EPA, 2010b; U.S. EPA, 2010c; U.S. EPA, 2010d). A few limitations that posed a threat to this study include: default assumptions used to estimate risks, potential gaps in data; risk estimates only reflect outdoor exposures, and the use of aerial data rather than location-specific data. A major limitation associated with the use of SCCCR cancer incidence data is the accessibility and availability of the data including limitations in representing actual rates in areas with small numbers.

Despite its limitations, this study has several strengthens. First, the study utilized an interdisciplinary approach to better understand a significant public health concern in Charleston MSA as well as nationally. Using an interdisciplinary approach drew upon theoretical concepts, methodological techniques, and diverse disciplines (e.g., health behavior, geography, and epidemiology) to demonstrate where disparities exist and show that more policies, and out-of-the-box thinking is needed. In addition, study findings can serve to inform dialogue on eradicating cancer and environmental health disparities using comprehensive approach. Another strengthen is how this study expands upon past and current literature on cancer and environmental health risk perceptions. Most of the literature on environmental health risk is outdated and does not explore overlapping disparities in relation to health behaviors and from the perspective of a "high risk" group as this study did. Cancer risk perceptions literature, on the other hand, is update but lacks there has been little to no discussion of overlapping risk and disparities. Also, a major strengthen to this study is its ability to expand the literature surrounding Blacks' perceiving they are at lower risk of developing cancer. Other studies have inferred that lower perceptions in this group were due to a lack of knowledge of family history of disease (Orom et al., 2010). However, in this study, respondents provided several explanations for their cancer risk perceptions. The ultimate strength of this study is that it is the only one to date that has statistically analyzed items from the PEW survey. Findings from this study can inform the development of cancer prevention and environmental health disparities interventions. Informing interventions will help public health professionals identify vulnerable areas where perceptions of cancer risk are low, health disparities exist and persistent and how geographic location places a role in disparities.

5.3 Conclusions

There are several key findings to highlighting in this study. Findings from the environmental health survey contribute to the literature on the role of risk perceptions and cancer worry in shaping risk-reducing health behaviors in predominately Black communities in Charleston MSA. North Charleston, a principal city in Charleston MSA, is predominately Black. Associations observed between cancer risk perceptions and cancer worry and specific health behaviors warrants further study and underscores how such outcomes would be useful in developing public health interventions in areas where Blacks are proximal to disparate environmental exposures that exacerbate cancer risk. In addition, these findings demonstrate exploring multifaceted aspects of the environment (e.g., place, disease, and racial factors) are important as the national agenda pushes for health equity. Developing and implementing dual reduction interventions in cancer and environmental health will make health promotion and disease prevention objectives established in *Healthy People 2020* achievable.

This study also highlights the importance of utilizing items that appropriately measure environmental health constructs. For instance, even though a relationship was anticipated between low perceived cancer risk or cancer worry and each independent variable (environmental health and SES), there was no such relationship identified. The lack of an association between the aforementioned dependent and independent variables may be explained by limitations in the number of existing scales that measure perceived environmental health risks. The most used survey instrument is the PEW Charitable Trust's national telephone survey on public perceptions of environmental health risks developed by Princeton Survey Research Associates (PSRA) (PSRA, 2000). Although the PEW survey is widely used, this study is the only one to date that has statistically analyzed items from the survey. Several PEW items were adapted to meet the needs of the target population and used to create a cumulative environmental health risk variable because the analysis revealed some of the items may have measured another latent construct, e.g., physical environment instead of environmental health risks.

This study used interdisciplinary methodologies to identify factors that are perpetuating health disparities. Geospatial techniques can be used to directly inform social and environmental factors to address in public health interventions. For example, geographic information systems store data with a spatial component so that relationships between data can be identified using maps. Geospatial techniques can improve upon issues that may be perpetuating health disparities in that they can be used to identify areas with higher risk of disease and simultaneously lower economic, educational, and/or health care resources. For this study, using both the Anselin Local Moran's Index and bivariate maps served to predict areas where cancer and environmental health disparities exist or may develop overtime. As is the goal of health promotion practice, these tools enable researchers to better identify, control through targeted intervention, and improve health on a larger scale, which is critical to maintaining or achieving optimal well-being in vulnerable populations. Geographical considerations when exploring correlations between cancer risk and outcomes (incidence and mortality) and environmental justice variables emphasized the importance of incorporating neighborhood factors into public health interventions.

