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Neighborhood Safety and Diabetic Health: Examining the Associations between Neighborhood Safety and Cardiometabolic Risk Factors

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Neighborhood Safety and Diabetic Health: Examining the Associations between Neighborhood Safety and Cardiometabolic Risk Factors

By

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Committee in charge:

Professor Mahasin Mujahid, Chair
Professor Barbara Laraia
Professor Alan Hubbard

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Abstract

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Doctor of Philosophy in Epidemiology

University of California, Berkeley

Professor Mahasin S. Mujahid, Chair

Incidence and prevalence of chronic diseases such as diabetes are increasing in the U.S. Effective diabetes management is essential to ensure healthy outcomes and avoid severe diabetes sequelae including blindness, myocardial infarction, and early mortality. Research and interventions on diabetes management have primarily targeted changes in individual level risk factors related to physical activity, diet, and medication adherence. Features of neighborhoods, such as neighborhood safety may also be risk factors for poor diabetic management. Research has associated neighborhoods with diabetes incidence and prevalence but few studies focus diabetic populations. To this end, the overall goal of these analyses is to examine how neighborhood safety is associated with diabetic health.

Methods:

Chapter 1 provides an introduction and overview to the diabetes and neighborhood safety literature. Three analyses investigating research aims related to neighborhood safety and diabetic management and health will be conducted over three chapters, as follows: Chapter 2: Perceived Neighborhood Safety and Crime in Relation to Cardiometabolic Risk Factors among type II diabetics, Chapter 3: Examining associations between police recorded crime and stress among type II diabetics, and Chapter 4: Examining associations between police recorded crime and obesity among type II diabetics. Chapter 5 provides a summary of findings, implications, and recommendations.

This study will use data from the Diabetes Study of Northern California (DISTANCE), one of the largest, racially and ethnically diverse U.S. cohorts of diabetics followed in a managed care health system. This cohort was established to study social determinants of diabetes and is ideally suited to explore how neighborhood safety, using measures of perceived and objective crime, influence stress and cardiometabolic risk factors such as glycemic control and body mass index.

Discussion and Significance:

Diabetics are at risk for a multitude of diabetic complications and early mortality. Understanding how neighborhood level risk factors affect diabetic health may help alleviate diabetes sequelae. Contextual risk factors such as neighborhood crime and safety may be amenable to policy changes and may lead to additional effective interventions for diabetics.

Dedication

To my husband, Anuj, because he encouraged me to apply for a PhD and he has been a constant support for me throughout the program. Anuj has an unwavering belief in me. No idea was too outlandish, no dissertation method too unreasonable, and no request of him ever deemed unimportant. Every class and every step of my PhD was easier because he was there.

This is also dedicated to my daughters, Anica and Minali, because their excitement **every** morning inspires me to do something useful in the world. Their beautiful, innocent, and genuine words of encouragement during my PhD program always gave me some much needed perspective. I hope they remember that they are never too old or too tired to develop knowledge in a field and that hard work is the only reliable key to getting what you want at any age.

Acknowledgements

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Lastly, I acknowledge the help and support I received from my fellow students. We talked and breathed Epidemiology together throughout the program and I enjoyed every minute of it. Really, and I still do. Thank you for the countless hours talking Epidemiology with me and for helping me to understand something when I just could not get it.

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Chapter One

Introduction

Background and Significance

The Problem of Diabetes Mellitus in the U.S.

Chronic diseases are on the rise in the United States. One of the fastest growing chronic diseases is diabetes mellitus; a disease where problems in insulin production and/or insulin sensitivity may cause high levels of blood glucose to build up in the body, leading to damage of tissues and organ systems. At present, 29.1 million people (9.3%) are estimated to have diabetes mellitus and in 2012 1.7 million new cases were diagnosed in adults over the age of 20 [1, 2]. Diabetes is associated with age and as the population ages diabetes incidence is expected to grow. Currently 37% of U.S. adults aged 20 years or older and 51% of adults aged 65 years or older are pre-diabetic, at risk to develop diabetes [1, 2]. Diabetes prevalence has more than tripled between 1980 and 2010 (from 5.8 million to 25.8 million) and it is estimated that up to 33% of U.S. population may suffer from diabetes in the year 2050 2-4[2-4]. In addition, diabetes and its sequelae have high economic costs. The total direct medical costs and indirect (disability, work costs, premature mortality) costs for diabetes was calculated at $245 billion in 2012 [2, 5].

As with many other diseases, large racial/ethnic and socioeconomic disparities exist in diabetes prevalence [1, 6]. In adults 20 years and older 7.6% of Whites, 9% of Asians, 12.8% of Latinos, 13.2% of blacks, and 15.9% of American Indians/Alaska Natives have diagnosed diabetes after adjusting for age differences in each group [2]. The proportion of minorities in the U.S. is growing and higher rates of diabetes in these groups will increase diabetes prevalence and widen health disparities in the U.S. [7, 8].

Diabetes Sequelae

Poorly controlled diabetes can have serious health consequences and lead to early mortality. Diabetes sequelae include blindness, kidney disease, nervous system damage (neuropathy), amputation, pregnancy complications, heart disease, stroke, and many additional complications [2, 9-13]. In fact, diabetes is currently the leading cause of blindness, kidney failure and lower-extremity amputations and diabetics have a 2-4 times higher risk than non-diabetics for heart disease and stroke [9-11], the first and third leading causes of death in the U.S, respectively. The risk for death among diabetics is twice that of non-diabetics of the same age. Diabetes is currently the seventh leading cause of death in the U.S. but is likely underreported as only about **35% to 40%** of deceased individuals with diabetes list it anywhere on the death certificate and only **10% -15%** list diabetes as the underlying cause of death [14-17].

Currently, two effective ways to control diabetes and reduce or avoid diabetes complications are through glycemic control and weight management. Glycemic control, control of the blood glucose in the body, is measured through assessments at health care visits, primarily through the Hemoglobin A1c (HbA1c) test measuring glycemic control for a three month interval of time. The primary ways that diabetics can control their blood glucose are to follow a healthy diet, exercise regularly, and take glucose regulating medication if required [2, 4, 18]. On its own, weight management by either losing excess weight and/or maintaining a healthy weight can also reduce diabetic complications [2, 4, 19]. Regular access to quality health care and medications are essential to manage and monitor glycemic and weight control and the progression of diabetes. Furthermore, diabetics may require ongoing monitoring and medication for other diseases because diabetics tend to have other comorbidities such as hypertension and high cholesterol [2, 20, 21].

Although the list of health risk behaviors and health care needs for diabetes management are clear, the practice of self-management may be very difficult for diabetics. Weight management is difficult for diabetics who are often already overweight and glycemic control has proven difficult for many diabetics. Healthy People 2020 is a national health promotion and disease prevention initiative which aims to improve the health of the nation [22]. Every ten years Healthy People identifies nationwide health improvement priorities, sets health objectives and goals, increases public awareness of health, identifies health research needs, and encourages positive health practices and policies. One of Healthy People 2020 goals includes "to improve glycemic control among the population with diagnosed diabetes" through objectives to 1) reduce the proportion of diabetics with a HbA1c value greater than nine percent and to 2) increase the proportion of the diabetics population with a HbA1c value less than seven percent." This goal was in part due to studies documenting poor control among U.S. Adults among diabetes [23]. For example, data suggests that an estimated 16.2 percent of diabetic U.S. adults (2005-2008) have an HbA1c greater than nine percent and only 53.5 percent of diabetic adults have an HbA1c less than seven percent (a typical treatment target). Healthy People 2020 targets are to decrease the number of diabetics with HbA1c greater than nine percent to 14.6 percent and to increase the number of diabetics with HbA1c less than seven percent to 58.9 percent. Achieving these goals will no doubt necessitate efforts from a variety of areas that impact diabetes management.

Neighborhoods and Health

Historically, individual health behaviors and health care have been the primary focus of risk reduction strategies for diabetes but there is a growing interest in public health to explore how neighborhood environments can also affect health [24]. Public health researchers are now examining how an individual's health management not only involves individual-level behaviors but is also a function of other risk factors such as their neighborhood environment. Researchers are striving to understand how context and neighborhoods matter to health. Much work has been focused on how neighborhoods may be associated with diet, physical activity, and obesity [24].

Many theoretical frameworks for understanding how neighborhoods matter for health management can be found in other disciplines such as psychology and sociology. Frameworks like the Social Ecological Model have many adaptations but can be utilized to understand how neighborhoods impact diabetes management. One of these frameworks is founded from the Ecological Systems Theory (EST) developed by Bronfenbrenner in 1979 [25]. Bronfenbrenner was a developmental psychologist whose theory is based on the interrelationships between individuals and their environments. His theory illustrates that behaviors do not occur in a vacuum and that environments help shape individual health behaviors. He outlines that individuals are situated within several, nested levels of their environment. The levels are composed of four nested systems beginning with the microsystem and followed by the mesosystem, exosystem, and macrosystem in that order. Neighborhood influences are found in the microsystem and neighborhoods may be important influences of health behaviors such as physical activity, diet, and smoking; may increase prevalence of stress; and may influence health above and beyond that of individual characteristics [26, 27]. There are several other variations of the Socio Ecological Model but all have similar characteristics in that individuals have multiple, interrelated levels of exposure or influences on their development.

The neighborhood health literature has focused on three broad areas: the built (or physical) environment, the social environment, and socioeconomic features of neighborhoods. The built environment encompasses all the human made physical structures we may interact with

while in our neighborhoods including sidewalks, availability of recreational resources and land use. The social environment concerns the social context of neighborhoods, how individuals live together with one another, and neighborhood features include social cohesion, social support, and safety and violence. Neighborhood socioeconomic factors often use census level or respondent level aggregate measures of sociodemographic or economic position to get at some measure of the social or physical characteristics of neighborhoods [24, 28].

To date the majority of the literature about neighborhood influences on health has revolved around obesity, cardiovascular disease (CVD), and to a lesser degree mental health [24, 28, 29]. Studies of the built environment and BMI in healthy populations have been mixed. One review of the literature saw that only 85% (17 out of 20) of studies reported an association between a feature of the built environment (e.g. food and physical activity access, walkability) and BMI [30]. Studies of neighborhood economic disadvantage (e.g. % residents in poverty, receiving public assistance), air pollution, crime, segregation, and other factors have tied these neighborhood characteristics to obesity rates in older populations [24, 31]. Some studies have seen that economic and social factors influenced obesity for men and that attributes of physical neighborhood environment were more important for women in an older population [31]. To date, incidence of CVD and obesity have been tied to some facets of neighborhood such as neighborhood deprivation, low area socioeconomic position, low urbanization, service availability and residential density, low access to supermarkets and low social cohesion [29, 32-34]. In general, neighborhood studies provide some good support that neighborhoods matter for health management.

Diabetes management is complex and influenced by factors on the individual, familial, community, and sociocultural levels [28, 35]. Health management may require a great deal of individual behavior changes in physical activity, dietary behaviors, adherence to medication, and regular visits to health care providers. Most diabetic interventions to date have been focused on improving these behaviors and services at the individual level. Interventions have focused on patient education to improve or change behaviors related to diet, physical activity, and medication adherence. Other interventions have focused on improving medication options and treatment guidelines in health care services [36]. An important omission is how neighborhoods and other environments may influence self-care behaviors in significant ways.

The associations between neighborhoods may be even stronger in a chronically ill population such as those with diabetes. There is little research on the influence of neighborhood resources on diabetes, especially diabetes management, and findings suggest that neighborhood characteristics matter for diabetes prevalence, incidence, complications, and disability [27, 37, 38]. In one study, data was collected for neighborhood suitability for physical activity including neighborhood opportunities to be physically active and pleasantness to walk in neighborhood [38]. The same study also examined availability of healthy foods was measured by the presence of a large selection of fresh fruits, high quality fruit, and low-fat products within neighborhoods. A lack of physical activity and healthy food resources were associated with a higher incidence of type II diabetes when residents were followed for five years. Neighborhood deprivation, a measure of neighborhood economic disadvantage compiled from the U.S. census, was also associated with a global score of disability in a diabetic population. While studies of neighborhoods and diabetes are growing very few studies to date explore how neighborhood measures may be associated with diabetic sequelae and diabetes self-management.

Using neighborhood models and schematic representations developed for cardiovascular disease incidence (see Appendix: Figure 1) we may infer how neighborhood characteristics might affect diabetes management and outcomes [28, 29]. We may hypothesize that it may be difficult to follow a healthy and recommended diabetic diet in neighborhoods where no full service grocery stores or few healthy restaurants exist and where many fast food establishments are located [37]. It may also be difficult to maintain regular physical activity in neighborhoods that have high crime, few recreational facilities and parks, poor or few sidewalks, dangerous cross walks, and/or few neighborhood destinations to walk [38]. These neighborhood characteristics can act alone or in concert with each other to hinder diabetes self-management activities [27]. For diabetics a lack of environmental supports, such as poor neighborhood safety, may lead to chronic stress and/or hinder diabetic patients' efforts to exercise regularly or leave the home to purchase diabetic friendly foods, both important self-management measures for controlling diabetes. The effectiveness of interventions targeted at individual behaviors may be reduced when the environment constrains behavior change [28, 39, 40].

Neighborhood Safety

One neighborhood feature that may be important for health behaviors and diabetes management is neighborhood safety. The safeness of neighborhoods may be influenced by aspects of the social and built environment[41]. Crime is the primary safety factor of the social environment although social support and social cohesion within neighborhoods may provide added security for neighborhood residents [28]. Traffic safety, poor physical activity infrastructure (e.g. no/poor sidewalks, poor lighting), and indicators of social decay or disorder are safety factors of the built environment [41]. Poor traffic safety may involve inadequate management or regulation of vehicular traffic, high traffic density, and poor infrastructure for pedestrians and bicyclists. Documented indicators of social disorder and social decay include graffiti, broken windows, abandoned damaged structures, and other physical signs of neglect that may instill feelings of personal insecurity and unsafeness [41].

Residents may consider one, some, or all these types of safety factors when considering the safeness of their neighborhoods. Neighborhood safety can be studied using objective or subjective (or perceived) safety measures. Objective measures are often collected from administrative databases from law enforcement and subjective measures are often gathered from self-reports of neighborhood residents. Objective safety and crime measures using administrative data have been utilized to explore health behaviors [42-47]. These studies have used police data or published police reports in newspaper to establish crime rates within an individual's neighborhood either by using a census administrative unit or within a certain buffer of an individual's home (proxy for neighborhood). These crime data have often been linked to individual level data for semi-ecological or multi-level type study designs where crime exposure is measured on the group level but outcomes are measured at the individual level.

Studies published comparing objective and perceived safety measures indicate that these two types of measures may both be significant to health but may often play different roles in affecting health behaviors, processes, and outcomes [42, 46, 47]. Some of these studies found that adolescent and adult males' physical activity is associated with objectively measured levels of crime and adolescent and adult females' physical activity can be influenced by both level of crime and self-perceived safety [43-45]. Another study linked objective crime with worse physical health for women but not men and found independent associations of perceived crime with worse physical health [47].

Various measures of safety have been tied to health management behaviors, psychosocial stressors, and health outcomes among adults. Increased crime has been associated with constrained and lower levels of physical activity such as daily minutes walked [48, 49]. Safety has been tied to specific types of physical activity such as walking for transport (i.e. walking to bus, work, or store) and leisure walking but not with non-walking leisure activities such as team sports [46]. More recently, one study examining perceived neighborhood safety in African-Americans found that living in a neighborhood that was not safe from crime was associated with increased BMI and abdominal fat adiposity for premenopausal women but not postmenopausal women or men. In addition, crime has also been tied to mental health outcomes such as depression [50].

Few studies have examined associations between neighborhood safety and disease management with inconsistent results. For example, in a recent population based, cross-sectional study authors found that among diabetics, living in an unsafe neighborhood safety was associated with an increase in diabetic non-adherence, not refilling a medication prescription for any reason or because of costs [51]. Two cross-sectional studies in diabetics found an association between a greater number of perceived neighborhood problems (including how serious of a problem crime and lighting at night were) and poorer blood pressure and/or BMI but no association was found with glycemic control [52, 53]. However, an extensive review of the neighborhood crime, walking, and built environment [48] saw mixed results but overall unsafe neighborhoods had lower levels of physical activity for residents, especially in older residents and women.

Mechanisms Linking Neighborhood Safety and Health

Further research is also needed to understand the mechanisms and pathways connecting neighborhood safety to diabetic glycemic control and BMI. Schematic representations of neighborhoods on health and studies have previously described mechanisms that involve diet, physical activity, and stress. Neighborhood safety affects two of these mediators directly. First, poor safety affects the amount and quality of physical activity of diabetics in their immediate neighborhood [41, 54]. Physical activity is a critical method to manage weight and BMI because diet changes alone are often not enough to manage weight. Dropping excess weight improves BMI, decreases insulin resistance of the body, and in some cases can improve glycemic control [2].

The other primary connection between neighborhoods safety and glycemic control or BMI is through stress, the state of threatened homeostasis of physiological mechanisms in response to an exposure to stressors [55, 56]. As mentioned, neighborhood safety may increase the prevalence of stress in individuals [57]. As several studies have explored, stress has been seen to affect glycemic control directly [58, 59]. In the Faulenbach study, diabetics were subjected to a psychological stress test and their blood glucose levels were monitored. The study found that glucose levels were raised above the levels seen on a day when no psychological stress test was administered. The pathophysiology for elevated glucose in response to psychological stress is still not fully characterized but this study suggested that activation of the sympathetic system and the release of adrenalin and other hormones in this process may play a part in keeping glucose levels higher than normal. Similarly, stress may also lead to the development of obesity or high BMI through dysfunction of the hypothalamic-pituitary-adrenal (HPA) axis which produces elevated levels of cortisol [60, 61]. Elevated cortisol and prolonged activation of the sympathetic nervous system may also support the body's accumulation of visceral fat [56, 62]. Other studies have also seen the benefits of stress management and

interventions in relation to glycemic control and BMI of diabetics [63, 64]. The implications of long term stressors like living in unsafe conditions on glycemic control and BMI remains understudied.

Neighborhood Safety and Vulnerable Populations

Neighborhood safety may be of particular importance to vulnerable populations, many of which suffer disproportionately with diabetes. Studies of neighborhood safety, particularly those using crime and violence as a the measure of safety, have shown that women, older adults, racial/ethnic minorities, and those with low socioeconomic status (SES) report higher lower levels of safety than younger adults, men, whites, and the non-poor [42, 49, 65, 66]. There are several reasons why certain groups may feel more insecure or sensitive to safety concerns than others [48, 67]. Women and older adults often feel more physically vulnerable to victimization and less able to protect themselves. Minorities and individuals with low SES often reside or spend more time in more unsafe and poorer environments due to long standing racial/ethnic, and economic residential segregation and the inability to move out of unsafe areas [65, 67]. Furthermore, vulnerable populations may also have fewer resources to buffer the negative effects of unsafe neighborhoods. Residence in unsafe neighborhoods may disproportionately affect certain populations and the adverse reaction of living in poorer neighborhoods may be higher in these vulnerable populations. Studies and reviews have shown effect modification by different vulnerable groups in the relation to neighborhoods and obesity and more research is necessary to understand how this association varies across subgroups [65].

Research Gaps and Implications

One of Healthy People 2020's four overarching goals includes a goal to "create social and physical environments that promote good health for all [22]." Understanding and reducing the effects of living in unsafe residential environments due to neighborhood crime and safety and emphasizing ecological approaches to reducing diabetes morbidity and mortality are clear goals for Healthy People 2020.

Furthermore, national attention has been placed on the increasing problem of diabetes. Healthy People 2020 includes a goal to: "Reduce the disease and economic burden of diabetes mellitus (DM) and improve the quality of life for all persons who have, or are at risk for, DM" [22]. Three of the healthy people objectives to achieve this goal are to: "reduce the death rate among the population with diabetes, reduce the diabetes death rate, and reduce the rate of lower extremity amputations in persons with diagnosed diabetes." Addressing these objectives to reduce the burden of diabetes will require efforts on number of fronts including health care access and addressing barriers to positive health risk behaviors such as physical activity and nutrition.