The geographic assessment of cancer risk has implications for the use of geographic information systems in identify neighborhood level needs and locate resources in close proximity that may be able to address those needs. Documenting perceptions using survey data provided a snapshot of residents' perceptions, while analyzing secondary data told a story of the risks associated with disparities. Together, the findings from this study demonstrate a need for more research to better understand underlying causes of disparities and population-specific decisions about health. Learning about health behaviors among Blacks has implications for future contextual public health interventions aimed at improving health behaviors among persons living in or proximal to a hazardous industrial facility. Lastly, this research emphasizes the need for diverse methodological approaches when addressing health disparities.

5.4 Public Health and Policy Implications

There are a number of ways the findings from this study can be used to prompt action from policymakers and community planners so that environmental health risks are better addressed in Charleston MSA. One way is to use the observed pattern of cancer risk across Charleston MSA to advocate for monitoring of exposures from local hazardous waste facilities to determine actual cancer risk from air toxics pre- and post-Port Expansion. The last monitoring of this area was conducted almost a decade ago (2005), the same year a local community-driven, non-profit organization formed to combat environmental justice issues in the City of North Charleston. Findings from this study can be used to prompt dialogue on one or all of the domains included on the survey or using the geospatial data to inform human health and environmental health action and advocate for policy changes that may be posing a threat to lives in Charleston MSA. Additionally, this study can be used to encourage research efforts addressing environmental hazards in areas with more minorities, higher levels of poverty, and less economic resources.

We observed positive spatial autocorrelation in Charleston MSA at the tract level meaning a spatial pattern was identified where cancer risk occurred (location) and the values of cancer risk were unified. Being able to identify areas in Charleston MSA with clusters of high and low cancer risk suggests a need for a local human health and environmental health action plan, both of which could inform local policies. The EPA has proposed health action plans at the individual level (U.S. EPA, 2012). Data from this study can be used to develop a community level environment health plan with particular emphasis on cancer risk hot spots and adjacent Census tracts. The EPA's Community-Focused Exposure and Risk Screening Tool (C-FERST), a "community mapping, information access, and assessment tool designed to help assess risk and assist in decision making with communities" (EPA, 2014). Findings from this study can be added to C-FERST so the community is abreast of the risks in and around their community. Furthermore, it will help to inform environmental policies by using C-FERST to make the EPA aware of some of the environmental challenges in Charleston MSA.

In addition to highlighting cancer clustering, this research identified disparities in the distribution of cancer risk from air toxics and the percent of the Black population, persons living in poverty, and persons with less per capita income. These findings are significant because they reiterate Ball's (2006) findings that one of the proposed areas to expand the Port of Charleston includes environmentally vulnerable communities and socioeconomically disadvantaged groups. These findings are further demonstrated in the correlations identified between cancer risk and environmental justice variables. More must be done to ensure that both environmental and socioeconomic vulnerabilities are not exacerbated. So, the questions that need to be asked relate to the cost in terms of lives of the proposed Port expansion into an already vulnerable area and potential health costs from health conditions that may form or worsen as a result of exposures from the Port.

Also, is there a plan in place to measures the impact of the Port Expansion, to assess it harm, to reduce exposure to harmful chemicals or toxins that may be emitted from the Port, or to intervene if such exposures occur?

In addition to serving as a baseline health assessment prior to the Port Expansion in 2017, results from the survey can be used to tailor educational materials on environmental health risks and cancer, increase knowledge about cancer risk perceptions and health behaviors among Blacks, and help to engage local policy makers in dialogue about environmental decision making. These data can also be used to develop a comprehensive community health document with harmonized data from this and other studies on environmental health challenges in Charleston MSA. The document would be used to raise awareness and provide education on environmental health risks and issues. Findings from this study will be shared with local non-profit organizations with an emphasis on environmental justice including the Charleston Community Research to Action Board, the Lowcountry Alliance for Model Communities, and the South Carolina Environmental Justice Advisory Committee.

After disseminating results from this study to the aforementioned groups, data will also be used to inform policies and shared with the National Environmental Justice Advisory Council (NEJAC), a federal advisory committee to the Environmental Protection Agency which provides both advice and recommendations on environmental justice issues, priorities and initiatives (U.S. EPA, 2014). Monitoring changes in community exposures and risk could help estimate the long-term effects of the Port expansion on health as well as inform ways to reduce community exposure to pollutants through education (forums, workshops, and materials), local, state, and national regulation of exposures, and reduction of preventable exposures e.g., cigarette smoke).

Despite the aforementioned limitations, the findings from this study provide various avenues for future research. Findings from the survey suggest future opportunities to further explore the basis of Blacks' perceptions of their risk for cancer. Respondents identified several factors that contribute to their beliefs about cancer, most of which involved social spheres of influence. One approach to exploring these beliefs is to conduct a qualitative assessment (e.g. group consensus) on risk perceptions and widely held beliefs of Blacks to determine the role circles of influence play in health decision-making. Also, validating the associations observed between perceived cancer risk and non-alcohol consumption and colon screening practices as well as the relationship between cancer worry and the four health behaviors (alcohol consumption, diet, cancer screenings, and smoking) could inform the development of future public health interventions. The associations observed in this study could be used to develop campaigns, initiatives, and/or interventions that reinforce Blacks engagement in health protective behaviors versus health damaging behaviors.

There is literature demonstrating that that adhering to specific cancer screenings for this group depends on sociocultural variables (Brittain & Murphy, 2014), which is a viable explanation for documented cancer disparities in Charleston MSA given the diversity of the Black population. In a recent study by Consedine and colleagues (2014), U.S.-born Blacks compared to Caribbean-born Blacks of African descent residing in the U.S were adhering to were screening more frequently. Respondents' personal and interpersonal sociocultural experiences with cancer and/or the environment, in addition their awareness of having a family history of cancer may explain why Blacks perceptions of cancer risk in Charleston MSA are low.

Another potential research study could be to explore the influence of social, physical, natural, and built environments on health behaviors to determine which has the greatest impact on environmental health risks for this group. In addition to performing an analysis to determine if risk perceptions act as a mediator between environmental health risks and health behaviors, it would be interesting to find out if significant associations hold true when individual perceptions are compared to the overall (i.e., community level) beliefs of respondents. Study findings suggest perceived cancer risk is associated with protective health behaviors. Since there are several modifiable health behaviors and environmental factors that increase personal risk of developing cancer, future studies should explore the role of psychosocial factors, such as stress and depression, in health outcomes of communities with a higher risk of cancer, and with social and environmental vulnerabilities.

This study helped elucidate perceived and actual cancer risk as well as identify perceived environmental health risk among Blacks in the Charleston MSA using a comprehensive approach. With documented environmental justice concerns and disparate cancer outcomes between groups in Charleston MSA, this research provides viable explanations for why Blacks commonly have lower perceptions of cancer risk. The relationships explored in this study demonstrate that understanding the link between perceptions, health and where people live is a critical part of achieving health equity in the United States. Ultimately, this research emphasizes the need for interdisciplinary interventions that emphasize social, environmental, and geographical context when addressing disproportionate disease outcomes. The findings from this work will be used to guide future public health interventions among Blacks and in other underserved communities and encourage further research on the associations identified in the Charleston area in other metropolitan statistical areas with similar concerns.

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APPENDIX A: USC IRB Approval Letter

From: MCWHORTER, ARLENE [maio:ARLENEM@mailbox.sc.edu] Sent: Tuesday, August 27, 2013 6:10 PM
To: hbrandt@sc.edu
Subject:FYI - Pro00027670

Hi Dr. Brandt,

The following new study was approved by the University of South Carolina Institutional Review

Board; this is for your information no response is required. el RB #: Pro00027670
Study Title: *Elucidating Perceived and Actual Cancer Risk in Disadvantaged Neighborhoods Differentially Impacted by Environmental Hazards to Inform Future Public Health Interventions*
Principal Investigator: Ms. LaShanta Rice
Review Category & Approval Date: Exempt - Not human subject -8/27/2013. If you have any

questions, please contact me at {803) 777-7095.