There are many gaps in the current literature concerning neighborhood features and diabetic management. First, very few studies have been done in diabetics and little known about the ways that diabetics are affected by their environments and safety [68]. Second, most studies of neighborhood safety are based on self-reported neighborhood safety and crime and few studies exist using objective measures of crime and safety. Third, there are few studies with diverse study populations powered to examine how any associations between neighborhood safety and health outcomes may differ for different race/ethnic groups or other subpopulations.

Research Questions

The proposed research will provide an in depth investigation of one feature of neighborhoods, neighborhood safety. In this study we will examine if and by what mechanisms neighborhood safety, measured using perceived neighborhood crime and objective crime data may affect stress, physical activity, glycemic control and/or BMI in a large diabetic cohort. We will also be able to investigate if safety influences diabetic control differently by race/ethnic group and/or by gender. Little research has been done on neighborhood safety among diabetics. Areas of possible interventions and/or policies to improve health and reduce sequelae can be expanded by this type of research. Improving neighborhood conditions or addressing personal safety concerns may prove to be beneficial in reducing poor outcomes in diabetics and the burden of this disease.

Proposed Methodology

The overall goal of the proposed research is to investigate the associations for neighborhood safety and management of diabetes. The proposed research will use data from the DISTANCE study, a cohort followed within the Kaiser Permanente Northern California (KPNC) managed care plan since 2005. DISTANCE is one of the largest (n=21,188) and most racially/ethnically, socioeconomically, and geographically diverse cohorts of diabetics in the U.S. The DISTANCE cohort provides a unique opportunity to model individual and neighborhood level predictors of diabetes management including stress, glycemic control, BMI, and health behaviors. The specific aims include:

Research Aim 1: To examine associations between perceived neighborhood crime and stress, physical activity, body mass index (BMI) independent of individual-level factors.

Research Aim 2: To examine cross-sectional associations between neighborhood police recorded crime and perceived stress, independent of individual and other neighborhood level factors.

- Aim 2a: To examine if race/ethnicity and/or gender modify any associations between neighborhood safety and stress.

Research Aim 3: To examine associations between neighborhood police recorded crime and body mass index (BMI), independent of individual and other neighborhood level factors.

- Aim 3a: To examine if race/ethnicity and/or gender modify any associations between neighborhood safety and BMI.

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Appendices

Figure 1: Schematic Representation of Possible Pathways Linking Residential Environments to Cardiovascular Risk

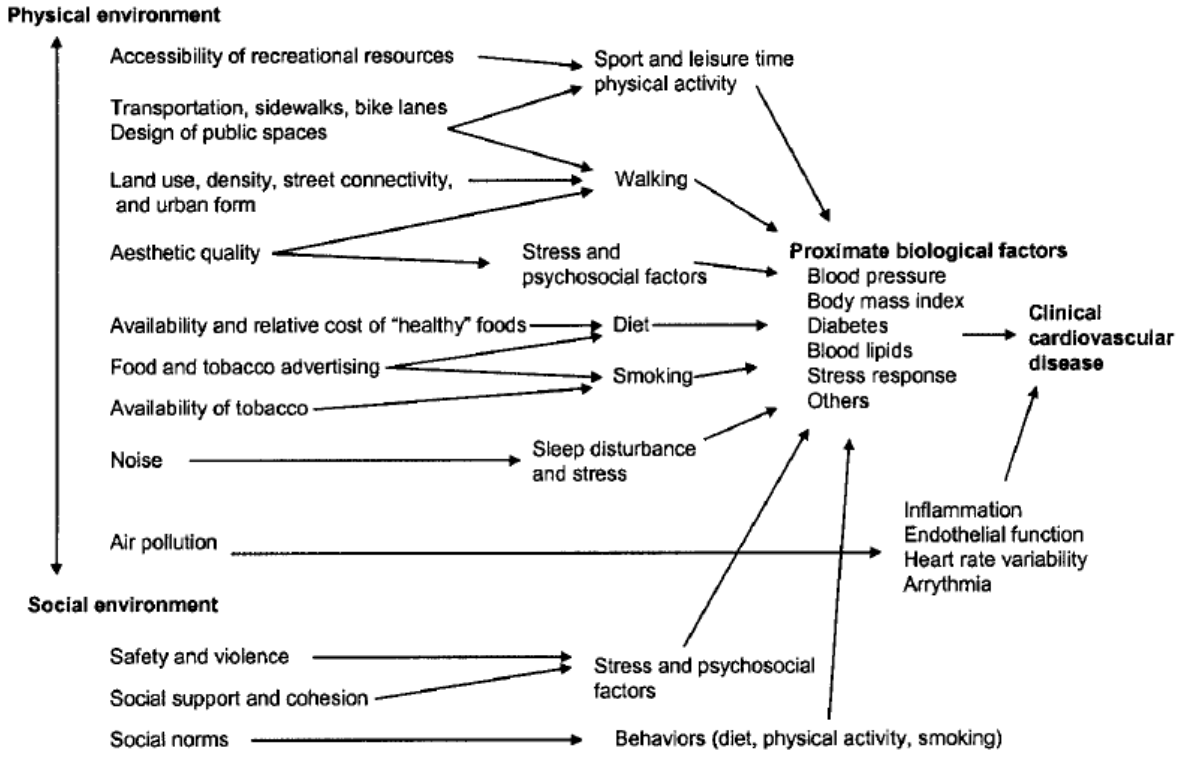


FIGURE Schematic representation of possible pathways linking residential environments to cardiovascular risk.

Source: Diez Roux AV. Residential environments and cardiovascular risk. J Urban Health 2003;80(4):569-89.

CHAPTER TWO

Perceived Neighborhood Safety and Crime in Relation to Cardiometabolic Risk Factors Among a Population of Type II Diabetics

ABSTRACT

Neighborhood built environments have been extensively studied in the literature but less is known how perceptions of the social environment may relate to health behaviors, body mass index (BMI), and glucose control in diabetics. Using a subsample (mean age: 63.2 range: 36-82) of a managed care plan diabetes cohort, we examined associations between perceptions of general neighborhood safety and recent neighborhood violent crime with self-reported stress and physical activity as well as clinical measurements of BMI, and hemoglobin A1c (HbA1c). Perceived crime, physical activity, and stress were collected as part of a survey in 2010-2011 and clinical measures of BMI and HbA1c were collected from 2012 medical records. Neighborhood safety was measured using self-reports of any neighborhood safety concerns versus no concerns and through any reports of violent crimes versus no violent crime occurring in respondents' neighborhood. Results: In our study (n=721), approximately 54% of the sampler reported any general neighborhood safety concern and 15% indicated having any neighborhood violent crimes. Both general (β=1.14, 95% C.I. 0.04-2.24) and violent crime (β=2.04, 95% C.I. 0.34-3.73), categorized as any versus none, were associated with increase in a continuous measure of BMI, after adjustment for age, sex, race/ethnicity, household income, and education. When dichotomous BMI was examined, violent neighborhood crime was associated with extreme obesity (BMI≥35) after adjustment (OR= 1.34, 95% CI: 1.02, 1.75). There were no significant associations between neighborhood safety and violent crime and stress, physical activity, and HbA1c, in adjusted models. Discussion: Perceived neighborhood safety may be associated with BMI and extreme obesity in some diabetics. Future studies, especially using longitudinal designs, are needed to study how people with diabetes may be influenced by poor personal security in their neighborhoods.

INTRODUCTION

Incidence and prevalence of chronic diseases such as diabetes are increasing in the U.S. as are the sequelae of these diseases [1]. Research and interventions to reduce diabetic morbidity and mortality have primarily targeted changes in individual level risk behaviors related to physical activity, diet, and adherence to medication [2]. More recently, there has been a growing study of how the built environment may influence health however studies of the social environment, such as neighborhood safety are sparse [3]. Neighborhood social environment can be described as the relationships or interactions and other social processes of individuals and groups in neighborhoods [4]. Neighborhood social environment can be measured using neighborhood level socioeconomic status, social norms, quality of social support and cohesion, and level of safety or violence [5].

Residential social environments, including features of neighborhood safety may influence diabetic stress, physical activity, weight management, and glucose control [6]. Fear of walking in one's neighborhood, low confidence in one's neighbors and social isolation may lead to increased stress and other poor psychosocial or health outcomes [5, 7]. Crime is a strong influence for neighborhood safety and it is comprised of both reported and unreported crime that may occur or that may be perceived as occurring within someone's home [5, 8]. Most of the neighborhood safety studies to date have used self-reported or perceived measures of neighborhood safety and this remains a useful manner to measure safety because even if perceptions of safety are inaccurate, they would still serve to constrain or modify a person's behavior and physiological responses such as stress [8]. Little research about perceived crime exists in diabetic populations.

There are inconsistent findings in general populations about the associations between perceived neighborhood safety and crime with physical activity and obesity. Several studies have documented that adolescent and adult females' physical activity is influenced by perceived safety and one study saw that crime was associated with increased average weekly walking time [6, 8, 9]. Two other studies in adults also found that perceiving higher neighborhood safety was associated with having lower BMI compared to those living in less safe residential areas [10, 11]. Some studies, however, have found no association of crime with BMI or physical activity [12, 13]. Mixed findings in this research may be influenced by the different study populations that include adolescents, only rural or urban residents, and/or few racial groups within these studies.

Even less research has been published about neighborhood safety's relationship to stress or glucose control and moreover, in all studies of neighborhood crime only two have been conducted in diabetic populations [14-16]. The two studies that included some measure of crime in diabetics both looked at how neighborhood problems overall were associated with BMI and blood pressure (BP). These studies found that neighborhood problems were associated with poorer control of BMI or BP. Both studies examined an index of all neighborhood problems that include neighborhood aesthetics, physical activity and food environment along with crime but these studies did not examine associations with crime and safety problems alone. For these and other studies of indices of neighborhood problems, crime is cited as the most commonly reported problem or is a strong influence on neighborhood problem indices. It may be useful to understand the influence of crime and safety factors alone on health outcomes in diabetics.

The overall goal of this study is to examine cross-sectional associations between perceived neighborhood safety and violent crime and cardiometabolic factors independent of individual level sociodemographic characteristics among a racially and ethnically diverse sample of diabetics enrolled in a managed care plan. We hypothesized that perception of one's neighborhood as unsafe and having recent incidents of violent crime would be associated with higher stress, less physical activity, poorer cardiometabolic factors, including higher BMI and higher HbA1c.

METHODS

Data and Sample

Sample and Study Design

Data for this study was collected in 2010-2011 from a subset of participants of the Diabetes Study of Northern California (DISTANCE) cohort. DISTANCE is a large, ethnically-diverse cohort (n=20,188) of diabetic adults aged 36-82, followed since 2005 by Kaiser Permanente Northern California (KPNC) a non-profit, group practice health plan. A complete description of the DISTANCE study methods, cohort and survey has been published previously [17].

Cohort members were eligible for inclusion in this subsample if they had type 2 Diabetes, current KPNC membership, were English speaking, and living at a non-rural address. The subsample was randomly selected from the DISTANCE cohort and oversampling individuals who lived in a poor food environment. A total of 770 of 1,500 participants completed the study survey for a response rate of 56.6%, after accounting for eligibility and people who were unable to be contacted. All study protocols were approved by UCSF and Kaiser Permanente Institutional Review Board Human Subjects Committee.

Study Exposures

Perceived neighborhood safety measures were derived from seven survey questions that asked respondents about general neighborhood safety and the recent occurrence of specific violent crimes. These measures on neighborhood environment have been validated in previous studies [18, 19]. A participant's general neighborhood was considered safe if participants agreed or strongly agreed to three questions, based on a five point Likert scale, asking if they felt their neighborhood was safe day or night, if violence was not a problem in their neighborhood, and if the neighborhood was safe from crime (Cronbach's alpha=.78). Neighborhoods were considered to be safe if respondents "agreed" or "strongly agreed" that their neighborhoods were safe or free of violence and crime. Neighborhoods were considered unsafe if respondents "neither agreed nor disagreed", "disagreed", or "strongly disagreed" with any of these general safety questions.

Four questions based on a four point Likert scale asked if specific violent crimes had occurred in the participant's neighborhood in the six months before the survey (Cronbach's alpha= .83). Participants were asked how often there had been a fight which a weapon was used, gang fights, sexual assault or rape, and a robbery/ mugging in their neighborhood within the last six months (responses: Often, Sometimes, Rarely, Never). Participants reporting that any of these crimes had occurred "often" or "sometimes" in their neighborhood were considered to have

high neighborhood crime. Participants who reported that all these crimes occurred "rarely" or "never" occurred in their neighborhood were considered to have low neighborhood crime. General safety and specific neighborhood crime were treated as separate exposures for this analysis as they did not have a strong correlation and might be capturing different aspects of neighborhood safety (Pearson correlation= 0.37 p=.0000). Few individuals clustered by neighborhoods in our study (mean: 1.1; range: 1 - 3 persons per census block group neighborhood) so we did not create an average score of crime across neighborhoods by aggregating residents by neighborhood.

Study Outcomes

There are four dependent variables for the analyses: stress, physical activity, body mass index (BMI) and hemoglobin A1c (HbA1c). Stress, BMI, and HbA1c were considered as both continuous and dichotomous measures. Physical Activity was a dichotomous measure. Below we provide details of each measure.

Perceived Stress Scale

Respondents perceived stress over the past four weeks was assessed using Cohen's 4-item Perceived Stress Scale (PSS-4 short version) [20]. The PSS-4 is a four item, self-report instrument that has been validated in ethnically diverse populations, with a five point scale with questions on how respondents view the stress of situations in one's life including how often respondents felt they were unable to control important things in their life or felt confident to handle personal problems (responses: never, almost never, sometimes, fairly often, very often) [20, 21]. Questions indicating more control or less stress are reverse-coded and the PSS-4 is summed across the four stress-related questions. Higher scores on the PSS-4 reflect higher stress levels. For this study, we calculated the mean score for the PSS questions and dichotomized PSS into higher stress as a mean PSS of >2 and lower stress, PSS≤2. The cut off point for this measure is the equivalent of people feeling they were almost never or never in control of their life or confident to handle problems and always or almost always felt things were not going their way and felt difficulties were piling up so high they could not overcome them.

Physical Activity

Physical Activity was measured using the International Physical Activity Questionnaire (IPAQ) short version that asks respondents about walking, moderate, and vigorous physical activities [22]. IPAQ assesses the time spent on the three types of physical activity and assigns metabolic expenditures for the activity using a scoring protocol. The IPAQ has been validated for adults 18-65 in diverse countries and populations and a complex scoring protocol and cutoffs, described elsewhere, is used to categorize levels of physical activity [22]. IPAQ cut points were used to create two categories: insufficient or sufficient physical activity.

BMI and Hemoglobin A1c

Cardiometabolic clinical risk factors including BMI and HbA1c, were ascertained through clinical records and using the mean of clinical measurements taken in 2012. Body mass index (BMI, in kg/m2) was calculated using a clinical measurement of weight and height recorded during an outpatient visit from clinical records in 2012. Glycosylated hemoglobin (HbA1c), an integrated measure of blood glucose control over approximately past three months,

was analyzed from a central KPNC laboratory and collected from electronic records. We examined BMI and HbA1c both as continuous and dichotomous measures. Diabetic populations have higher than average rates of obesity and extreme obesity and diabetes management involves reducing weight especially for those who have extreme obesity. Very extreme obesity (BMI>35) and very poorly controlled HbA1c (HbA1c>9) were derived to examine the poor control of these clinical outcomes among diabetics.

Covariates

Covariates for the analysis include age, sex, race/ethnicity, education, and income. Age and sex were collected from KPNC administrative data. Respondent age at time of survey was calculated using date of birth in administrative data and the date survey was completed. Other covariates were collected from the survey including race/ethnicity (African American, Asian, Latino, White non-Latino, and Other race including missing). Socioeconomic indicators included education (defined as high school degree or less or more than high school, employment status (working/student, retired, unemployed/other) and household income. We defined household income as self-reported family income divided by the poverty line income for a given age and household size based on the US Department of Health and Human Services 2010 Poverty Guidelines (23). We categorized percent of poverty into four categories (< 130%, 130 - <200%, 200-<400%, > 400%). A missing indicator was included for the 13.2% respondents who chose not report their income (n= 95).

Statistical Analysis

We conducted bivariate analyses of perceived neighborhood general safety and incidents of violent crimes by patient sociodemographic factors and cardiometabolic outcomes. Chi-square tests and one-way analysis of variance tests were used to assess associations with categorical and continuous measures with our exposures, respectively. Pearson correlations were used to examine associations between continuous sociodemographic characteristics and outcomes.

Linear and logistic regression using generalized linear models (GLM) using main terms, robust standard errors, and accounting for clustering (using Huber/White sandwich estimator) at the census block group level were used to examine unadjusted and adjusted associations between perceived crime and our outcomes measured continuously and categorically [23]. GLM is a marginal linear model estimator able to account for neighborhood clustering and can be used to estimate prevalence risks or relative risks even for common dichotomous outcomes. In addition, Modified Poisson and GLM was used to model the prevalence ratios for dichotomous outcomes that were common (i.e. extreme obesity and physical activity) in our population (>20%) [24, 25]. Age was centered in our models. All analyses were performed using STATA/SE 13.1.

RESULTS

Among our original (N=770), 39 (4.8%) people had missing values for both general safety and violent crime responses, 9 people had missing education, and 1 person was missing all outcomes and not included in the final analytic sample (n=721). Not all respondents answered questions or had lab measurements for study outcomes, subsequently, sample size vary slightly (stress n=704, physical activity n=675, BMI n=644, and HbA1c n=673).

In this sample, the mean age was 63.2 (SD=9.9), 52.6% were female and 22.9% were white, 23.3% African American, 17.2% Latino, 20.8% Asian, and 16% other or unknown race/ethnicity. Forty two participants (5.8%) had high stress, 353 (49%) had insufficient physical activity, 119 (17.7%) had uncontrolled HbA1c, and 199 (30.9%) people were extremely obese (BMI <35). In our study, 385 (53.4%) respondents reported at least one general neighborhood safety concern and110 (15.3%) cited at least one incidence of violent crime in their neighborhood.

Table 1 shows sample characteristics overall and by dichotomous study outcomes for the study sample (n=721) that included respondents with any of our two exposures and outcomes. Stress was associated with gender (p<0.000) and income (p=.04) where more women than men (8.1% vs 3.6%) and those with the lowest income had more stress (12.7%) than people with the highest income (3.4%). Physical Activity was associated with sex, (p=<.000), education (p=.009), and income (p=.002). BMI was associated with age, sex, and race/ethnicity (all p<.000). More women (37.6%) than men (23.5%), tended to be extremely obese. Rates of extreme obesity differed for African-Americans (40%), Asians (8%), Latinos (31%), Other race/ethnicity (35%), and Whites (39%). HbA1c was associated with only age (p<.000) and race/ethnicity (p=.001). Sociodemographic characteristics and continuous measures of stress, BMI, and HbA1c revealed the same trends as categorized measures of the outcomes (not shown). Women had higher mean stress, BMI, and HbA1c than men. Race/ethnicity was related to mean BMI and HbA1c (both p<.0001) where Whites had the highest mean BMI (33.7) compared to African-Americans (33.2), Latino (33.4), Asian (27.8), and Other race (32.9) respondents. For HbA1c, African-Americans and Latinos both had the highest HbA1c (mean=8.2) compared to Whites (7.5), Asians (7.7), and Other race (7.8) group respondents.

Sample characteristics by our two study exposures, general neighborhood safety concerns and violent neighborhood crime are found in Table 2 results. More females (61.5%) than males (46.5%) and certain race/ethnic groups such as African-Americans (64.6%) and other race/ethnicity (61.4%) compared to Asians (37%) perceived greater general safety concerns. Those who had lower education indicated more violent crimes (19.3%) occurred in their neighborhoods than those with higher education (12.5%).

Figure 1 describes the age and gender adjusted prevalence of perceived neighborhood safety by the study outcomes. Perceived neighborhood safety and violent crime was associated with prevalence of high stress and extreme obesity, independent of age and gender. Those who endorsed living in an unsafe neighborhood safety or a neighborhood with violent crime in the past six months had a higher prevalence of high stress and extreme obesity compared to those living in safe neighborhoods with no recent incidents of violent crime.

Multivariate Results

Table 3 shows the results from the multivariate logistic regression for dichotomous measures of stress, physical activity, BMI, and HbA1c in relation to any neighborhood safety and any violent crime. Reporting any violent neighborhood crime was associated with a 1.34 (95% CI 1.02- 1.75) increased odds of having extreme obesity adjusting for age, gender, race/ethnicity, income, and education. Additional adjustments for possible mediators, stress and physical activity, did not change results (OR: 1.32, 95% CI: 1.00- 1.74). Any general neighborhood safety concerns was not associated with extreme obesity for either model 1 (OR:

1.24, 95% CI .97-1.59, p=.09) or model 2 (OR: 1.25, 95% CI .97-1.6 p=.08). There was no association between any neighborhood general safety concerns or any violent crime with dichotomous measures of stress, physical activity, and Hba1c.

Unlike our categorical analysis of BMI, the analysis using continuous BMI found significant associations with both general safety and violent crime in both model 1 and model 2 (Table 4). Participants' perception of having general neighborhood safety concerns was associated with a 1.14 point higher BMI (95% CI: 0.04 - 2.24) and reports of violent crime was associated with a 2.04 higher in BMI (95%CI: 0.34 -3.73) compared to participants not reporting neighborhood unsafeness, independent of age, gender, race/ethnicity, income, and education. For models that included physical activity and stress, higher BMI remained associated with reports of both general safety (β: 1.22 95% CI: 0.12- 2.32) and with violent crime in neighborhoods (β: 2.13, 95% CI: 0.48, 3.77). There was no association between safety and continuous stress or HbA1c.

There was no association of crime between neighborhood general safety or violent crime and dichotomous or continuous measures of stress, HbA1c, and dichotomous physical activity. We also tested interactions between race and perceived crime but did not have sufficient power to evaluate any associations.

Table 1: Sociodemographic Characteristics and Study Outcomes

Sociodemographic Characteristics	Total Study Sample	Stress (n=704) No high stress Mean PSS≤2	Stress (n=704) High Stress Mean PSS>2	Stress (n=704) p-value*	Physical Activity (n=675) Sufficient Physical Activity	Physical Activity (n=675) Insufficient Physical Activity	Physical Activity (n=675) p-value*
All Sample	721	662 (91.8%)	42 (5.8%)		322 (44.7%)	353 (49%)	
Mean age in years (SD)	63.2 (9.9)	63.3 (9.9)	60.5 (10)	0.082	62.3 (9.5)	64.1 (10.1)	**0.020**
Sex							
Female	379 (52.6%)	340 (91.9%)	30 (8.1%)	**0.012**	138 (39.2%)	214 (60.8%)	**<0.000**
Male	346 (47.4%)	322 (96.4%)	12 (3.6%)		184 (57%)	139 (43.0%)	
Race/Ethnicity							
White	165 (22.9%)	156 (95.7%)	7 (4.3%)	0.551	79 (50%)	79 (50%)	0.815
African American	167 (23.2%)	154 (93.9%)	10 (6.1%)		74 (47.4%)	82 (52.6%)	
Latino	124 (17.2%)	114 (93.4%)	8 (6.6%)		49 (43.4%)	64 (56.6%)	
Asian	150 (20.8%)	137 (95.1%)	7 (4.9%)		66 (46.8%)	75 (53.2%)	
Other/Missing	115 (16%)	101 (91%)	10 (9%)		54 (50.5%)	53 (49.5%)	
Education							
≤ High School/GED/TS	377 (51.6%)	343 (93.7%)	23 (6.3%)	0.711	151 (42.9%)	201 (57.1%)	**0.009**
More than HS/GED/TS	344 (47.1%)	319 (94.4%)	19 (5.6%)		171 (52.9%)	152 (47.1%)	
% Poverty Line							
< 130%	62 (8.6%)	48 (87.4%)	7 (12.7%)	**0.038**	18 (31.6%)	39 (68.4%)	**0.002**
130% - <200%	70 (9.7%)	62 (89.9%)	7 (10.1%)		33 (53.2%)	29 (46.8%)	
200% - <400%	229 (31.8%)	213 (93.4%)	15 (6.6%)		94 (43.3%)	123 (56.7%)	
> 400%	265 (36.8%)	255 (96.6%)	9 (3.4%)		143 (55.9%)	113 (44.1%)	
Missing	95 (13.2%)	84 (95.5%)	4 (4.6%)		34 (41%)	49 (59%)	

n (%) reported in table cells unless otherwise noted.
*p-values were calculated using chi-square tests of association for categorical sociodemographic characteristic and analysis of variance for continuous sociodemographic characteristics.

Table 1: Sociodemographic Characteristics and Study Outcomes (continued)

Sociodemographic Characteristics	Total Study Sample	BMI (n=644)			HbA1C (n=673)		
		BMI ≤35	BMI >35	p-value	HbA1C ≤9%	HbA1C >9%	p-value
All Sample	721	445 (69.1%)	199 (30.9%)		554 (82.3%)	119 (17.7%)	
Mean age in years (SD)	63.2 (9.9)	65.3 (9.7)	59.7 (9.4)	**<0.000**	64.6 (9.7)	58.3 (8.8)	**<0.000**
Sex							
Female	379 (52.6%)	211 (62.4%)	127 (37.6%)	**<0.000**	285 (81.4%)	65 (18.6%)	0.529
Male	346 (47.4%)	234 (76.5%)	72 (23.5%)		269 (83.3%)	54 (16.7%)	
Race/Ethnicity							
White	165 (22.9%)	92 (61.3%)	58 (38.7%)	**<0.000**	137 (87.3%)	20 (12.7%)	**0.001**
African American	167 (23.2%)	93 (59.6%)	63 (40.4%)		120 (76.4%)	37 (23.6%)	
Latino	124 (17.2%)	75 (69.4%)	33 (30.6%)		83 (72.8%)	31 (27.2%)	
Asian	150 (20.8%)	120 (92.3%)	10 (7.7%)		124 (89.2%)	15 (10.8%)	
Other/Missing	115 (16%)	65 (65%)	35 (35%)		90 (84.9%)	16 (15.1%)	
Education							
≤ High School/GED/TS	377 (51.6%)	232 (68.2%)	108 (31.8%)	0.616	275 (79.7%)	70 (20.3%)	0.069
More than HS/GED/TS	344 (47.1%)	213 (70.1%)	91 (29.9%)		279 (85.1%)	49 (14.9%)	
% Poverty Line							
< 130%	62 (8.6%)	36 (66.7%)	18 (33.3%)	0.442	39 (72.2%)	15 (27.8%)	0.215
130% - <200%	70 (9.7%)	44 (73.3%)	16 (26.7%)		49 (80.3%)	12 (19.7%)	
200% - <400%	229 (31.8%)	139 (68.8%)	63 (31.2%)		185 (85.3%)	32 (14.8%)	
> 400%	265 (36.8%)	161 (66.3%)	82 (33.7%)		207 (81.5%)	47 (18.5%)	
Missing	95 (13.2%)	65 (76.5%)	20 (23.5%)		74 (85.1%)	13 (14.9%)	

n (%) reported in table cells unless otherwise noted.
*p-values were calculated using chi-square tests of association for categorical sociodemographic characteristic and analysis of variance for continuous sociodemographic characteristics.

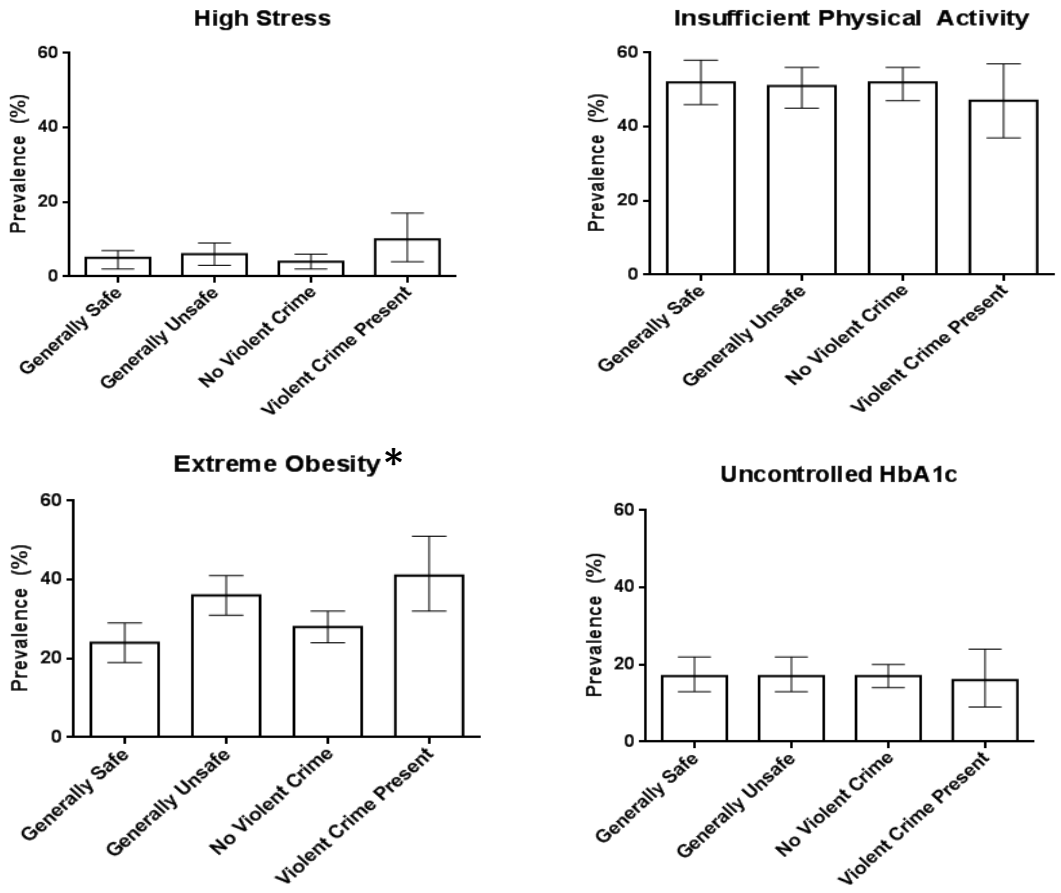
Table 2: Sociodemographic Characteristics and Study Exposures, Perceived General Neighborhood Safety and Violent Crime

	Perceived Neighborhood Safety Concerns n=709			Perceived Neighborhood Violent Crime n=683		
Sociodemographic Characteristics	**No Neighborhood safety concerns** (44.9%)	**Any neighborhood safety concerns** (53.4%)	**p-value***	**No violent crimes** (79.5%)	**Any violent crimes** (15.3%)	**p-value***
Mean age in years (SD)	63.2 (10.2)	63 (9.7)	0.769	63.5 (9.9)	62.6 (10)	0.369
Sex						
Female	143 (38.5%)	228 (61.5%)	**<0.000**	294 (82.6%)	62 (17.4%)	0.331
Male	181 (53.6%)	157 (46.5%)		279 (85.3%)	48 (14.7%)	
Race/Ethnicity						
White	80 (49.4%)	82 (50.6%)	**<0.000**	136 (86.1%)	22 (13.9%)	0. 257
African American	58 (35.3%)	106 (64.6%)		133 (84.7%)	24 (15.3%)	
Latino	50 (41.0%)	72 (59.0%)		93 (78.2%)	26 (21.9%)	
Asian	92 (62.6%)	55 (37.4%)		124 (87.3%)	18 (12.7%)	
Other	44 (38.6%)	70 (61.4%)		87 (81.3%)	20 (18.7%)	
Education						
≤ High School/GED/TS	159 (43.1%)	210 (56.9%)	0.146	293 (80.7%)	70 (19.3%)	**0.016**
More than HS/GED/TS	165 (48.5%)	175 (51.5%)		280 (87.5%)	40 (12.5%)	
% Poverty Line						
< 130%	21 (35%)	39 (65%)	0.282	48 (78.7%)	13 (21.3%)	0.374
130% - <200%	34 (50%)	34 (50%)		56 (83.6%)	11 (16.4%)	
200% - <400%	97 (43.7%)	125 (56.3%)		175 (82.6%)	37 (17.5%)	
> 400%	130 (49.2%)	134 (55.8%)		211 (84.1%)	40 (15.9%)	
Missing	42 (44.2%)	53 (55.8%)		83 (90.2%)	9 (9.8%)	

n (%) reported in table cells unless otherwise noted.

*p-values were calculated using chi-square tests of association for categorical sociodemographic characteristic and analysis of variance for continuous sociodemographic characteristics.

Figure 1: Age and Gender Adjusted Prevalence of Cardiometabolic Factors by Perceptions of Neighborhood General Safety and Violent Crime[1]



Age and gender adjusted prevalence were calculated using Generalized Linear Models (GLM) with clustering at the census block group level with robust SEs, adjusted for age and gender. Modified poisson models were used for extreme obesity and physical activity.

[1] P-values for age and gender adjusted prevalence: stress (general safety p=0.564, violent crime p=0.053), physical activity (general safety: p= 0.413, violent crime: p= 0.514), extreme obesity (general safety p= 0.006, violent crime p=0.031), and hbA1c (general safety p=0.812, violent crime p=0.501).

*p-value <.05

Table 3: Associations from Adjusted Logistic Regression of Stress, Physical Activity, BMI, and HbA1c by Perceived General Neighborhood Safety or Neighborhood Violent Crime

Outcomes – Dichotomized

	High Stress (n=704)		**Insufficient Physical Activity (n=675)**		**Extremely Overweight (BMI>35) (n=644)**		**Uncontrolled HbA1c (HbA1c >9%) (n=673)**	
	PR 95%CI	p-value	PR 95%CI	p-value	PR 95%CI	p-value	PR 95%CI	p-value
Any Neighborhood General Safety Concerns[1]								
Model 1	1.10 [0.50 - 2.43]	0.82	0.94 [0.79 -1.10]	0.42	1.24 [0.97 - 1.59]	0.09	0.80 [0.49 - 1.30]	0.37
Model 2	n/a	n/a	n/a	n/a	1.25 [0.97 - 1.60]	0.08	0.79 [0.49 - 1.28]	0.34
Any Neighborhood Violent Crime[2]								
Model 1	2.04 [0.83 -4.98]	0.12	0.91 [0.73 - 1.15]	0.43	1.34 [1.02 - 1.75]	**0.03**	0.83 [0.43 - 1.59]	0.57
Model 2	n/a	n/a	n/a	n/a	1.32 [1.00 - 1.74]	**0.05**	0.81 [0.42 - 1.56]	0.52

[1]Neighborhood General Safety – Any general safety concerns: if participants disagreed or strongly disagreed with any question regarding whether their neighborhood was safe day or night, if violence was not a problem in their neighborhood, and if the neighborhood was safe from crime. No safety concerns: participants agreed/strongly agreed to all questions.
[2]Neighborhood Violent Crime – Any violent crime: Neighborhood considered to have violent crime if participants reported often/sometimes to any question asking whether there had often or sometimes been a fight which a weapon was used, gang fights, sexual assault or rape, and a robbery/ mugging in their neighborhood. No violent crime: if participants reported rarely or never to all questions.

Model 1 adjusted for age, sex, race/ethnicity, household income, and education.

Model 2 adjusted for age, sex, race/ethnicity, household income, education, stress, and physical activity

Table 4: Associations from Adjusted Clustered Linear Regression of Stress, Physical Activity, BMI, and HbA1c by Perceived General Neighborhood Safety or Neighborhood Violent Crime

Outcomes - Continuous

	Continuous Stress (n=704)		**Physical Activity (n=675)***		**Continuous BMI (n=644)**		**Continuous HbA1c (n=673)**	
	β 95%CI	p-value			β 95%CI	p-value	β 95%CI	p-value
Any Neighborhood General Safety Concerns [1]								
Model 1	0.05 (-0.07, 0.17)	0.45	n/a	n/a	1.14 (0.04, 2.24)	**0.04**	-0.08 (-0.32, 0.17)	0.53
Model 2	-	-	n/a	n/a	1.22 (0.12, 2.32)	**0.03**	-0.07 (-0.32, 0.17)	0.56
Any Neighborhood Violent Crime[2]								
Model 1	0.13 (-0.03, 0.29)	0.12	n/a	-	2.04 (0.34, 3.73)	**0.02**	-0.02 (-0.35, 0.32)	0.93
Model 2	-	-	n/a	n/a	2.13 (0.48, 3.77)	**0.01**	-0.01 (-0.35, 0.32)	0.95

* Physical Activity scale (IPAQ) is not used as a continuous measure.

[1]Neighborhood General Safety – Any general safety concerns: if participants disagreed or strongly disagreed with any question regarding whether their neighborhood was safe day or night, if violence was not a problem in their neighborhood, and if the neighborhood was safe from crime. No safety concerns: participants agreed/strongly agreed to all questions.

[2]Neighborhood Violent Crime – Any violent crime: Neighborhood considered to have violent crime if participants reported often/sometimes to any question asking whether there had often or sometimes been a fight which a weapon was used, gang fights, sexual assault or rape, and a robbery/ mugging in their neighborhood. No violent crime: if participants reported rarely or never to all questions.

Model 1 adjusted for age, sex, race/ethnicity, household income, and education.

Model 2 adjusted for age, sex, race/ethnicity, household income, education, stress, and physical activity

DISCUSSION

In our study of diabetic members of a managed care plan we examined whether two measures of perceived neighborhood safety, general neighborhood safety concerns and reports of violent crime in the neighborhood were related to cardiometabolic risk factors including stress, physical activity, BMI, and HbA1c. We found that neighborhood violent crime was associated with extreme obesity (BMI>35) independent of age, sex, race/ethnicity, income, and education in this cross-sectional study. Additional adjustment of possible mediators, stress and physical activity did not attenuate the findings. We also found that both neighborhood general safety and violent crime were associated with continuous BMI. There were no associations with the other study outcomes of stress, physical activity, and HbA1c.

This study contributes to the literature exploring neighborhood influences in a population with diabetes in two ways. First, it is one of the few studies examining neighborhood security and cardiometabolic risk factors among a racially and ethnically diverse group of diabetics. This study found that neighborhood safety was associated with BMI and specifically with severe obesity (BMI over 35). Severe obesity in diabetics is associated with increase morbidity and mortality. Two other studies examining neighborhood safety in diabetics did so by including neighborhood safety as one component of a scale of general neighborhood problem [15, 16]. In these studies, neighborhood problems were associated with increase BMI and one found that crime was the most commonly perceived neighborhood problem. Crime is more often examined within a collection of neighborhood problems; however, it may be an important influence on stress, physical activity, BMI, and other health outcomes alone and warrants further study. This study showed that perceiving crime alone was associated with higher BMI.

Second, our study is one of only two studies examining two different measurements of perceived neighborhood crime. One of our measures, general safety concerns, asked about how safe neighborhoods were day and night, and how much neighborhood violence and crime was a problem. Our other measure asked about the occurrence of certain violent crimes in the last six months. These types of safety measures may individually get at different exposures of poor neighborhood safety and correlations between these two measures was low in our study (Pearson correlation= 0.37 $p<.0000$). Living in neighborhoods with presence of violent crime may be reflecting acute stressor(s) within neighborhoods while individuals who identify having any general concerns safety concerns may reflect a less acute exposure to neighborhood crime but one that may be a chronic stressor over long periods of time. Studies in stress have identified that both acute and chronic stressors may affect development differently. More study is needed to understand how neighborhood crime survey questions that may get at different qualitative and quantitative exposures to residential safety that may affect health behaviors and health risk factors.