}lrlene

Arlene McWhorter
Systems Administratorr
SPONSORED AWARDS MGMNT &
Office of Research Compliance
University of South Carolina
901 Sumter Street, Byrnes 515
Columbia, SC 29208
(803) 777-7095 Work
arl enem@mailbox.sc.edu

APPENDIX B: SCCCR IRB Approval Letter

D H E C
PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

INSTITUTIONAL REVIEW BOARD
FWA 00003803
IRB00000092 SC DHEC IRB #1
Public Health Statistics & Information Services
South Carolina Department of Health & Environmental Control
2600 Bull Street
Columbia, S.C. 29201

November 26, 2013

LaShanta Rice
University of South Carolina
800 Sumter Street, suite 216
Columbia, SC 29208

RE: DHEC IRB.13-024

Dear Ms. Rice:

The DHEC IRB has reviewed the research material associated with your proposed study entitled, "*Elucidating Cancer Risk Perceptions in Disadvantaged Neighborhoods Differentially Impacted by Environmental Hazards to Inform Future Public Health Interventions*". It is the understanding of this IRB that the purpose of the proposed project is to use exploratory spatial data analysis to assess the relationship between actual cancer risk and cancer outcomes (incidence and mortality) and demographic characteristics (race/ethnicity and socioeconomic factors) that influence social vulnerability to environmental hazards. The SC Central Cancer Registry will provide you county rates and census tract counts where the count is great than 16.

Since risks are minimal and cases will be anonymous to you, **this study is granted an EXEMPTION from IRB review based on 45 CFR 46.101(b)(4).** No further action or IRB oversight is required, as long as the project remains the same. Should there be any changes in the research protocol, which may affect the type of IRB certification given, you are required to notify this office and resubmit the study for IRB review prior to enacting any change in the protocol.

Please reference the number assigned to this study protocol, **IRB.13-024,** with any contact made with this office regarding this study.

Best Regards,

Shae R. Sutton, PhD, Chair
DHEC Institutional Review Board
Director, Office of Public Health Statistics & Information Services
Office: 803-898-1808
Email: suttonsr@dhec.sc.gov

APPENDIX C: Environmental Health Survey

UNIVERSITY OF SOUTH CAROLINA

Assessment of Environmental Determinants of Cancer Risk and Disparities Survey Charleston, South Carolina

The Environmental Health Core at the Institute for Partnerships to Eliminate Health Disparities at the University of South Carolina is working with the Charleston Community Research to Action Board (CCRAB) on an environmental health survey. The survey is part of a study entitled “Assessment of Environmental Determinants of Cancer Risk and Disparities (Project #2).” The purpose of the study is to learn about what people in Metropolitan Charleston think about the environment and its potential impact on health and health risks, such as cancer.

The overall goal of the study is to find out what people know about the environment and determine how the environment is related to people’s risk of cancer. To achieve this goal, researchers and the CCRAB have decided to create and distribute a community-wide environmental health survey.

We are asking you to take part in the survey because you live in the Metropolitan Charleston area and are age 18 or older. As a result, we want you to share information about where you live, what you think about where you live, and what you think about how the environment around you affects your health.

If you choose to take part in this study, you will be asked to fill out the survey and return it in-person once it is completed or to return it by mail in the postage-paid envelope provided with the survey. The survey should take you about 20 minutes to complete.

You do not have to answer any questions that you do not want to answer. Although you may not benefit directly from taking part in this study, you may learn more about the way that the environment is connected to health.

Participation is anonymous and therefore totally private. This means that no one (not even members of the research team) will know your name or specific answers. Please do not write your name on the survey. Taking part in the study is your choice. You do not have to be in this study by filling out and returning the survey if you do not want to be. You may also quit being in the study at any time or choose not to answer any question you are not comfortable answering.

We are happy to answer any questions you have about the study. You may contact

LaShanta Rice at 803.251.2232 or ricelj@email.sc.edu or Heather Brandt at 803.576.5649 or hbrandt@sc.edu if you have study related questions or problems. If you have any questions about your rights as a research participant, you may contact the Office of Research Compliance at the University of South Carolina at 803.777.7095.

The following questions will ask about where you live, in particular we will ask about your experiences based on the state of the natural environment in your community and your beliefs about the environment's impact on your health.