There are several limitations of the current study. First, this was a small, cross-sectional survey study and any findings should be interpreted carefully. In our small sample, only 15% of individuals reported violent crime in the neighborhood during the past six months. Thus, we may not have had enough statistical power to detect differences in uncommon exposures, especially after adjusting for covariates. Due to the cross-sectional design of this analysis we cannot rule out reverse causation in interpreting any associations. We also had few individuals within neighborhoods or areas to generate an aggregate measure of perceived neighborhood crime. The neighborhood problems measure, the source for our neighborhood safety questions, was

validated based on aggregating participants' responses within neighborhoods [18]. Aggregating respondents' neighborhood perceptions can often generating a more reliable measure of a neighborhood feature and reduce the influence of same-source bias. The neighborhood problems measure was initially One often cited criticism of self-reported measures including those assessing neighborhood safety are that they may or may not reflect real or actual or objective crime or security concerns. Even if self-reports of safety are inaccurate, however, perceptions may nonetheless serve to change and influence behavior and physiology [8, 26]. One study found that while perceived and objective measures of crime were not closely related, they individual were independent predictors of physical activity [27]. In this study, only stress and physical activity were gathered from self-report and susceptible to same source bias while BMI and HbA1c measures were gathered from medical records.

Finally, while we controlled for a number of sociodemographic variables in our study, we cannot rule out residual confounding to account the significant associations between our neighborhood exposure and BMI. In studies involving neighborhood exposures we may not be able to control for all known and unknown individual characteristics that may account for self-selection into neighborhood and with our outcomes. Our current study was a non-random sample of diabetics from an existing cohort of diabetics who had completed a sub sample survey. While participants were sampled from the larger cohort, non-English speaking and people living in rural areas were excluded and people from poorer areas were oversampled limiting our generalizability and external validity of our findings to the larger cohort or other similar populations.

Despite these limitations, this study on perceived neighborhood safety and health related outcomes adds to the literature examining area-based risk factors for health but in an ethnically and racially diverse group of diabetics. This study found an association between general neighborhood safety and increased BMI but saw no relationships with neighborhood safety and stress, physical activity, or glucose control (HbA1c). Nationally, the number of diabetics is growing and more studies in the diabetic population are needed to characterize what environmental influences are important for this at risk population. Possible links between neighborhood safety and diabetic cardiometabolic risk factors could better clarified using longitudinal studies.

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CHAPTER THREE

Examining associations between police recorded crime and stress among type II diabetics

ABSTRACT

Neighborhood physical environments have been extensively studied but less is known about how objective measures of neighborhood crime relate to stress in people with diabetes. Using a subsample of a managed care plan diabetes cohort, we examined associations between police recorded crime and self-reported stress using the Perceived Stress Scale (PSS-4) stratified by gender and testing interactions of race/ethnicity by gender. Police recorded crime for 2005-2007 for Part I crimes were collected from law enforcement agencies, aggregated to census block group and tract units, and linked to participants' home addresses. Generalized linear regression models clustering for neighborhood were used in analysis. Results: In our study sample (n=3,188) , 51% of our sample was female and mean age was 59 (range: 30-77). Ten percent of the sample had high stress (n=334). Significant associations were found for crime and stress among women by race/ethnicity. In women, Part I crime rates measured at the census block group level were associated with an increase in odds of stress for African American women (OR=1.10, 95% C.I.: 1.02-1.22) and Latina women (OR=1.36, 95% C.I.: 1.10-1.67) after adjustment for age, sex, race/ethnicity, household income, education, and neighborhood deprivation. We also found significant associations of stress for African American women with property crime (OR=1.10 95% CI: 1.01-1.19) and for Latina women with property crime (OR=1.34 95% CI: 1.10-1.63) and visible crime (OR=1.43 95% CI: 1.14-1.78). Analysis at the census tract level did not change results. Among men, there were no associations in our study and associations did not vary by race/ethnicity. Discussion: Police recorded crime is associated with increase stress in African-American and Latina women but not in White, Asian or Other race/ethnic groups of women or for men. Different neighborhood definitions did not significantly change results. High crime levels may disproportionately affect certain historically disadvantaged female minority groups compared to other groups and men. Future studies, especially using more robust measures of stress and longitudinal designs, are needed to study how stress in diabetics and subgroups in this population may be influenced by residential neighborhood crime.

INTRODUCTION

Diabetes is a costly chronic disease with complex disease management. For people diagnosed with diabetes nationwide, 61% of the $176 billion spent on direct medical costs are due to inpatient care and medications to treat complications of diabetes [1, 2]. While medications and weight management to control blood glucose levels are primary areas for intervention, other factors such as psychosocial stress may influence glycemic control and increase the risk for diabetes sequelae [3]. The American Diabetes Association recognizes stress as a risk factor for poor glycemic control in diabetics and recommends stress control as an important aspect of diabetes management [1, 3]. Putative mechanisms of negative effects of chronic stress on diabetes management include inability to adhere to management plans, physical activity or nutrition plans and may also cause chronic elevations of sympathetic hormones and cortisol resulting in elevated levels of glucose and fat accumulation [1, 3-7]. While stress among diabetics may come from several sources such as job strain or health problems, the safety of the surrounding neighborhood may also contribute to chronic stress. The gold standard for measuring stress in the literature has been by analyzing cortisol but other measurement include physiological responses to stimuli and by self-reports of stress.

The growing research connecting neighborhood environments to health and health management has focused on general populations and few studies have been done in diabetics [8]. Crime, a strong influence of neighborhood safety, can be a significant source of stress to residents living nearby because individuals may be victims, witness crimes, and/or hear of crimes in their neighborhoods [9, 10]. Both objective crime measures, collected from law enforcement agencies, and perceived safety measures, like self-reports have been used to study neighborhood crime. Studies comparing objective and perceived safety measures indicate that these two types of measures may both be significantly related to health [10]. Links between neighborhood crime and health behaviors have focused mostly on crime's influence on physical activity and BMI but not stress. Crime has been linked to feelings of being constrained and lower levels of physical activity such as walking for transport (i.e. walking to bus, work, or store) and leisure walking [11-14]. One study in a population based sample found an association for men between police reported burglaries and C-reactive protein (CRP), a marker of inflammatory response that may be linked to stress [15]. In two studies that did focus on diabetic populations, crime was examined in an index with many other types of self-reported neighborhood problems [16, 17]. These studies found that neighborhood problems overall were associated with elevated BMI but these studies focused on perception of crime and were not done with objective crime data.

Neighborhood Safety, Race/Ethnicity, and Gender

Neighborhood safety may also differ in importance to certain vulnerable populations. Studies of neighborhood safety, particularly those using crime and violence as a the measure of safety, have shown that women, older adults, racial/ethnic minorities, and those with low socioeconomic status (SES) report lower levels of safety than younger adults, men, whites, and the non-poor [13, 18-20]. Historically, minorities and individuals with low SES often reside in more unsafe and poorer environments due to a longstanding racial/ethnic and economic residential segregation; women and older individuals may feel physically vulnerable to victimization [12, 19, 21]. One review found that minorities and individuals with low SES both experience poorer neighborhood environments and are adversely affected by poorer environment

compared to non-minorities and those who are high SES had been shown [19]. Other race/ethnic groups or those with higher incomes may have resources to counter detrimental neighborhood environments.

In this study we examined whether neighborhood police recorded crime, measured using objective crime data from law enforcement agencies, is associated with stress in a large diabetic cohort and whether associations vary by gender and for race/ethnicities by gender. We hypothesized that any associations between crime and stress may differ by gender. Areas of possible interventions and/or policies to improve health and reduce sequelae can be expanded by this type of research. Interventions to change neighborhood conditions or to reduce stress in diabetics may prove to be beneficial in reducing poor outcomes in diabetics and the burden of this disease.

METHODS

Study population

The Kaiser Permanente Northern California (KPNC) is a non-profit, group practice, prepaid, health plan in the United States. KPNC currently provides medical services in a 14-county region of Northern California that includes the San Francisco Bay and Sacramento metropolitan areas. Study participants were drawn from KPNC's Diabetes Study of Northern California cohort (DISTANCE), a cohort gathered to study social health disparities in a managed care population [22]. A stratified random sample was formed from the diabetes registry with approximately equal numbers of the five largest ethnic groups in the KPNC diabetes registry: African Americans, Asians, Latinos, Whites, and Other race. A baseline survey was administered from 2005-2007 as part of the enrollment into the cohort and 21,188 adults completed the survey, giving a survey response rate of 62%. This baseline survey collected information on respondent sociodemographic characteristics, health behaviors, and disease characteristics and was linked to respondents' clinical information. A more complete description of the study methods, cohort and survey has been published previously [22]. This study was approved by the Institutional Review Boards of the Kaiser Division of Research, University of California, San Francisco School of Medicine, and University of California, Berkeley.

Description of Study Variables

Variables for these study aims were assembled from the 2005 cohort survey and the contextual/environmental database. In this study we considered two neighborhood definitions that have been studied in the literature, census block group and census tract.

Police Recorded Crime

Police recorded crime data for three years (2005-2007) in the four largest bay area cities of Oakland, Sacramento, San Francisco, and San Jose were collected, categorized, and used to create our crime exposure for the present analysis. We used the FBI Uniform Crime Report (UCR) standards, the most commonly used crime cataloging system, to classify and create crime categories [23, 24]. UCR's Part I crimes are the most commonly collected crimes by U.S. law enforcement agencies because they represent the most severe or numerous crimes committed.

We utilized and mapped all eight Part I crimes comprised of homicide, forcible rape, robbery, burglary, aggravated assault, and motor vehicle theft as a measure of crime in this study and 95% of crime was successfully geocoded to the census block group and tract. We also created two routinely evaluated categories of crimes, violent crime (homicide, robbery, aggravated assault, forcible rape) and property crime (arson, burglary, larceny/petty theft, vehicle motor theft) [13]. An additional crime category, visible crime, was created by the study investigators using homicide, aggravated assault, robbery, burglary, and arson to identify crimes that the investigators theorized were most likely to be known by or visible to neighborhood residents either because they are serious in nature (i.e. homicide) or because news of these crimes (i.e. burglaries, arson) may circulate more easily among neighborhoods.

Location information was not released by Sacramento and Oakland Police Departments for certain crimes such as forcible rape and incidents of aggravated assault from domestic violence and child abuse due to department policies on confidentiality. We identified and excluded as many of these crimes as possible for San Francisco and San Jose crime data to compare crime more easily across cities. All Part I crimes occurring in 2005-2007 were geocoded to the residential census block group and tract of respondents. All spatial measures were mapped and calculated using ArcGIS v. 2.1 (ESRI, Inc., Redlands, CA, USA).

Rescaling of Crime Rate

Continuous crime was rescaled using the interquartile range (IQR), the distance between the 25^{th} and 75^{th} percentiles. The IQR is calculated by using the sample 75^{th} percentile value and subtracting the 25^{th} percentile value from it. We rescaled crime rate by dividing all respondents' crime rate value by the IQR. Other rescaling methods for continuous variables include scaling by the standard deviation, however the IQR is preferable in highly skewed predictors as the IQR scaling factor will reduce extrapolation of the predictor value and will always produce predictor values that are well-represented in the sample. The interpretation of regression coefficient of an IQR rescaled predictor is that it compares predicted high stress for a 1- unit change in crime equivalent to the IQR, or the difference between the 75^{th} and 25^{th} percentile.

Crime rates were calculated at the block and census track level for our four categories of crime [11, 13]. Our numerator consisted of counts of relevant crime incidents for each crime category. Our crime rate denominators were either block group or tract population and were gathered from the 2000 Census. We calculated annual block group or tract crime rates (counts/per person in census unit) for each of our three years of study and calculated the mean rate for all three years for each of our respondents to create a three year crime average rate (mean of 2005 rate, 2006 rate, and 2007 rate divided by census unit population). We multiplied our average annual crime rate by 1000 to create a crime rate per 1000 block or tract group residents per year.

Perceived Stress Scale

Respondents stress over the past four weeks was assessed using Cohen's 4-item Perceived Stress Scale (PSS-4 short version) [25]. The PSS-4 is a four item~~,~~ self-report instrument that has been validated in ethnically diverse populations, with a five point scale with questions on how respondents view the stress of situations in one's life including how often respondents felt they were unable to control important things in their life or felt confident to

handle personal problems (responses never, almost never, sometimes, fairly often, very often) [25, 26]. Questions indicating more control or less stress are reverse-coded and the PSS-4 is summed across the four stress-related questions. Higher scores on the PSS-4 reflect higher stress levels. It is common for the PSS-4 to be used as a continuous measure and cut points to indicate higher stress depend on the population under study [25]. For this study, we calculated the mean score for the PSS questions and dichotomized PSS into higher stress as a mean PSS of >2 and lower stress, PSS≤2. The cut off point for this measure is the equivalent of people feeling they were almost never or never in control of their life or confident to handle problems and always or almost always felt things were not going their way and felt difficulties were piling up so high they could not overcome them.

Covariates

Covariates for the analyses include age, sex, race/ethnicity, education, income, and marital status. Age and sex were collected from KPNC administrative data. Respondent age at time of survey was calculated using date of birth in administrative data and the date survey was completed. Other sociodemographic covariates were collected from the survey including race/ethnicity (African American, Asian, Latino, White non-Latino, and Other race) where respondents were asked to choose the single group they identified with the most strongly. The Other race category included respondents who identified as Pacific Islanders, Native Americans/Alaskan natives, mixed race, or other race not abovementioned categories. Socioeconomic indicators included education (defined as high school degree or less or more than high school, employment status (working/student, retired, unemployed/other), and household income. We defined household income as self-reported family income divided by the poverty line income for a given age and household size based on the US Department of Health and Human Services 2010 Poverty Guidelines. We categorized percent of poverty into four categories (<130%, 130-<200%, 200-<400%, > 400%). A missing indicator was included for the 11% of respondents who chose not to report their income (n= 335). Current marital status was also collected at the time of the survey (Married/partnered, divorced/separated/widowed, single/never married).

We used the Neighborhood Deprivation Index (NDI) to control for structural confounding, a concern for identifying neighborhood effects of crime on stress, by other neighborhood factors such as socioeconomic status [27]. Neighborhood deprivation index (NDI) was created using 2000 US Census of Housing and Population data [28, 29] and assigned to respondent addresses. Eight census-derived variables, including percentage of households below the 2000 income to poverty ratio, percentage of households on public assistance, percentage of female-headed households with dependent children, percentage of households with annual income <$30,000 per year, and percentage of adults not completing high school were used to create neighborhood deprivation at the census tract level. The NDI was created at the census tract level within the DISTANCE region using principal components analysis [29]. NDI quartiles were created using the quartile cut points (Q1- Q4) from the continuous NDI measure for all census tracts, with quartile 1 being the least deprived and quartile 4 being the most deprived neighborhoods.

Statistical Analysis

Means and descriptive analysis were conducted for our samples by sociodemographic variables for our study sample were calculated. We examined our continuous exposures, crime rates per 1000 population, using the 25^{th}, 50^{th}, and 75^{th} percentile for gender and race/ethnic combinations at both the census block group and census tract crime levels. Bivariate analyses of patient sociodemographic factors and stress, including Chi-square tests and one-way analysis of variance tests were used to assess associations with categorical and continuous measures with our outcome, respectively. Means and descriptive analysis were also conducted for our samples for sociodemographic variables by gender and race/ethnicity.

Logistic regression using generalized linear models (GLM) using main terms, robust standard errors and accounting for clustering (using Huber/White sandwich estimator) at the block group level crime or at the census tract were used to examine unadjusted and adjusted associations between crime and stress measured categorically [30]. GLM is a marginal linear model estimator able to account for neighborhood clustering and can be used to relative risks even for common dichotomous outcomes. We tested our hypothesized race/ethnicity and crime interaction terms by gender in our models using a Wald test. We ran race/ethnic group stratified models for our analysis. Age was centered in our models. All final models did not include marital status as it was not associated with our outcome stress and controlling for this variable in our models could decrease precision of the estimated exposure effect without decreasing bias [31]. For model 1 we included age, sex, household income, and education as our covariates. In model 2 we additionally included neighborhood deprivation. All analyses were performed using STATA/SE 13.1.

RESULTS

Approximately 25% of DISTANCE respondents lived the four cities where crime data was collected (n=5050). We restricted our analyses to DISTANCE respondents who had data available for our exposure outcome stress and 1,688 respondents did not have stress measured. Stress was not asked in the shorter forms of the survey for a large number of respondents. We also excluded from our analysis people who were missing our crime exposure (n=174) had missing race (n= 19). The final analytic sample size was 3,188.

Table 1 shows sample characteristics overall and by our dichotomous study outcome high stress. In our sample, the mean age was 58 years (SD=10), 51% of our sample was female and 14% were White, 26% African American, 20% Latino, 26% Asian, and 13% answered Other race/ethnicity. Only 10% of the sample has high stress (n=334). A majority of the sample was married or partnered (65%, n=2,074), with smaller numbers of respondents either divorced/separated/widowed (22%, n=687) or single/never married (13%, n=403). About equal numbers of our participants resided in Oakland (23%), Sacramento (20%), and San Francisco (21%), while San Jose had the most participants (35%). Our sample had a similar distribution for neighborhood deprivation where Quartiles 1 (19%), 2 (21%), and 3 (23%) had similar percentages of the sample represented and more people were in the most deprived census tracts compromising quartile 4 (37%). Stress was associated with age ($p<.001$) as people with high stress were on average four years younger (56 years, SD=11) than those with no high stress age

(59 years, SD=10). Stress was also associated with gender ($p<0.000$), income ($p<0.000$), race/ethnicity ($p=0.021$), education ($p<0.000$), where more women than men (12% vs 8%), those with the lowest income had more stress (19%) than people with the highest income (6%) , and those with lower education also had more stress than people with higher education (13% vs 7%). Stress was also associated with NDI ($p=0.024$) with higher stress as neighborhood deprivation increased.

Sociodemographic characteristics by race/ethnicity and by race/ethnicity and gender are shown in table 2. Distributions for all sociodemographic variables by race/ethnicity and by gender were significantly associated with race/ethnicity ($p<0.000$ for all comparisons). Mean age for Latinos (56.0) was lower than for Whites (58.4), African Americans (60), Asians (59.3), and Other race (56.9). African Americans and Asians in our samples had the most skewed gender distribution as 60% of African-Americans and 41% of Asians respondents were women. Educational attainment varied widely for the five race/ethnic groups. In education attainment, Latinos were the most poorly educated group as only 16% had more than a high school level and Asians were the most educated group where 62% had more than high school education). Fifty-one percent of White, 39% of African Americans, 48% of Other race respondents had a higher education than high school. The study's five race ethnic groups varied in their distributions by study cities. Nearly half of whites lived in San Jose (48%) and a quarter lived in Sacramento. For African-Americans over half (54%) lived in Oakland and 23% in Sacramento. For Latinos, 56% lived in San Jose and 19% in Sacramento while Asians lived primarily in San Francisco (41%) and San Jose (36%). Finally, there were significant race/ethnic differences by NDI. For White respondents, 38% lived in the two most deprived census tracts (quartiles 3 and 4) compared to 78% of African-American, 69% of Latino, 42% of Asian, and 67% of Other race respondents. Overall, men of all race/ethnic groups tended to be more educated, had higher incomes, and were more likely to married compared to their female counterparts.

Figure 1 and 2 both display the race/ethnic and gender distributions for the 25^{th}, 50^{th}, and 75^{th} percentiles for this study's crime measures. Across all spatial levels and for all crime types African-Americans had the highest levels of crime compared to all other groups. In descending other, Other race and Latinos have the next highest crime rates while Whites and Asians both had the lowest levels of crime. At the block group crime level, crime is similar for men and women although when there are differences women tend to live in census block groups with slightly higher crime than their male race/ethnic counterparts. Similar trends in crime rates between race/ethnic groups and by gender were seen at the census track level. For Latinos, however, men had very slightly higher crime rates than Latina women at the census tract level for all part I crimes, violent crimes, property crime but not visible crimes.

Multivariate Results

No statistically significant main effects for crime were found in our analysis. Effect measure modification of race/ethnicity and crime and of race/ethnicity, gender, and crime with odds of high stress were tested for our models and evaluated using our specified cutoff. We found significant race/ethnic interactions among gender (using a cutoff of <0.1) for many of our exposure models. Interaction test for crime measures at the block group level were significant for all part I crime, property crime, visible crime but not violent crimes. Similarly to crime at the block group level, interaction test for crime measures at the tract level were significant for all part I crimes, property, and visible crimes but not for violent crime. Race interactions with crime

for all crime measures and models were significant for women but no race and crime interactions were seen for men in our sample.

Our results for crime and race/ethnic interactions for women are shown in Table 3 (no race crime interactions were found for men- not shown). We found significant associations of crime for African-American and Latina women. For African-American women we found that block group measures of all part I crimes and property crime were associated with an increased odds of having high stress with OR=1.11 (95% CI 1.02- 1.22) and OR=1.10 (95% CI 1.02- 1.19), respectively when we adjusted for age, gender, income, and education. These associations did not change with the addition of NDI in model 2. Census tract crime associations were similar in magnitude and significance for African-Americans for all Part I crimes (OR= 1.13 95% CI 1.02-1.26), property crimes (OR=1.11 95% CI 1.02-1.21) and for visible crime (OR=1.19 95%CI 1.02-1.38) when we adjusted for individual and area based covariates (model 2).

For Latina women, all census block group and census tract crime measures were associated with increase odds of higher stress. The odds of higher stress for women at crime corresponding to a difference between the 75^{th} versus 25^{th} percentile were slightly higher at the block group versus census tract level for models with and without NDI. For Part I crimes at the block group level the odds of high stress for Latina women was 1.35 times higher with a 1 unit increase in crime rate equivalent to the difference between the 75^{th} and 25^{th} percentile of crime (95% CI 1.11- 1.64). Similar magnitude in odds were also seen for block group violent crime (OR= 1.31 95% CI: 1.12-1.55), property crime (OR= 1.34 95% CI: 1.11-1.61), and visible crime (OR= 1.40 95% CI: 1.15-1.70). Adjustment for NDI in model 2 did not change associations. No associations were seen for men at either the block group or tract level (not shown).

Table 1: Sociodemographic Characteristics and Stress

Sociodemographic Characteristics	Total Study Sample	No high stress Mean PSS≤2	High Stress Mean PSS>2	p-value
All Sample	3,118	90%	10%	
Mean age in years (SD)	58 SD:10 Range: 30-77	59 (10)	56 (11)	**0.000**
Sex				**0.000**
Female	1,631 (51%)	1,428 (88%)	203 (12%)	
Male	1,557 (49%)	1,426 (92%)	131 (8%)	
Race/Ethnicity				
White	456 (14%)	406 (89%)	50 (11%)	**0.021**
African American	829 (26%)	741 (89%)	88 (11%)	
Latino	643 (20%)	557 (87%)	85 (13%)	
Asian	842 (26%)	775 (92%)	63 (8%)	
Other	418 (13%)	375 (90%)	42 (10%)	
Education				**0.000**
≤ High School/GED/TS	1,804 (57%)	1,571 (87%)	233 (13%)	
More than HS/GED/TS	1,330 (42%)	1,234 (93%)	96 (7%)	
Unknown/Missing	54 (2%)	49 (91%)	5 (9%)	
Income, % Poverty Line				**0.000**
<100%	317 (10%)	256 (81%)	61 (19%)	
100%-<300%	956 (30%)	823 (86%)	133 (14%)	
300%-<600%	977 (31%)	902 (92%)	75 (8%)	
>600%	598 (19%)	565 (94%)	33 (6%)	
Missing	340 (11%)	308 (91%)	32 (9%)	
Marital Status				0.095
Married/Partner	2,074 (65%)	1,873 (90%)	201 (10%)	
Divorced/Separated/Widowed	687 (22%)	599 (87%)	88 (13%)	
Never Married/Single	403 (13%)	362 (90%)	41 (10%)	
Missing	24 (1%)	20 (83%)	4 (6%)	
City				**0.048**
Oakland	748 (23%)	659 (88%)	89 (12%)	
Sacramento	650 (20%)	572 (88%)	78 (12%)	
San Francisco	683 (21%)	610 (89%)	73 (11%)	
San Jose	1,107 (35%)	1,013 (92%)	94 (8%)	
Neighborhood Deprivation[2] (NDI)				**0.024**
Quartile 1, Least Deprived	592 (19%)	550 (93%)	42 (7%)	
Quartile 2	681 (21%)	612 (90%)	69 (10%)	
Quartile 3	730 (23%)	651 (89%)	79 (11%)	
Quartile 4, Most Deprived	1,173 (37%)	1,031 (88%)	142 (12%)	
Not available	12 (<1%)	10 (83%)	2 (17%)	

[1]Stress was measured the Perceived Stress Scale (PSS-4)
[2]Neighborhood Deprivation was calculated at the census tract level and categorized by quartiles
P-values were calculated using chi-square tests of association for categorical sociodemographic characteristic and analysis of variance for continuous sociodemographic characteristics

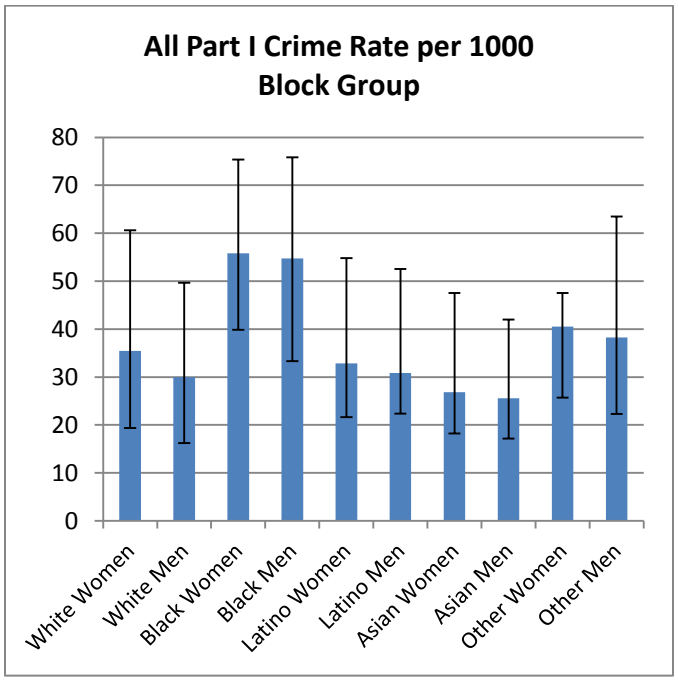
Table 2: Sociodemographic characteristics By Study Race/Ethnic Groups and Gender

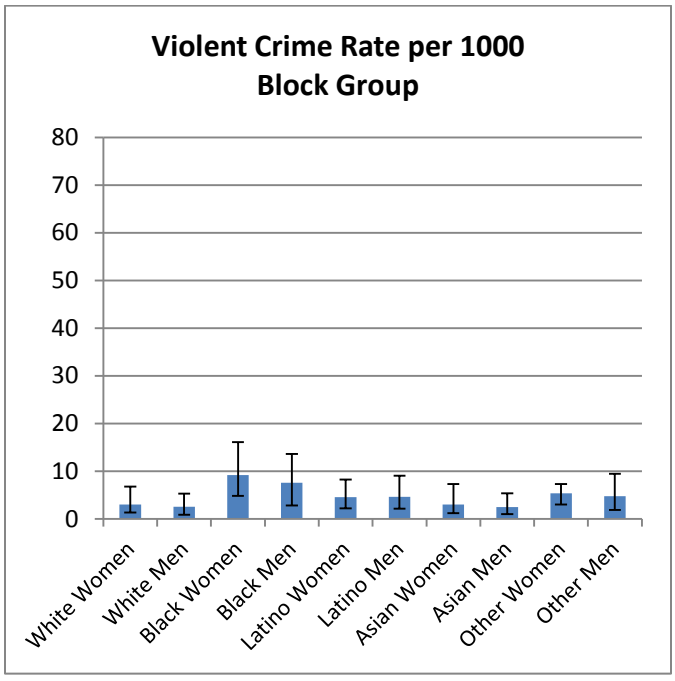
Sociodemographic Characteristics	White			African-American			Latino			Asian			Other Race		
N (%)	All n=456	Women n=215	Men n=241	All n=829	Women n=494	Men n=335	All n=623	Women n=355	Men n=288	All n=842	Women n=348	Men n=494	All n=418	Women n=219	Men n=199
Mean age in years(SD)	58.4 (9.8)	58.1(10.1)	58.6(9.4)	60.0(9.8)	59.8(9.8)	60.3(9.8)	56.0(11)	55.7(11.1)	56.3(10.8)	59.3(9.9)	59.4(9.9)	59.2(9.9)	56.9(10.6)	56.5(10.6)	57.4(10.5)
Sex															
Female	215 (47 %)			494 (60%)			355 (55%)			348 (41%)			219 (52%)		
Male	241 (53%)			335 (40%)			288 (45%)			494 (59%)			199 (48%)		
Education															
≤ High School/GED/TS	219 (48%)	57%	40%	496 (60%)	63%	55%	519 (81%)	83%	78%	309 (37%)	41%	34%	254 (62%)	65%	59%
More than HS/GED/TS	234 (51%)	42%	60%	320 (39%)	36%	43%	102 (16%)	14%	18%	522 (62%)	58%	65%	147 (36%)	34%	39%
Unknown/Missing	3 (1%)	1%	<1%	13 (2%)	1%	2%	22 (3%)	3%	4%	11 (1%)	1%	1%	5 (1%)	<1%	2%
Income, % of Pov Line															
<100%	16 (4%)	6%	2%	81 (10%)	13%	5%	109 (17%)	20%	13%	63 (7%)	10%	6%	48 (11%)	14%	9%
100%-<300%	92 (20%)	25%	16%	251 (30%)	35%	24%	268 (42%)	43%	40%	209 (25%)	27%	23%	136 (33%)	33%	32%
300%-<600%	165 (36%)	38%	34%	287 (35%)	33%	37%	136 (21%)	18%	25%	268 (32%)	30%	33%	121 (29%)	29%	29%
>600%	137 (30%)	23%	37%	122 (15%)	9%	24%	62 (10%)	7%	13%	212 (25%)	18%	30%	65 (16%)	11%	20%
Missing	46 (10%)	9%	11%	88 (11%)	11%	10%	68 (11%)	12%	9%	90 (11%)	14%	8%	48 (11%)	12%	11%
Marital Status															
Married/Partner	317 (70%)	60%	78%	408 (49%)	38%	66%	456 (71%)	63%	81%	637 (76%)	63%	82%	256 (61%)	53%	70%
Divorced/Sep/Widowed	76 (16%)	26%	8%	274 (33%)	44%	17%	127 (20%)	28%	10%	110 (13%)	28%	6%	100 (24%)	32%	16%
Never Married	61 (14%)	14%	13%	141 (17%)	18%	15%	57 (9%)	9%	9%	92 (11%)	9%	11%	52 (12%)	13%	12%
Missing	2 (<1%)	<1%	<1%	6 (1%)	<1%	1%	3 (<1%)	1%	0	3 (<1%)	1%	<1%	10 (2%)	2%	3%
City															
Oakland	35 (8%)	8%	7%	452 (55%)	56%	52%	76 (12%)	12%	12%	85 (10%)	13%	8%	100 (24%)	28%	20%
Sacramento	119 (26%)	34%	19%	189 (23%)	23%	22%	121 (19%)	20%	18%	119 (14%)	12%	16%	102 (24%)	26%	23%
San Francisco	82 (18%)	14%	22%	117 (14%)	15%	12%	83 (13%)	11%	16%	336 (40%)	43%	38%	65 (16%)	14%	18%
San Jose	220 (48%)	44%	52%	71 (9%)	5%	13%	363 (56%)	58%	55%	302 (36%)	33%	38%	151 (36%)	33%	40%
NDI[1]															
Quartile 1, least dep	146 (32%)	27%	37%	99 (12%)	9%	17%	85 (13%)	11%	16%	209 (25%)	23%	26%	53 (13%)	8%	18%
Quartile 2	136 (30%)	28%	31%	82 (10%)	7%	14%	105 (16%)	17%	16%	277 (33%)	30%	35%	81 (19%)	20%	19%
Quartile 3	86 (19%)	19%	19%	173 (21%)	20%	21%	163 (25%)	26%	25%	210 (25%)	29%	22%	98 (23%)	24%	23%
Quartile 4, most dep	86 (19%)	25%	13%	474 (57%)	63%	48%	285 (44%)	45%	43%	145 (17%)	18%	17%	183 (44%)	47%	40%
Missing	2 (<1%)	<1%	<1%	1 (<1%)	<1%	0	5 (1%)	1%	1%	1 (<1%)	0	<1%	3 (1%)	1%	0

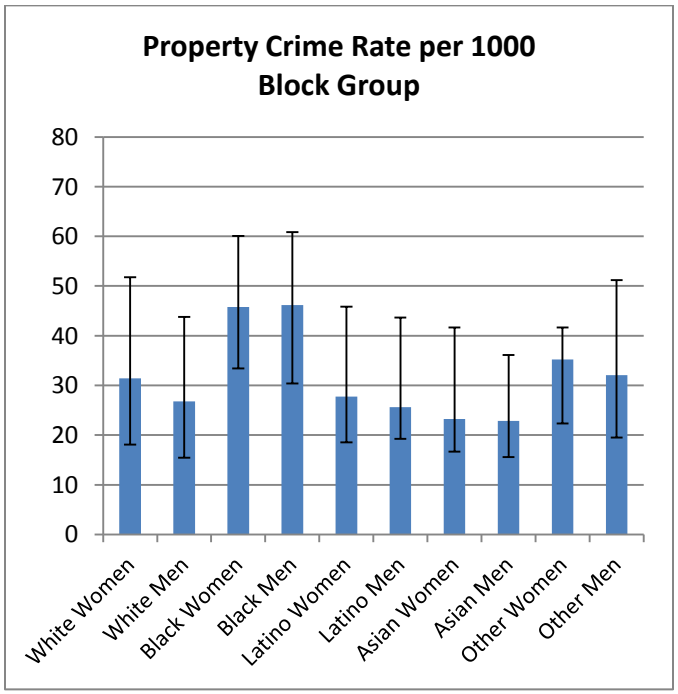
n (%) reported in table cells for race/ethnicity overall and % reported for gender by race/ethnicity
All p-values for race/ethnicity and gender associations with sociodemographic variables were significant at p<.0001
P-values were calculated using chi-square tests of association for categorical sociodemographic characteristic and analysis of variance for continuous sociodemographic characteristics.
[1]Neighborhood Deprivation was calculated at the census tract level and categorized by quartiles

Figure 1. Three year Crime Rate (Crimes per 1000 People) Distribution (25th, 50th, and 75th percentiles*) for Crime Exposure by Race/Ethnicity and Gender for Census Block Group

*Column height represents median crime rate and whiskers on plot represent 25th and 75th percentiles







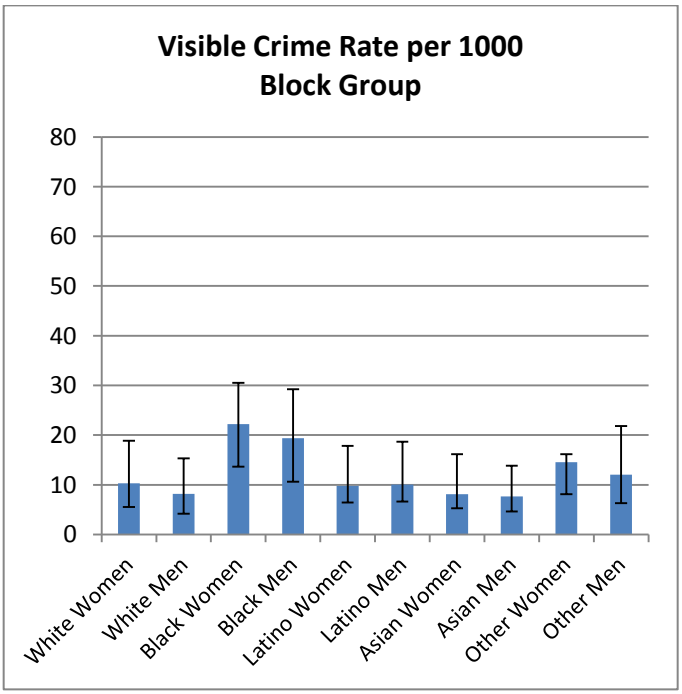


Figure 2. Three year Crime Rate (Crimes per 1000 People) Distribution (25th, 50th, and 75th percentiles*) for Crime Exposure by Race/Ethnicity and Gender for Census Tract

*Column height represents median crime rate and whiskers on plot represent 25th and 75th percentiles

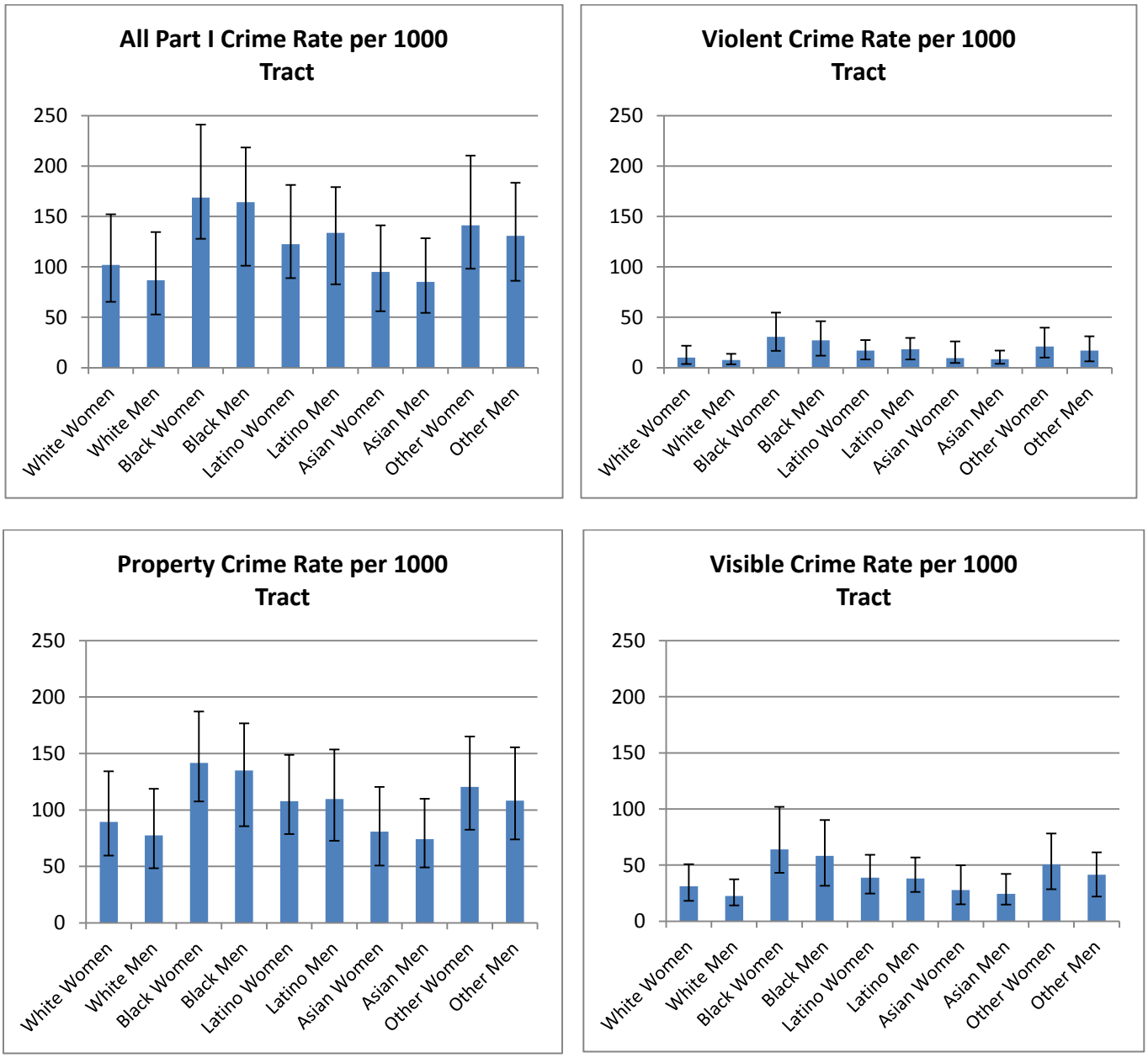


Table 3: Adjusted ORs for High Stress Corresponding to a Difference Between the 75th and 25th Percentiles in Neighborhood Police Recorded Crime Rates (Per 1000 population) by Race/Ethnicity for Women