1. **Overall, how would you rate your community (Charleston) as a place to live?**
   - ☐ Very good
   - ☐ Somewhat good
   - ☐ Somewhat poor
   - ☐ Very poor

2. **How important do you think the environment is in causing disease, in general?**
   - ☐ Very important
   - ☐ Somewhat important
   - ☐ Not too important
   - ☐ Not important at all

3. **Would you say being exposed to one of the following is a very serious health threat, somewhat serious, somewhat minor, or not a health threat at all?**

	Very serious	Somewhat serious	Not too serious	Not at all a health threat
a. Air pollution (contamination of indoor and outdoor air)	☐	☐	☐	☐
b. Water pollution (contamination of water with chemicals or foreign substances that are harmful to health)	☐	☐	☐	☐
c. Soil contamination (a solid or liquid harmful substance mixed in the soil)	☐	☐	☐	☐
d. Toxic waste (waste material or chemicals that cause death, injury, or birth defects)	☐	☐	☐	☐

4. **Have you or a close family member ever lived in a community where air pollution, water pollution, soil contamination, and/or toxic waste were problems?**
   - ☐ Yes
   - ☐ No
   - ☐ Don't know

5. **Is air pollution, water pollution, soil contamination, and/or toxic waste a problem in the community where you live now?**
   - ☐ Yes [Go to question 6.]
   - ☐ No [Go to question 7.]
   - ☐ Don't know [Go to question 7.]

6. **Place an X in the box to show the degree to which each is or is not a problem in your community (Charleston).**

	Very big problem	Somewha t big problem	Not too big a problem	Not at all a problem
a. Air pollution (contamination of indoor and outdoor air)	☐	☐	☐	☐
b. Water pollution (contamination of water with chemicals or foreign substances that are harmful to	☐	☐	☐	☐
c. Soil contamination (a solid or liquid harmful substance mixed in the soil)	☐	☐	☐	☐
d. Toxic waste (waste material or chemicals that cause death, injury, or birth defects)	☐	☐	☐	☐

7. **Do you think that living in a community with air pollution, water pollution, soil pollution, and/or toxic waste is harmful to your health?**
   - ☐ Yes
   - ☐ No
   - ☐ Don't know

8. **How would you rate your level of concern that living in a community with air pollution, water pollution, soil contamination, and/or toxic waste could be harmful to your health?**

- ☐ Very concerned
- ☐ Not too concerned
- ☐ Somewhat concerned
- ☐ Not at all concerned

9. **Thinking about specific illnesses, do you think the environment plays a major role, minor role, or no role at all in causing each of these?**

	Major role	Minor role	No role at all	Don't know
a. Cancers (breast, prostate, cervical, and lung)	☐	☐	☐	☐
b. Infertility (being unable to make a baby)	☐	☐	☐	☐
c. Asthma in children	☐	☐	☐	☐
d. Sinus and allergy problems	☐	☐	☐	☐
e. Birth defects	☐	☐	☐	☐
f. Learning disabilities	☐	☐	☐	☐
g. Colds and flu	☐	☐	☐	☐
h. Parkinson's disease	☐	☐	☐	☐

10. **Is there anyone you know personally whose health has been affected by environmental factors?**

- ☐ Yes
- ☐ No
- ☐ Don't know

The next questions will ask your opinion about health information, government priorities, and research efforts.

11. **Would you say you have enough information or would like more about the following:**

	Yes, I have enough information	No, I would like more information	I am not interested
a. The state of the environment in your community	☐	☐	☐
b. What I can do to protect myself and my family from environmental health problems	☐	☐	☐

12. **In your opinion, how important is it that the local government/city lawmakers do more research to learn about the health effects associated with environmental hazards?**
    - ☐ Very important
    - ☐ Not too important
    - ☐ Somewhat important
    - ☐ Not at all important

13. **How much of a priority do you think the local government/city lawmakers <u>is giving</u> to reducing the number of illnesses that may be caused by environmental hazards such as pollution and toxic waste?**
    - ☐ Top priority
    - ☐ Not too important
    - ☐ Important, but not top priority
    - ☐ Not a priority at all

The next questions will ask about your health and health-related behaviors.