	White (n=215)				African-American (n=494)				Latino (n=355)				Asian (n=348)				Other Race (n=219)			
	OR	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**
Census Block Group																				
All Part I Crimes																				
Model 1	0.93	0.85	1.01	0.085	1.11	1.02	1.22	**0.022**	1.35	1.11	1.64	**0.003**	0.86	0.70	1.06	0.156	1.05	0.88	1.25	0.598
Model 2	0.84	0.65	1.10	0.204	1.11	1.01	1.22	**0.038**	1.36	1.10	1.67	**0.004**	0.88	0.75	1.03	0.123	1.04	0.86	1.25	0.696
Violent Crime																				
Model 1	0.91	0.79	1.06	0.229	1.01	0.73	1.40	0.942	1.31	1.12	1.55	**0.001**	0.84	0.61	1.16	0.287	1.04	0.90	1.20	0.594
Model 2	0.83	0.62	1.11	0.211	1.07	0.81	1.42	0.625	1.34	1.12	1.61	**0.002**	0.88	0.66	1.17	0.366	1.04	0.89	1.21	0.657
Property Crime																				
Model 1	0.93	0.86	1.01	0.083	1.10	1.02	1.19	**0.016**	1.34	1.11	1.61	**0.002**	0.87	0.73	1.05	0.149	1.05	0.87	1.25	0.626
Model 2	0.85	0.65	1.10	0.220	1.10	1.01	1.19	**0.032**	1.34	1.10	1.63	**0.003**	0.89	0.77	1.03	0.118	1.03	0.86	1.25	0.728
Visible Crime																				
Model 1	0.93	0.84	1.02	0.127	1.14	0.99	1.30	0.065	1.40	1.15	1.70	**0.001**	0.84	0.67	1.05	0.128	1.04	0.84	1.28	0.716
Model 2	0.89	0.76	1.04	0.131	1.14	1.00	1.30	0.057	1.43	1.14	1.78	**0.002**	0.87	0.73	1.03	0.107	1.02	0.81	1.29	0.849
Census Tract																				
All Part I Crimes																				
Model 1	0.98	0.90	1.06	0.568	1.13	1.02	1.25	**0.018**	1.27	1.07	1.51	**0.006**	0.71	0.42	1.20	0.207	0.84	0.63	1.11	0.213
Model 2	0.96	0.88	1.04	0.320	1.13	1.02	1.26	**0.018**	1.31	1.09	1.58	**0.004**	0.76	0.47	1.24	0.273	0.75	0.50	1.12	0.158
Violent Crime																				
Model 1	1.22	0.87	1.71	0.246	1.01	0.76	1.33	0.965	1.26	1.06	1.50	**0.008**	0.77	0.48	1.24	0.287	0.85	0.63	1.14	0.277
Model 2	1.13	0.80	1.58	0.487	1.14	0.85	1.55	0.381	1.31	1.08	1.59	**0.005**	0.82	0.50	1.34	0.424	0.76	0.51	1.14	0.190
Property Crime																				
Model 1	0.97	0.91	1.04	0.454	1.11	1.02	1.21	**0.011**	1.26	1.06	1.49	**0.008**	0.72	0.44	1.18	0.190	0.85	0.65	1.11	0.220
Model 2	0.96	0.89	1.03	0.268	1.11	1.02	1.21	**0.017**	1.29	1.07	1.55	**0.006**	0.77	0.48	1.22	0.261	0.77	0.53	1.13	0.178
Visible Crime																				
Model 1	1.00	0.89	1.13	0.979	1.16	0.99	1.36	0.065	1.27	1.07	1.52	**0.007**	0.76	0.49	1.19	0.228	0.79	0.56	1.11	0.178
Model 2	0.97	0.86	1.10	0.637	1.19	1.02	1.38	**0.023**	1.33	1.09	1.62	**0.005**	0.82	0.58	1.16	0.257	0.67	0.41	1.10	0.113

Model 1 adjusted for age, sex, household income, and education. Model 2 adjusted for age, sex, household income, education, and neighborhood deprivation.
Visible crime was defined as: homicide, aggravated assault, robbery, burglary, and arson.

DISCUSSION

In this study we examined whether four measures of objectively measured neighborhood crime: all Part I crimes, violent crime, property crime, or visible crimes were associated with reports of high stress in a group of diabetic members of a managed care plan. There were no associations for the main effects of crime on stress for men and women overall but based on *a priori* study questions we conducted interactions tests for associations by race/ethnicity for each gender. We found significant race/ethnic interactions for women but not for men and conducted a stratified analysis by race/ethnic group for women. Objective neighborhood crime was positively associated to higher stress for African-American and Latina women only. For African-American women all part I crimes and property crimes were associated with higher stress at the block group and tract neighborhood levels. Additionally, visible crime at the tract level was significantly associated with increased stress for African American women. For Latina women, all part I, violent, property, and violent crimes at both the block group and tract neighborhood level were all positively associated with higher stress.

African-Americans and Latinos, two historically disadvantaged groups experienced more crime than their White and Asian counterparts overall and by gender. For African-American women, we found that all crimes and property crimes increased the odds of having high stress for models controlling for individual and neighborhood variables at the block group level. At the census tract level we found similar and slightly higher associations for all crimes, property crimes. Further, visible crime was associated with higher stress. Latina women did not experience as high rates of crime as African-Americans but maintained associations of higher crime and stress for all crime categories at all spatial levels. Associations were more robust for block level crime compared to tract level crime.

Other work examining the sociology of crime have also revealed connections between gender and crime as women may often feel more physically vulnerable to the presence of crime [10, 19]. Our findings further corroborate other neighborhood work showing disadvantaged groups to be affected by and/or experience higher levels of poor neighborhood health environments [10, 19]. Previous studies tying crime to other outcomes such as physical activity and obesity have additionally found gender and/or race interactions but no studies have examined stress [9, 19]. One study found associations between crime and higher BMI for women but not men in an African-American study sample and another found that police recorded crime in New Zealand was associated with worse health but only for women [19, 32]. In contrast to other studies we did not find associations for any one particular gender overall but rather for certain race groups for women [19, 33, 34]. This may be due in part to the diversity of the race/ethnicities in our sample that is uncommon in other studies.

This study contributes to the literature exploring neighborhood influences in a population with diabetes. This is the first study examining neighborhood police recorded crime and stress among a diverse ethnic and racial group of diabetics. Other studies have focused on diabetes incidence, and general populations, but few studies have been conducted in populations with chronic illnesses like diabetes. The large diverse cohort in this study permitted evaluation of interactions between race/ethnicity and crime relationships with stress. This is one of the few studies that have used spatial mapping of police recorded crime rather than relying on respondent self-reports of crime to examine predictors of stress allowing for a less biased evaluation of crime rates on a local level. Whereas most prior studies using police recorded crime have

focused on one city this study evaluated several cities across several years allowing for more stable crime rates for our study exposures. In addition, we categorized our crime to examine where crime in general or specific types of crime varied in their association with stress. Last, we examined two fine scale units of spatial aggregation of crime for our study.

There are several limitations to our study. Due to the cross-sectional design of this analysis we cannot rule out reverse causation in interpreting any associations. We used crime incidents from 2005-2007 and self-reports of stress were collected in surveys during the same timeframe. We also controlled for a number of sociodemographic variables in our study, however, we also cannot rule out residual confounding to account the significant associations between neighborhood crime and high stress for African-Americans. In studies involving neighborhood exposures we may not be able to control for all known and unknown individual characteristics that may account for self-selection into neighborhood and with our outcomes. Our sample was a non-random sample of diabetics from an existing cohort of diabetics who lived in the four cities where crime data was collected. Cohort members living in other cities or in rural areas were excluded limiting our generalizability and external validity of our findings to the larger cohort or other similar populations. This study examined only police recorded crime and did not include any measures of perceived crime. We are interested in crime because it may affect perception of crime and influence stress however, studies have found that objective and perceived measures of crime may be independent predictors of behavior and that each is important to study [11, 35].

There are also several limitations of our study measures. First, police recorded crime is an objective measurement of neighborhood crime but there may be many inconsistencies in the way crime is addressed or recorded across a law enforcement agencies and between neighborhoods. In our study we attempted to attenuate law enforcement agency differences in crime collecting by utilizing only Part I crimes. Part I crimes are the most serious and/or numerous of crimes that are routinely reported to the FBI UCR system and are the most consistently defined and reported crimes [24]. Furthermore, due to police confidentiality for serious sexual, domestic and child abuse we were not able to collect all of these crimes at the address level and removed these crimes from all cities in our analysis. Removing these crimes could have led to misclassification of crime for certain respondents however, these crimes comprise a small percentage of all part I crimes, violent crime, and visible crime and the effect of removing these crimes may subsequently be small as well.

A final limitation of our neighborhood crime measurement involves the spatial units, census block group and census tract, we defined as neighborhoods. Our neighborhood definitions were not respondent delineated neighborhood buffers or boundaries and can lead to misclassification of neighborhood crime. It remains difficult to identify what people would define as their neighborhood and much research has used census and other administrative units. While census blocks are the smallest geographic unit where census data is available, census tracts are relatively stable over time to be used over several census counts and are generally homogeneous with respect to population, economic, and living conditions. This study used both areal units for analysis.

In the stress literature, stress has been measured in a variety of ways including analyzing cortisol, physiological responses to stimuli, and by self-report. In our study we captured stress using the four-item perceived stress scale developed by Cohen [25]. While this measure has been used extensively in the literature, it may be reduced in its validity and reliability, due to the

small number of items in the scale, to capture stress compared to the 10 or 14 item PSS scales and compared to physiological or cortisol measurements. One confirmatory factor analysis study of the PSS-4 found that women may respond differently and worse than men under the PSS-4 but not all studies have seen differences in the psychometric properties of the PSS-4 compared to the PSS-10 or PSS-14 [36, 37]. Additional studies are needed to tie objective neighborhood crime data to better measurements of stress such as cortisol.

Despite the limitations, this study on neighborhood crime and stress adds to the literature examining area-based risk factors for health and in an ethnically and racially diverse group of diabetics. There have been no studies to date on associations between police recorded neighborhood crime and stress in diabetics and this study may encourage further research in this area. This study found an association between all Part I crimes, property crime, and visible crime with stress for African-American women and Latina women but saw no relationships with other groups. In our study, African-Americans lived in areas with higher crime compared to other race and ethnic groups and Latinos also lived in higher crime areas compared to Whites and Asians. Nationally, the number of diabetics is growing and more studies in the diabetic population are needed to characterize what environmental influences are important to improve quality of life for this vulnerable population. Possible links between neighborhood crime and stress could better identified by conducting longitudinal studies.

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CHAPTER FOUR

Examining associations between police recorded crime and obesity among type II diabetics

ABSTRACT

Neighborhood physical environments have been extensively studied but less is known about how the social environment such as neighborhood crime may relate to obesity in diabetics or whether any associations may differ by gender and for different race/ethnic groups by gender. Using an urban subsample of a managed care plan diabetes cohort, we examined associations between police recorded crime with obesity [body mass index (BMI) ≥ 30 kg/m2]. Police recorded crime for 2005-2007 for Part I crimes were collected from law enforcement agencies, aggregated to census block group and tract units, and linked to participants' home addresses. Generalized linear regression models clustering for neighborhood were used in the gender stratified analysis. Results: In the overall study sample (n=4, 667 mean age: 59 range: 30-77), approximately 50% of the respondents were obese but there was higher obesity among women (57%) compared to men (43%). Women African American women had a small increase in odds of obesity for part I crimes (OR=1.01 95% CI: 1.00-1.03) and for visible crimes (OR= 1.03, 95% CI: 1.01-1.05) at the census block, in models adjusted for individual level covariates. For Asian women we found a negative associations between crime and odds of obesity for Part I crimes (OR=.91 95% CI: .83-1.00) and property crime (OR=.91 95% CI: .84-1.00) at the block level, controlling for individual level covariates. These associations for Asian women remained significant when we controlled for other covariates in our models including neighborhood deprivation For all part 1 crimes (OR=.86 95% CI: .76-.97), property crimes M2: (OR=.88 95% CI: .79-.97), and violent crime M2: (OR=.81 95% CI: .66-.99) and visible crime M2: (OR=.86 95% CI: .76-.97) M3: (OR=.85 95% CI:.75-.97) associations reached significance. Analysis at the census tract level did not significantly change estimates but more of these associations were significant for Asian women. Among men, there were no associations for crime and obesity in our study and associations did not vary by race/ethnicity. Discussion: For African-American women higher crime was related to increased obesity and for Asians women, higher crime was associated with lower obesity. Future studies, in diverse populations able to examine gender and race/ethnicity interactions between crime and BMI are needed to corroborate these findings. Additional studies, especially using longitudinal designs, are needed to better capture how residential area crime may influence obesity in diabetics and by gender and race/ethnicity.

INTRODUCTION

Neighborhood residential environments have been tied to obesity in general populations but little work has tied neighborhood environment to other populations with high health management needs, like diabetics [1, 2]. Most neighborhood research examining relationships with body mass index (BMI) or obesity have focused on the physical environment with few studies investigating the impact of the social environment [1]. Studies evaluating the social environment have focused more on neighborhood deprivation or economic environment and evaluation of other factors including crime are limited [1-4]. Chronic diseases, like diabetes, often require more health management activities, such as weight control through physical activity and adherence to a healthy diet, to avoid complications and residential social environments may affect these groups more strongly than the general population [1, 2].

Crime remains an important feature of neighborhoods that can present barriers to key health management behaviors for diabetics. Presence of neighborhood crime may limit positive health promoting behaviors such as physical activity, socialization, and may decrease the ability to make good choices in diet if individuals feel unable to travel in or through their neighborhoods to meet diabetic management goals [5-8]. Increased crime has been associated with feelings of being constrained and lower levels of physical activity such as daily minutes walked and tied to specific types of physical activity such as walking for transport (i.e. walking to bus, work, or store) and leisure walking [9-13]. Neighborhood safety may also differ in significance to certain vulnerable populations, many of which suffer disproportionately with diabetes. Studies of neighborhood crime have shown that women, older adults, racial/ethnic minorities, and those with lower socioeconomic status (SES) report lower levels of safety than younger adults, men, whites, and the non-poor [6, 12, 14, 15]. Minorities and individuals with low SES often reside or spend more time in more unsafe and poorer environments due to long standing racial/ethnic and economic residential segregation and the inability to move out of unsafe areas; women, older, and those with functional limitations may feel physically vulnerable to victimization [11, 14, 16].

There is little work examining objective crime measures but work among self-reported neighborhood safety has found links between these perceived safety measures and health in vulnerable populations. Among African-Americans, lower perceived neighborhood safety was associated with increased BMI and abdominal fat adiposity for premenopausal women but not postmenopausal women or men and studies conducted in diabetic populations demonstrated self-reported crime to be associated with BMI [17-19]. Despite these associations of crime and BMI, few studies have the power to test for interactions by race/ethnicity within gender due to small sample sizes or due to limitations of race or ethnic diversity of study samples [10, 17, 20].

Further, using objective measures of crime across multiple cities and over time can allow for more stable measures of crime rates and a wider sampling of crime across multiple police districts. Studies published comparing objective and perceived safety measures indicate that these two types of measures may both be significant to health but may often play different roles in affecting health behaviors, processes, and outcomes [6, 9, 10].

The goals of this study were to examine if there are any associations between police recorded crime and obesity by gender and for race/ethnic groups by gender among a diverse group of diabetics. We hypothesize that crime and obesity may have differing associations for women versus men. Presence of high neighborhood crime may be a serious barrier to health and

disease management for diabetics and may be related to risk of obesity in this clinically vulnerable population.

METHODS

Study population

The Kaiser Permanente Northern California (KPNC) is a non-profit, group practice, prepaid, health plan in the United States. KPNC currently provides medical services in a 14-county region of Northern California that includes the San Francisco Bay and Sacramento metropolitan areas. Study sample for this study was drawn from the KPNC Diabetes Study of Northern California cohort (DISTANCE), a cohort gathered to study social health disparities in a managed care population [21]. A stratified random sample was formed from the 2005 KPNC diabetes registry with approximately equal numbers of the five largest ethnic groups in the KPNC diabetes registry: African Americans, Asians, Latinos, Whites, and Other race. A baseline survey was administered from 2005-2007 as part of the enrollment into the cohort and 21,188 adults completed the survey, giving a survey response rate of 62%. A more complete description of the study methods, cohort and survey has been published previously [21]. This study was approved by the Institutional Review Boards of the Kaiser Division of Research, the University of California, San Francisco, and University of California, Berkeley.

Description of Study Variables

Variables for these study aims were assembled from the 2005 cohort survey and the neighborhood/ contextual database. In this study we considered two neighborhood definitions that have been studied in the literature, census block group and census tract.

Police Recorded Crime

Police recorded crime data for three years (2005-2007) in the four largest bay area cities of Oakland, Sacramento, San Francisco, and San Jose were collected, categorized, and used to create our crime exposure for the present analysis. We used the FBI Uniform Crime Report (UCR) standards, the most commonly used crime cataloging system, to classify and create crime categories [22, 23]. UCR's Part I crimes are the most commonly collected crimes by U.S. law enforcement agencies because they represent the most severe or numerous crimes committed. We utilized and mapped all eight Part I crimes comprised of homicide, forcible rape, robbery, burglary, aggravated assault, and motor vehicle theft as a measure of crime in this study and 95% of crime was successfully geocoded to the census block group and tract. We also created two routinely evaluated categories of crimes, violent crime (homicide, robbery, aggravated assault, forcible rape) and property crime (arson, burglary, larceny/petty theft, vehicle motor theft) [12]. An additional crime category, visible crime, was created by the study investigators using homicide, aggravated assault, robbery, burglary, and arson to identify crimes that the investigators theorized were most likely to be known by or visible to neighborhood residents either because they are serious in nature (i.e. homicide) or because news of these crimes (i.e. burglaries, arson) may circulate more easily among neighborhoods.

Location information was not released by Sacramento and Oakland Police Departments for certain crimes such as forcible rape and incidents of aggravated assault from domestic violence and child abuse due to department policies on confidentiality. We identified and excluded as many of these crimes as possible for San Francisco and San Jose crime data to compare crime more easily across cities. All Part I crimes occurring in 2005-2007 were geocoded to the residential census block group and tract of respondents. All spatial measures were mapped and calculated using ArcGIS v. 2.1 (ESRI, Inc., Redlands, CA, USA).

Crime rates were calculated at the block and census track level for our four categories of crime [9]. Our numerator consisted of counts of relevant crime incidents for each crime category. Our crime rate denominators were either block group or tract population and were gathered from the 2000 Census. We calculated annual block group or tract crime rates (counts/per person in census unit) for each of our three years of study and calculated the mean rate for all three years for each of our respondents to create a three year crime average rate (mean of 2005 rate, 2006 rate, and 2007 rate divided by census unit population). We multiplied our average annual crime rate by 1000 to create a crime rate per 1000 block or tract group residents per year.