14. **In general, would you say your health is...**
    - ☐ Excellent
    - ☐ Very good
    - ☐ Good
    - ☐ Fair
    - ☐ Poor

15. **Overall, how confident are you about your ability to take good care of your health?**

☐ Completely confident
☐ Very confident
☐ Somewhat confident
☐ A little confident
☐ Not confident at all

16. **How much do you think that you can do to protect yourself from the following health issues?**

	A great deal	A moderate amount	A little	Nothing at all
a. Infectious diseases such as measles, tuberculosis and hepatitis	☐	☐	☐	☐
b. Health problems caused by environmental problems, such as pollution or toxic waste	☐	☐	☐	☐
c. Chronic diseases, such as heart disease and cancer	☐	☐	☐	☐
d. Sexually transmitted infections (or sexually transmitted diseases), such as HIV, herpes, syphilis, and Chlamydia	☐	☐	☐	☐

17. **How likely do you think you are to get cancer in your lifetime?**

☐ Very unlikely
☐ Unlikely
☐ Neither unlikely nor likely
☐ Likely
☐ Very likely

18. What are your beliefs about cancer based on? Check all that apply.

- ☐ What you have heard from other people
- ☐ Information from the internet
- ☐ Your past or family experiences
- ☐ Cultural beliefs
- ☐ Information from a medical or health professional
- ☐ Talks with family members or friends
- ☐ Media (e.g., TV, radio, newspapers)
- ☐ Other: ________________________________

19. How worried are you about getting cancer?

	Not at all	Slightly	Some-what	Moderately	Extremely
a. Cancer in general	☐	☐	☐	☐	☐
b. Breast cancer	☐	☐	☐	☐	☐
c. Prostate cancer	☐	☐	☐	☐	☐
d. Cervical cancer	☐	☐	☐	☐	☐
e. Lung cancer	☐	☐	☐	☐	☐
f. Colon cancer	☐	☐	☐	☐	☐

Females continue with question 20. Males go to question 22.

20. A mammogram is an x-ray of each breast to look for breast cancer. When did you have your most recent mammogram, if ever?

- ☐ A year ago or less
- ☐ More than 1 year, up to 2 years
- ☐ More than 2 years, up to 3 years
- ☐ More than 3, up to 5 years
- ☐ More than 5 years ago
- ☐ I have never had a mammogram

Females continue with question 21. Males go to question 22.

21. **A Pap test is a test for cancer of the cervix. How long ago did you have your most recent Pap test, if ever?**
    - ☐ A year ago or less
    - ☐ More than 1 year, up to 2 years
    - ☐ More than 2 years, up to 3 years
    - ☐ More than 3, up to 5 years
    - ☐ More than 5 years ago
    - ☐ I have never had a Pap test

Females go to question 23. Males continue with question 22.

22. **A Prostate-Specific Antigen (PSA) test is a blood test used to check men for prostate cancer. How long has it been since your last PSA test?**
    - ☐ A year ago or less
    - ☐ More than 1 year, up to 2 years
    - ☐ More than 2 years, up to 3 years
    - ☐ More than 3, up to 5 years
    - ☐ More than 5 years ago
    - ☐ I have never had a PSA test

23. **How long has it been since you had your last colonoscopy, sigmoidoscopy, or blood stool test to check for colon cancer?**
    - ☐ A year ago or less
    - ☐ More than 1 year, up to 2 years
    - ☐ More than 2 years, up to 3 years
    - ☐ More than 3, up to 5 years
    - ☐ More than 5 years ago
    - ☐ I have never had a colon cancer screening test

24. Which of the following best describes your decision to have the following test? Please choose only one option.

	I made the decision	My medical or health care provider made the decision	My medical or health care provider and I made the decision together	My spouse/ signifi-cant other/ family member made the decision	Never had the test
a. Mammogram (*Women only*)	☐	☐	☐	☐	☐
b. Pap test (*Women only*)	☐	☐	☐	☐	☐
c. PSA test (*Men only*)	☐	☐	☐	☐	☐
d. Colonoscopy, Sigmoidoscopy, or Blood stool test	☐	☐	☐	☐	☐

25. Would you say each of the following increases a person's chances of getting cancer a lot, a little, or not at all or you do not know?

	A lot	A little	Not at all	Don't Know
a. Air pollution	☐	☐	☐	☐
b. Water pollution	☐	☐	☐	☐
c. Soil contamination	☐	☐	☐	☐
d. Toxic waste	☐	☐	☐	☐

26. Have any of your family members ever been diagnosed with cancer?

☐ Yes [Go to question 27.]
☐ No [Go to question 29.]
☐ Don't know [Go to question 29.]

27. Do you believe your family member having cancer influences your chances of developing cancer?

☐ Yes
☐ No
☐ Don't know

28. Please indicate relatives that have ever been diagnosed with cancer. <u>Check all that apply.</u>

☐ Parent
☐ Aunt
☐ Uncle
☐ Grandparent
☐ Child
☐ Sister
☐ Brother
☐ Other relative

29. What kind of health care coverage do you currently have? <u>Check all that apply.</u>

☐ Private health insurance
☐ Prepaid plan such as HMO or PPO
☐ Military health care (e.g., TRICARE/VA/CHAMP-VA)
☐ Government program (e.g., Medicare, Medicaid, other government-assistance, or Indian Health Service)
☐ Single service plan (e.g., dental, vision, prescriptions)
☐ I have health coverage, but I don't know what type
☐ No coverage of any type

30. What is your regular source of medical care?

- ☐ Primary health care provider (e.g., doctor, nurse/nurse practitioner, physician's assistant)
- ☐ Emergency Room
- ☐ Free Health Clinic
- ☐ Community Health Center
- ☐ Other: ________________________________

31. Right now, how often do you smoke cigarettes?

- ☐ Everyday [Go to question 32.]
- ☐ Some days [Go to question 32.]
- ☐ Not at all [Go to question 33.]

32. Do you plan to quit smoking cigarettes for good…

- ☐ In the next 7 days
- ☐ In the next year
- ☐ In the next 30 days
- ☐ More than 1 year from now
- ☐ In the next 6 months
- ☐ No, never

33. Right now, do you consider yourself to be…...

- ☐ Overweight
- ☐ Underweight
- ☐ About the right weight

34. In a typical week, how many days do you do any physical activity or exercise of at least moderate intensity, such as brisk walking, bicycling at a regular pace, and/or swimming at a regular pace?

- ☐ None
- ☐ 1 day per week
- ☐ 2 days per week
- ☐ 3 days per week
- ☐ 4 days per week
- ☐ 5 days per week
- ☐ 6 days per week
- ☐ 7 days per week

35. In general, how healthy is your overall diet? Would you say it is….

- ☐ Excellent
- ☐ Very good
- ☐ Good
- ☐ Fair
- ☐ Poor

36. A drink of alcohol is 1 can or bottle of beer, 1 glass of wine, 1 can or bottle of wine cooler, 1 cocktail, or 1 shot of liquor. How many days per week did you have at least one drink of any alcoholic beverage such as beer, wine, a malt beverage or liquor?

- ☐ No days
- ☐ 1 day
- ☐ 2 days
- ☐ 3 days
- ☐ 4 days
- ☐ 5 days
- ☐ 6 days
- ☐ 7 days

37. When you are outside for more than one hour on a warm, sunny day, how often do you wear sunscreen?

- ☐ Always
- ☐ Often
- ☐ Sometimes
- ☐ Rarely
- ☐ Never
- ☐ I do not go out on sunny days

38. Have you ever received one or more doses of the HPV vaccine?

- ☐ Yes
- ☐ No

39. Has your daughter or son ever received one or more doses of the HPV vaccine?

- ☐ Yes
- ☐ No
- ☐ I do not have a daughter or son.

40. Which, if any, of the following diseases have you ever been diagnosed with?

- ☐ Heart disease
- ☐ Diabetes
- ☐ Breast cancer
- ☐ Cervical cancer
- ☐ Colon cancer
- ☐ Lung cancer
- ☐ Prostate cancer
- ☐ Other disease: ________________________________
- ☐ Alzheimer's disease
- ☐ Respiratory disease
- ☐ Stroke
- ☐ Nephritis
- ☐ Lupus
- ☐ None

The next questions will ask about your social support, which are the social resources that you believe are available to you through your involvement in community, social organizations, and other social activities.