Rescaling of Crime Rate

Continuous crime was rescaled using the interquartile range (IQR), the distance between the 25^{th} and 75^{th} percentiles. The IQR is calculated by using the sample 75^{th} percentile value and subtracting the 25^{th} percentile value from it. We rescaled crime rate by dividing all respondents' crime rate value by the IQR. Other rescaling methods for continuous variables include scaling by the standard deviation, however the IQR is preferable in highly skewed predictors as the IQR scaling factor will reduce extrapolation of the predictor value and will always produce predictor values that are well-represented in the sample. The interpretation of regression coefficient of an IQR rescaled predictor is that it compares predicted obesity for a 1- unit change in crime equivalent to the IQR, or the difference between the 75^{th} and 25^{th} percentile.

Obesity

Body mass index (BMI, in kg/m2) was calculated from Kaiser clinical records using the first clinical measurement of height and weight recorded in an outpatient visit after or closest to the survey date. Self- reported weight and height from the survey was used (n =626, 13%) if individuals had no clinically measured weight and height within two years after the survey. BMI was categorized into obese and not obese using BMI cutoff of BMI<30 indicating not obese weight and BMI≥30 as obese. We also categorized BMI into extreme obesity (BMI≥35) versus not extremely obese (BMI<35) and considered extreme obesity in our analysis.

Covariates

Covariates for the analyses include age, sex, race/ethnicity, education, income, and marital status. Age and sex were collected from KPNC administrative data. Respondent age at time of survey was calculated using date of birth in administrative data and the date survey was completed. Other sociodemographic covariates were collected from the survey including race/ethnicity (African American, Asian, Latino, White non-Latino, and Other race) where respondents were asked to choose the single group they identified with the most strongly. The

Other race category included respondents who identified as Pacific Islanders, Native Americans/Alaskan natives, mixed race, or other race not abovementioned categories. Socioeconomic indicators included education (defined as less than high school, high school or GED, technical/vocational/associate degree, bachelors' degree, or graduated degree), employment status (working/student, retired, unemployed/other), and household income. We defined household income as self-reported family income divided by the poverty line income for a given age and household size based on the US Department of Health and Human Services 2010 Poverty Guidelines. We categorized percent of poverty into four categories (< 130%, 130 - <200%, 200-<400%, > 400%). A missing indicator was included for the 11% of respondents who chose not report their income (n= 335). Current marital status (Married/partnered, divorced/separated/widowed, single/never married) was also collected at the time of the survey.

We used the Neighborhood Deprivation Index (NDI) to control for structural confounding, a concern for identifying neighborhood effects of crime on obesity, by other neighborhood factors such as socioeconomic status (Chaix 2010). Neighborhood deprivation index (NDI) was created using 2000 US Census of Housing and Population data [3, 24] and assigned to respondent addresses. Eight census-derived variables, including percentage of households below the 2000 income to poverty ratio, percentage of households on public assistance, percentage of female-headed households with dependent children, percentage of households with annual income <$30,000 per year, and percentage of adults not completing high school were used to create neighborhood deprivation at the census tract level. The NDI was created at the census tract level within the DISTANCE region using principal components analysis [3]. NDI quartiles were created using the quartile cut points (Q1- Q4) from the continuous NDI measure for all census tracts, with quartile 1 being the least deprived and quartile 4 being the most deprived neighborhoods.

Statistical Analysis

Means and descriptive analysis were conducted for our samples by sociodemographic variables for our study sample were calculated. We examined our continuous exposures, crime rates per 1000 population, using the 25^{th}, 50^{th}, and 75^{th} percentile for gender and race/ethnic combinations at both the census block group and census tract crime levels. Bivariate analyses of patient sociodemographic factors and obesity, including Chi-square tests and one-way analysis of variance tests were used to assess associations with categorical and continuous measures with our outcome, respectively. Means and descriptive analysis were also conducted for our samples for sociodemographic variables by gender and race/ethnicity.

To reduce bias from list-wise deletion of missing covariates we used multiple imputation with chained equations for missing covariates using STATA command *mi impute chained* to impute missing values [25]. All covariates were used in imputation models and 10 imputations were calculated for our missing covariates only. Ordinal logistical regression was used to impute ordered categorical variables (education, income, NDI). Multinomial logistic regression was used to impute nominal categorical variables (race/ethnicity, marital status). Linear and logistic regression using generalized linear models (GLM) using main terms, robust standard errors and accounting for clustering (using Huber/White sandwich estimator) at the block group level crime or at the census tract were used to examine unadjusted and adjusted associations between crime and BMI measured continuously and categorically using obesity cutoffs [26]. GLM is a marginal linear model estimator able to account for neighborhood clustering and can be used to

relative risks even for common dichotomous outcomes such as obesity (50%) in this population using Modified Poisson [27, 28]. We tested our hypothesized race/ethnicity and crime interactions terms in our model using a Wald test. We ran gender and race/ethnic group stratified models for our analysis. Age was centered in our models. We ran race/ethnic group stratified models for our analysis. We created iterative models of crime and obesity first, using a model using only individual level covariates (age, sex, race, education, income, and marital status) and adding NDI in our second model. We tested our hypothesized race/ethnicity and crime interaction terms by gender in our models using a Wald test. All analyses were performed using STATA/SE 13.1.

For sensitivity analysis, we modeled BMI continuously and using extreme obesity (BMI≥35) cutoffs for outcome but increases in continuous BMI were too small to interpret and there were no associations found for extreme obesity.

RESULTS

Approximately 25% of DISTANCE respondents lived the four cities where crime data was collected (n=5050). We excluded from analyses DISTANCE respondents with Type 1 diabetes (n=26), those with a history of any lower extremity amputation (n=40), and respondents who did not have complete data available for our exposure (n =147) or for our outcome BMI (n=149). In addition, we excluded those who had a BMI lower than 18, an extremely low and unlikely value for BMI (n=6). The final analytic sample size was 4,667.

Characteristics of the study sample by obesity are provided in Table 1. The sample was 12% white (n=551), 24% African-American (n=1,102), 20% Latino (n=910), 30% Asian (n=1,395), 15% Other race (n=539), and 4% were missing race. The level of education varied widely for our sample, 18% had less than a high school education, 28% had competed high school or a GED, and 23% had some technical, vocational, or associate degree. Very few individuals in our sample had a bachelors' degree (19%) or post graduate degree (10%). There was a diverse range of income in our sample with 10% of respondents living under the federal poverty line, almost half (49%) had incomes 100-<600% of the poverty line, and 14% had incomes that were 600% of the poverty line for their household size. In our sample more respondents lived in San Jose (34%) compared to the other three cities that had comparable numbers with 22% living in Oakland, 20% in Sacramento, and 23% in San Francisco. We found variation also, in the distribution of respondents by neighborhood deprivation. Seventeen percent of respondents lived in the least deprived census tracts, 45% of respondents lived in the middle two quartiles of deprivation, and 38% of our respondents lived in most deprived neighborhood quartiles. All individual- level covariates, including age, sex, race/ethnicity, education, income, marital status, and work status were associated with obesity (all p<.000). Both neighborhood level covariates, city and neighborhood deprivation were also significantly associated with obesity and extreme obesity (all p<.000).

Sociodemographic characteristics by race/ethnicity and gender are shown in table 2. All sociodemographic variables by race all variables by race and gender were significantly different at p<.0001 levels. There were more female than male respondents for African-Americans, Latinos, and Other race groups. Females were younger than their male counterparts for Whites and Other race. There were differences in income by race/ethnicity as Whites had highest proportion (59%) of people with incomes above 300% of the poverty line compared to Asians

(40%), African-Americans (42%), Other race (39%), and Latinos (26%) had incomes in the same range. Race and ethnic respondents also differed in how they were distributed between our four cities. Seventy four percent of Whites lived in Sacramento and San Jose, 78% of African-Americans lived in Oakland and Sacramento, 55% of Latinos lived in San Jose alone with about equal distribution in the other three cities, 76% of Asians lived in San Francisco and San Jose, and for Other race respondents 62% lived in Sacramento and San Jose.

Figure 1 and 2 display the race/ethnic and gender distributions for the 25^{th}, 50^{th}, and 75^{th} percentiles for this study's crime measures. Across all spatial levels and for all crime types African-Americans had the highest levels of crime compared to all other groups. Whites and Asians both had the lowest levels of crime followed by Latinos, and finally by Other race respondents. For all race/ethnic groups except Latinos, women lived in block groups and tracts with consistently higher crime than their male counterparts. Latinos' crime rate levels were similar across for block group crime exposures and Latino men had slightly higher crime rates than Latina women at the census tract level.

Multivariate Results

There were no statistically significant main effect associations between crime and obesity for men or women overall. Tests for race/ethnic interactions were significant for women for both census block group and census tract crime and obesity. At the census block group level interaction tests were significant using our cutoff (of $p<.1$) for part I crimes, all property crimes, and for visible crime. Race/ethnic interactions tests for violent crime at the block group level were not significant for women. At the census tract interactions tests were significant for all of our four crime exposures. Interaction tests for men were not significant at either the block group or tract level.

Adjusted associations for crime and race/ethnic interactions for women are shown in Table 3 (no race crime interactions were found for men- not shown). No associations between crime and obesity were seen for White, Latino, or Other race women. For African-American women we found that both census block group and tract crime were associated with modest increases in odds of obesity with increased neighborhood crime rate. At the census block spatial level, African American women had a minimal increase in odds of obesity for part I crimes (OR=1.01 95% CI: 1.00-1.03) and for visible crime (OR= 1.03, 95% CI: 1.01-1.05) when crime rate increased one unit of crime (equal to the difference from the 25^{th} to 75^{th} percentile of crime) in models with only individual-level covariates. Significance for these associations was attenuated and not significant when neighborhood and other variables were included in subsequent models. For crime at the census tract level, African-Americans had a slightly higher but still modest increase in odds of obesity for all part I crimes (OR= 1.02 95% CI: 1.00- 1.03), violent crime (OR=1.06 95% CI: 1.02-1.10), and visible crime (OR=1.04 95% CI: 1.01-1.06) when adjusting only for individual level covariates (model 1). This association was not significant when the models were adjusted for additional covariates.

For Asian women we also found significant associations between increased crime and odds of obesity however, crime was inversely associated with odds of obesity, associations were in the opposite direction than those found for African-Americans. For Asian women in models controlling for individuals level covariates (model 1) we found significant associations of higher block group crime with lower odds of obesity for all part I crimes (OR=.91 95% CI: .83-1.00)

and for property crime (OR=.91 95% CI: .84-1.00). Again, these associations at the block level were not significant when NDI was included in the model (model2). Similarly, we also found associations for Asian women at the census tract level for all part I crimes (OR=.90 95% CI: .83-.98) and property crimes (OR=.91 95% CI: .85-.98) in model 1. We adjusted for NDI (model 2) and these associations for Asian women remained significant for all part 1 crimes (OR=.86 95% CI:.76-.97), property crimes (OR=.88 95% CI:.79-.97), and violent crime (OR=.81 95% CI:.66-.99) and visible crime (OR=.86 95% CI:.76-.97) associations reached significance. Finally, we found a significant negative association for increased census tract crime and increased odds of obesity for Other race women for all part one crimes for model 1 and model 2 (both OR=.96 95% CI: .92-1.00)].

Table 1: Sociodemographic Characteristics and BMI of Study Sample

Sociodemographic Characteristics N(%)	Total Study Sample	Mean BMI (SD)	P value	Obese (BMI>30)	P value
All Sample	4, 667	30.8 (6.6)		2,323 (50%)	
Mean age in years (SD)	58.9 (10.2) range: (30-77)	corr:-0.20	0.000	57.3 (10.1)	0.000
Sex			0.000		0.000
Female	2,405 (52%)	32.0 (7.2)		1,362 (57%)	
Male	2,256 (48%)	29.6 (5.6)		962 (43%)	
Race/Ethnicity			0.000		0.000
White	551 (12%)	33.2 (6.8)		373 (68%)	
African American	1,102 (24%)	33.0 (6.8)		715 (65%)	
Latino	910 (20%)	32.2 (6.0)		551 (61%)	
Asian	1,395 (30%)	26.8 (4.4)		302 (22%)	
Other	539 (15%)	32.0 (6.9)		306 (54%)	
Missing	164 (4%)	30.3 (6.0)		77 (47%)	
Education			0.000		0.000
≤ High School	844 (18%)	30.6 (6.3)		414 (49%)	
High School/GED	1,283 (28%)	31.6 (6.7)		713 (56%)	
Technical/Vocational/AA	1,094 (23%)	31.8 (6.7)		617 (56%)	
Bachelors	880 (19%)	29.3 (6.2)		337 (38%)	
Graduate	444 (10%)	29.8 (6.5)		186 (42%)	
Unknown/Missing	116 (3%)	30.9 (5.8)		57 (49%)	
Income, % Poverty Line			0.000		0.000
<100%	479 (10%)	30.1 (6.4)		217 (45%)	
100%-<300%	1,174 (25%)	31.2 (6.8)		606 (52%)	
300%-<600%	1,124 (24%)	31.5 (6.6)		609 (54%)	
>600%	672 (14%)	30.7 (6.5)		332 (49%)	
Missing	1,212 (26%)	30.1 (6.3)		560 (46%)	
Marital Status			0.000		0.000
Married/Partner	2,967 (64%)	30.3 (6.3)		1,393 (47%)	
Divorced/Separated/Widowed	998 (21%)	31.6 (6.7)		547 (55%)	
Never Married/Single	516 (11%)	32.8 (7.6)		304 (59%)	
Missing	180 (4%)	29.8 (6.0)		80 (44%)	
Work Status			0.000		0.000
Working/Student	2,150 (46%)	31.3 (6.6)		1,135 (53%)	
Retired	1,346 (29%)	30.0 (6.2)		613 (46%)	
All Other	532 (11%)	32.0 (7.3)		306 (58%)	
Missing	633 (14%)	29.9 (6.3)		270 (43%)	
City					
Oakland	1,041 (22%)	31.8 (6.7)	0.000	589 (57%)	0.000
Sacramento	923 (20%)	32.8 (7.2)		553 (60%)	
San Francisco	1,093 (23%)	28.6 (5.8)		364 (33%)	
San Jose	1,604 (34%)	30.6 (6.1)		818 (51%)	
NDI Quartile			0.000		0.000
Quartile 1, Least Deprived	808 (17%)	29.9 (6.2)		357 (44%)	
Quartile 2	974 (21%)	29.9 (6.0)		438 (45%)	
Quartile 3	1,109 (24%)	30.3 (6.4)		501 (45%)	
Quartile 4, Most Deprived	1,756 (38%)	32.1 (6.9)		1,022 (58%)	
Not Available	14 (<1%)	33.1 (9.9)		6 (43%)	

[1]Neighborhood Deprivation was calculated at the census tract level and categorized by quartiles
P-values were calculated using chi-square tests of association for categorical sociodemographic characteristic and analysis of variance for continuous sociodemographic characteristics.

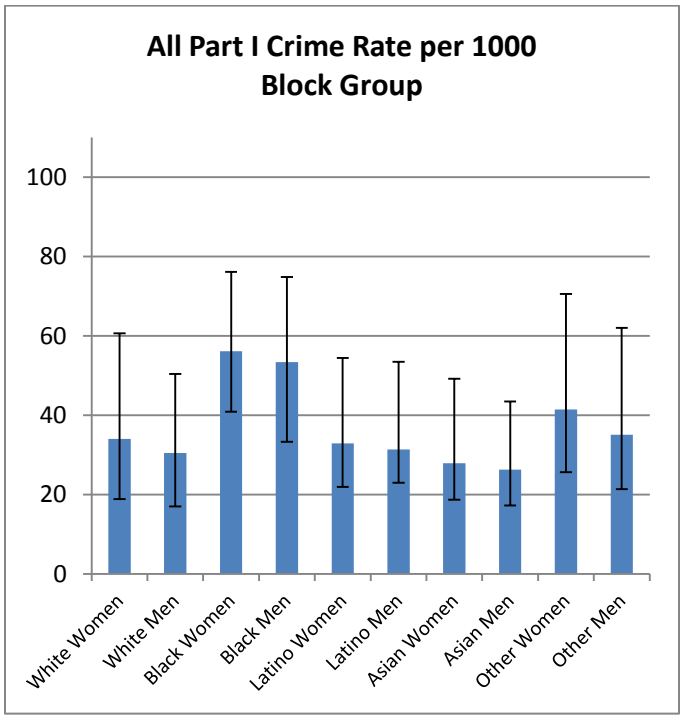
Table 2: Sociodemographic Characteristics by Study Race/Ethnic Groups and Gender