41. Read each statement carefully and select the option that best describes how you feel.

	Strongly agree	Agree	Disagree	Strongly disagree
a. There are people I can depend on to help me if I really need it.	☐	☐	☐	☐
b. There are people that I can talk to about personal matters including my health.	☐	☐	☐	☐
c. I frequently attend a worship service or religious meeting.	☐	☐	☐	☐
d. I participate in community activities such as neighborhood association meetings.	☐	☐	☐	☐
e. I feel that I do not have close personal relationships with other people.	☐	☐	☐	☐

	Strongly agree	Agree	Disagree	Strongly disagree
f. I am involved in social activities outside of work.	☐	☐	☐	☐
g. I have close relationships that provide me with a sense of emotional security and well-being.	☐	☐	☐	☐
h. There is no one I feel comfortable enough to talk with about my problems.	☐	☐	☐	☐
i. A place of worship is an important place to formulate good social relationships.	☐	☐	☐	☐

42. Other than family members, how many people in your community or neighborhood do you feel you can depend on or feel very close to?

☐None ☐3-4
☐1 ☐5-8
☐2 ☐9 or more

43. Other than at work, how many times in a week do you spend time with someone who does not live with you (e.g., go to see them, or they come to visit you, or you go out together)?

☐None ☐3-4
☐1 ☐5-6
☐2 ☐7 or more

The next questions will ask information about you.

44. **What is your gender?**
- ☐ Male
- ☐ Female

45. **What is your age?** ___ ___

46. **What two-digit month and two-digit year were you born (e.g., 07/65)?**

___ ___ / ___ ___
(Month) (Year)

47. **What is your current working or occupation status? Check all that apply.**
- ☐ Employed
- ☐ Unemployed
- ☐ Homemaker
- ☐ Student
- ☐ Retired
- ☐ Disabled
- ☐ Other

48. **Are you of Hispanic or Latino origin, such as Mexican, Puerto Rican, Cuban, or some other Spanish background?**
- ☐ Yes
- ☐ No

49. **What is your race? Check all that apply.**
- ☐ African American/Black
- ☐ White
- ☐ Native Hawaiian/Other Pacific Islander
- ☐ Asian
- ☐ American Indian/Alaska Native
- ☐ Other: ______________

50. **What is the highest level of schooling that you completed?**
- ☐ Less than 8 years
- ☐ 8 through 11 years
- ☐ High school diploma or GED
- ☐ Post high school training (vocational or technical)
- ☐ Some college
- ☐ College graduate
- ☐ Postgraduate degree

51. **What is your combined annual income, meaning the total pretax income from all sources earned in the past year?**
- ☐ $0 to $9,999
- ☐ $10,000 to $14,999
- ☐ $15,000 to $19,999
- ☐ $20,000 to $34,999
- ☐ $35,000 to $49,999
- ☐ $50,000 to $74,999
- ☐ $75,000 to $99,999
- ☐ $100,000 or more

52. **Do you own or rent your home?**

- ☐ Own
- ☐ Rent
- ☐ Occupied without paying monetary rent

53. **How many children under age 18 live in your household?**

☐ None	☐ 3
☐ 1	☐ 4
☐ 2	☐ 5 or more

54. **Do you have access to the Internet or the World Wide Web at home?**

- ☐ Yes
- ☐ No

55. **Do you have access to the Internet or the World Wide Web at work?**

- ☐ Yes
- ☐ No

56. **Do you have a cell phone capable of accessing the internet?**

- ☐ Yes
- ☐ No
- ☐ Don't know

57. **Please provide us with your zip code.**

___ ___ ___ ___ ___

58. **Please indicate if you live in one of the following North Charleston neighborhoods/communities listed below.**

- ☐ Accabee
- ☐ Five Mile
- ☐ Chicora/Cherokee
- ☐ Liberty
- ☐ Howard Heights
- ☐ Rosemont
- ☐ Union Heights
- ☐ Windsor Place
- ☐ Other: ______________________________
- ☐ I do not live in North Charleston

59. **About how long have you lived in your community (Charleston)?**

- ☐ Less than 1 year
- ☐ 1 to 5 years
- ☐ 6 to 10 years
- ☐ 11 to 20 years
- ☐ 20 or more years

Thank you for participating in this survey!

If you would like to be entered into our monthly raffle giveaway, please complete the postcard provided with the survey.