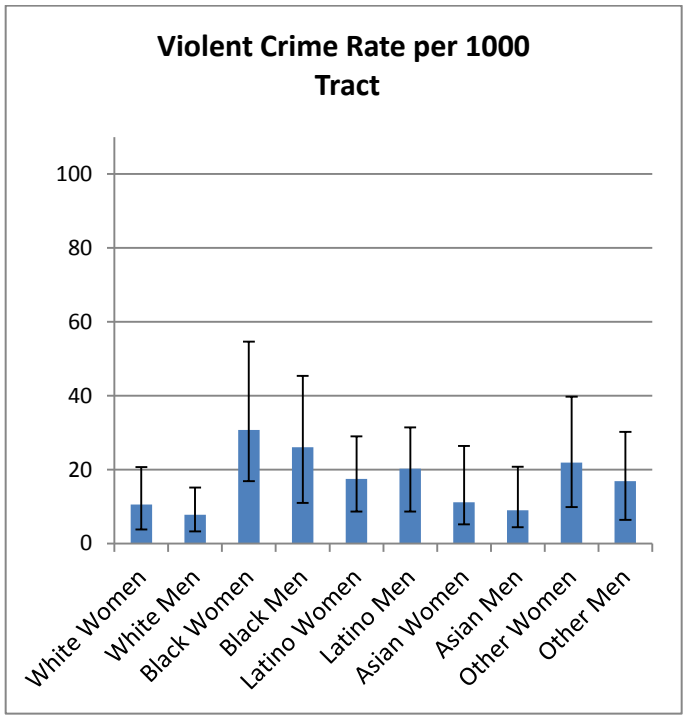
Sociodemographic Characteristics	White			African-American			Latino			Asian			Other Race		
N (%)	All n=551	Women n=263	Men n=288	All n=1102	Women n=658	Men n=444	All n=910	Women n=495	Men n=415	All n=1395	Women n=619	Men n=776	All n=539	Women n=288	Men n=251
Mean age in years(SD)	59.1(9.7)	59 (9.9)	59.2 (9.5)	60.3 (9.6)	60.4 (9.5)	60.1 (9.6)	56.4 (11)	56.6 (11.1)	56.2 (10.9)	59.8 (9.8)	60.2 (9.9)	59.5 (9.7)	57.4 (10.5)	56.9 (11.0)	58.0 (9.9)
Sex															
Female	263 (48)			658 (60)			495 (54)			619 (44)			288 (53)		
Male	288 (52)			444 (40)			415 (46)			776 (56)			251 (47)		
Education															
≤ High School	48 (9%)	10%	7%	112 (10%)	10%	11%	333 (37%)	35%	39%	182 (13%)	17%	10%	102 (19%)	20%	18%
High School/GED	159 (29%)	34%	24%	379 (34%)	35%	33%	276 (30%)	32%	29%	282 (20%)	22%	19%	153 (28%)	30%	27%
Technical/AA	123 (220	25%	19%	342 (31%)	33%	28%	195 (21%)	24%	19%	270 (19%)	20%	19%	144 (27%)	29%	24%
Bachelors	128 (23%)	19%	27%	145 (13%)	12%	14%	32 (4%)	2%	5%	469 (34%)	32%	35%	89 (17%)	14%	19%
Graduate	88 (16%)	11%	21%	104 (9%)	8%	12%	32 (4%)	3%	4%	168 (12%)	8%	15%	44 (8%)	6%	10%
Missing	5 (1%)	1%	1%	20 (2%)	2%	2%	42 (5%)	5%	5%	24 (2%)	2%	2%	7 (1%)	1%	1%
Income, % of Poverty Line															
<100%	19 (3%)	5%	2%	95 (9%)	11%	5%	146 (16%)	19%	13%	152 (11%)	14%	9%	65 (12%)	15%	9%
100%-<300%	107 (19%)	23%	16%	291 (26%)	30%	21%	324 (36%)	36%	35%	293 (21%)	21%	21%	151 (28%)	30%	26%
300%-<600%	180 (33%)	34%	31%	320 (29%)	29%	29%	163 (18%)	15%	21%	320 (23%)	21%	25%	137 (25%)	26%	25%
>600%	142 (26%)	19%	32%	138 (13%)	7%	20%	69 (8%)	5%	10%	243 (17%)	12%	22%	76 (14%)	10%	19%
Missing	103 (19%)	19%	18%	258 (23%)	22%	25%	208 (23%)	25%	20%	387 (28%)	32%	24%	110 (20%)	20%	21%
Marital Status															
Married/Partner	369 (67%)	59%	75%	550 (50%)	39%	67%	632 (69%)	61%	80%	1070 (77%)	67%	84%	330 (61%)	54%	69%
Divorced/Sep/Widowed	109 (20%)	29%	11%	366 (33%)	44%	17%	190 (21%)	29%	11%	193 (14%)	23%	7%	135 (25%)	32%	18%
Never Married	70 (13%)	12%	14%	175 (16%)	17%	15%	78 (9%)	8%	9%	121 (9%)	9%	8%	70 (13%)	14%	12%
Missing	3 (1%)	1%	<1%	11 (1%)	1%	2%	10 (1%)	2%	<1%	11 (1%)	1%	1%	4 (1%)	1%	1%
City															
Oakland	46 (8%)	8%	8%	591 (54%)	56%	50%	107 (12%)	12%	12%	149 (11%)	14%	8%	110 (20%)	24%	16%
Sacramento	145 (26%)	33%	20%	263 (24%)	24%	23%	167 (18%)	18%	18%	184 (13%)	13%	13%	137 (25%)	27%	24%
San Francisco	95 (17%)	14%	20%	148 (13%)	14%	12%	131 (14%)	13%	16%	591 (42%)	43%	42%	93 (17%)	16%	19%
San Jose	265 (48%)	44%	52%	100 (9%)	6%	14%	505 (55%)	57%	54%	471 (34%)	30%	36%	199 (37%)	33%	42%
NDI[1]															
Quartile 1, least deprived	172 (31%)	27%	35%	128 (12%)	8%	17%	108 (12%)	11%	13%	305 (22%)	21%	23%	70 (13%)	9%	18%
Quartile 2	163 (30%)	29%	30%	113 (10%)	8%	14%	142 (16%)	16%	15%	431 (31%)	27%	34%	99 (18%)	16%	21%
Quartile 3	109 (20%)	20%	19%	217 (20%)	20%	19%	233 (26%)	27%	24%	376 (27%)	30%	25%	134 (25%)	27%	23%
Quartile 4, most deprived	104 (19%)	24%	14%	643 (58%)	64%	50%	422 (46%)	46%	47%	280 (20%)	22%	19%	234 (43%)	48%	38%
Missing	3 (1%)	<1%	1%	1 (<1%)	<1%	0	5 (<1%)	<1%	1%	3 (<1%)	<1%	<1%	2 (<1%)	1%	0

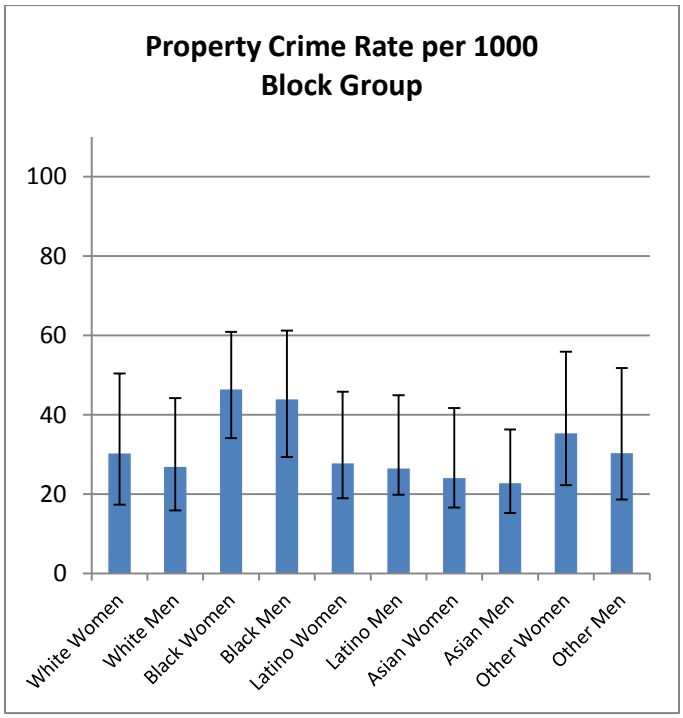
n (%) reported in table cells for race/ethnicity overall and % reported for gender by race/ethnicity
All p-values for race/ethnicity and gender associations with sociodemographic variables were significant at p<.0001
P-values were calculated using chi-square tests of association for categorical sociodemographic characteristic and analysis of variance for continuous sociodemographic characteristics.
[1]Neighborhood Deprivation was calculated at the census tract level and categorized by quartiles

Figure 1. Three year Crime Rate (Crimes per 1000 People) Distribution (25th, 50th, and 75th percentiles*) for Crime Exposure by Race/Ethnicity and Gender for Census Block Group

*Column height represents median crime rate and whiskers on plot represent 25th and 75th percentiles







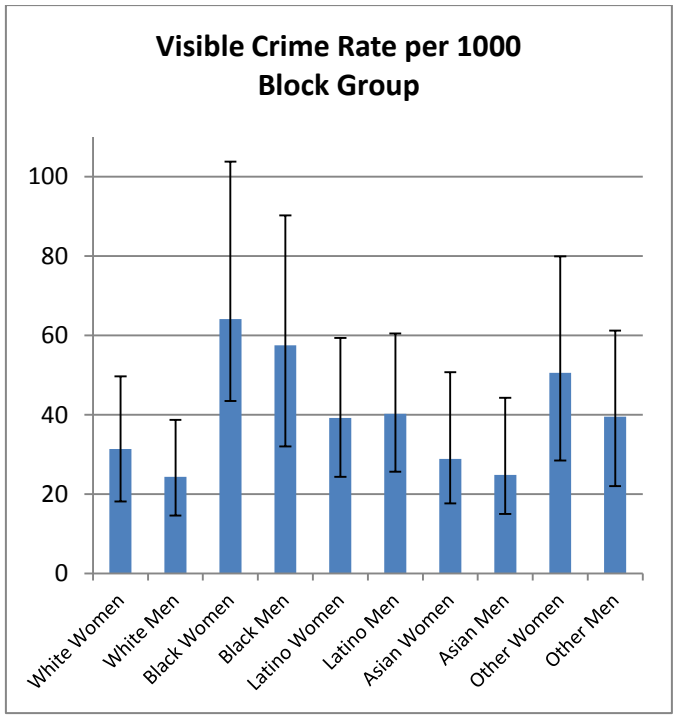


Figure 2. Three year Crime Rate (Crimes per 1000 People) Distribution (25th, 50th, and 75th percentiles*) for Crime Exposure by Race/Ethnicity and Gender for Census Tract

*Column height represents median crime rate and whiskers on plot represent 25th and 75th percentiles

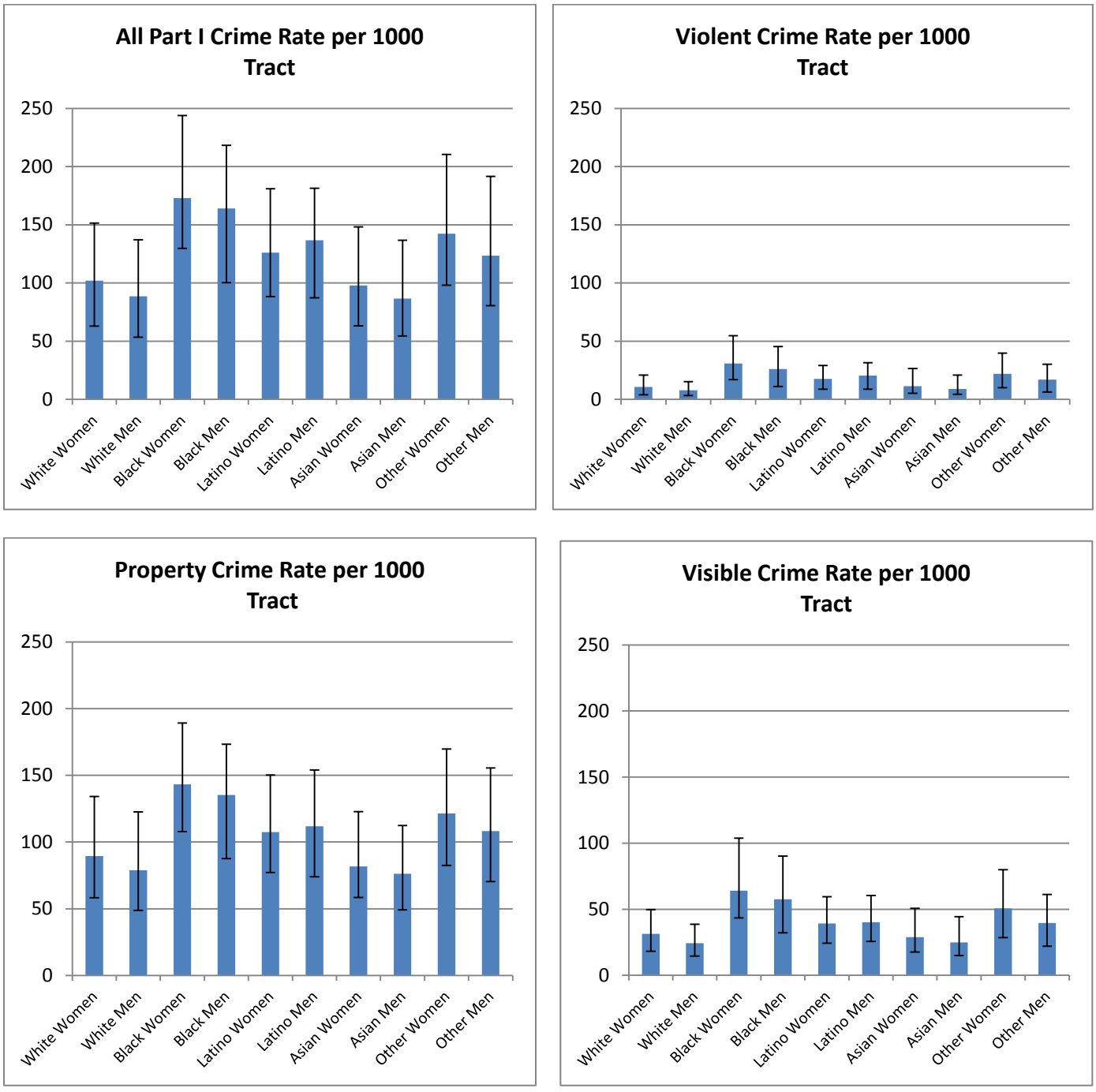


Table 3: Associations Between Recorded Crime Rates Rescaled by Interquartile range and Obesity by Race/Ethnicity for Women

	White n=263				African-American n=658				Latino n=495				Asian n=619				Other Race n=288			
	OR	95%CI		p-value	OR	95%CI		p-value	OR	95%CI		p-value	OR	95%CI		p-value	OR	95%CI		p-value
Block Group																				
All Part I Crimes																				
Model 1	1.00	0.99	1.01	0.75	1.01	1.00	1.03	**0.04**	0.96	0.89	1.05	0.38	0.91	0.83	1.00	**0.05**	0.97	0.93	1.02	0.27
Model 2	1.00	0.99	1.01	0.74	1.01	1.00	1.02	0.16	0.96	0.88	1.04	0.33	0.89	0.79	1.01	0.07	0.97	0.92	1.02	0.29
Violent Crime																				
Model 1	1.01	0.98	1.04	0.42	1.04	1.01	1.08	**0.02**	0.96	0.89	1.03	0.24	0.92	0.79	1.06	0.25	0.98	0.93	1.04	0.58
Model 2	1.01	0.97	1.05	0.61	1.03	0.99	1.07	0.19	0.95	0.88	1.02	0.18	0.88	0.74	1.04	0.14	0.98	0.92	1.05	0.56
Property Crime																				
Model 1	1.00	0.99	1.01	0.77	1.01	1.00	1.02	0.08	0.97	0.89	1.05	0.45	0.91	0.84	1.00	**0.05**	0.97	0.93	1.02	0.27
Model 2	1.00	0.99	1.01	0.75	1.01	1.00	1.02	0.20	0.96	0.89	1.05	0.41	0.90	0.80	1.01	0.08	0.97	0.93	1.02	0.29
Visible Crime																				
Model 1	1.00	0.99	1.01	0.56	1.03	1.01	1.05	**0.00**	0.95	0.87	1.03	0.24	0.93	0.84	1.02	0.11	0.98	0.92	1.03	0.39
Model 2	1.00	0.99	1.02	0.59	1.02	1.00	1.04	**0.02**	0.94	0.86	1.03	0.17	0.90	0.80	1.02	0.10	0.97	0.92	1.03	0.39
Tract																				
All Part I Crimes																				
Model 1	0.99	0.97	1.02	0.68	1.02	1.00	1.03	**0.04**	0.99	0.93	1.05	0.76	0.90	0.83	0.98	**0.01**	0.96	0.92	1.00	**0.05**
Model 2	0.99	0.96	1.02	0.38	1.01	0.99	1.03	0.29	0.98	0.92	1.05	0.62	0.86	0.76	0.97	**0.01**	0.96	0.91	1.00	**0.05**
Violent Crime																				
Model 1	1.00	0.90	1.11	0.97	1.06	1.02	1.10	**0.01**	0.97	0.92	1.03	0.40	0.90	0.76	1.07	0.24	0.97	0.91	1.02	0.25
Model 2	0.95	0.84	1.06	0.35	1.03	0.99	1.08	0.16	0.96	0.90	1.03	0.28	0.81	0.66	0.99	**0.04**	0.96	0.90	1.02	0.21
Property Crime																				
Model 1	0.99	0.97	1.02	0.66	1.01	1.00	1.03	0.08	1.00	0.94	1.06	0.90	0.91	0.85	0.98	**0.01**	0.96	0.92	1.00	0.06
Model 2	0.99	0.97	1.01	0.39	1.01	0.99	1.02	0.34	0.99	0.93	1.06	0.77	0.88	0.79	0.97	**0.01**	0.96	0.92	1.00	0.06
Visible Crime																				
Model 1	0.99	0.95	1.04	0.71	1.04	1.01	1.06	**0.00**	0.98	0.93	1.04	0.48	0.91	0.83	1.01	0.07	0.96	0.91	1.01	0.09
Model 2	0.98	0.93	1.03	0.36	1.02	1.00	1.05	0.07	0.97	0.91	1.03	0.33	0.86	0.76	0.97	**0.02**	0.95	0.90	1.01	0.08

Results of Race/ethnic stratified analysis for women. Model 1 adjusted for age, household income, education, and marital status. Model 2 adjusted for age, household income, education, marital status, and NDI. Violent crime at block group level was not significant in race interaction tests.

DISCUSSION

In this study we examined whether four measures of objective neighborhood crime: all Part I crimes, violent crime, property crime, or visible crimes all at two spatial levels (census block group and census tract) were associated with obesity in a group of diabetic members in a managed care plan. There were no associations for the main effects of objective crime on obesity for men or women overall. Based on *a priori* study questions we tested moderation of any associations of crime on obesity by race for both men and women in our sample. We did find significant race interaction tests for women but not in men in our adjusted models and conducted a gender and race/ethnic stratified analysis for women. We found significant positive associations of crime and obesity for African-American and a negative association between crime and obesity in Asian women. No associations were found for White, Latina, and Other race women.

African-Americans in our study lived in neighborhoods that had the highest crime rates compared to other race/ethnic groups. Whites and Asians had the lowest and similar neighborhood crime rates. Other race and Latino respondents lived in neighborhood with crime rates between those of African-Americans and Whites/Asians. In our race-stratified models for women we found that very small but significant associations between crime and odds of obesity for African-American women and for Asian women. For African-American women increased crime was associated with higher prevalent obesity perhaps due to the higher rates of crime experience by this group compared to all other race/ethnic groups. The negative association for Asian women and prevalent obesity seems counterintuitive but there may be explanations for this relationship. One reason for this association may be that Asian women may have or the particular neighborhoods where Asian women live may have resources or benefits that may counter the disadvantages of living in higher crime neighborhoods. More than half of the Asians in our sample lived in either San Francisco or San Jose; cities where large Asian communities live that may provide additional salutatory benefits not accounted for in our analysis. Furthermore, Asians lived in areas with the lowest crime rates in our studies, 57% of Asians lived in the two least deprived neighborhoods, and may have economic resources different from that of other race/ethnic minorities that may offset negative effects of living in high crime areas. Other clinical differences between diabetes in Asian populations may also influence our findings for Asian women.

Historically disadvantaged race/ethnic groups in our study experienced or report higher levels of crime than Whites and Asians respondents in our study. Our findings support other studies that have found disadvantaged populations experience poorer residential environments than other groups [14]. Associations we found for African-American women was were also found for premenopausal women in a study examining African-Americans [17]. In contrast to other studies we did not find associations for any one particular gender overall but rather for certain race groups for women [10, 17, 20].

This study contributes to the literature exploring neighborhood influences in a population with diabetes in three ways. First, it is the first study examining neighborhood police recorded crime and obesity among a diverse ethnic and racial group of diabetics. The diverse cohort in this study had sufficient numbers in several race/ethnic groups by gender to examine and test interaction between race/ethnicity and gender in evaluating neighborhood crime relationships with obesity. This is one of the few studies that have police recorded crime from several large

cities rather than relying on respondent self-reports of crime to examine predictors of BMI. Research on police recorded crime and BMI is limited and this study adds to the literature examining this relationship. In addition, we categorized our crime to examine whether all crime or specific types of crime varied in their association with obesity. Finally, we examined two fine scale units of spatial aggregation of crime for our study. Many other studies examining mapped incidents of crime often examine only one spatial unit and findings may not agree with results using other units of spatial aggregation. In our study, we found slightly different associations for both block group and tract crime.

Several limitations of our study warrant discussion. First, our analysis was cross-sectional and we cannot rule out reverse causation in interpreting any associations. In this study crime rates, BMI, and study covariates were all collected for the same timeframe. We also controlled for a number of sociodemographic variables in our study, however, we also cannot rule out residual confounding to account for the very small associations we did find for African-American and Asian women. One of the limitations of neighborhood level exposures is our inability to fully account for all known and unknown confounders, specifically of individual-level characteristics that may account for self-selection into neighborhood and that may be associated with obesity. This study's sample was a non-random sample of diabetics who lived in the four cities where crime data was collected. Cohort members not living in these four cities were excluded from the analysis, a limitation to generalizability of our findings to the larger DISTANCE cohort or other populations. This study did not include any measures of perceived crime. Crime incidents may affect perceptions of safety and these may subsequently affect BMI but other studies have shown that objective and perceived measures of crime are each independent predictors of health behavior and status [2, 12, 23, 29].

There are also several limitations of our measurement of crime. First, while considered an objective, police recorded crime may be recorded inconsistency across the four city law enforcement agencies. In our study we attempted to attenuate the differences in crime collection by law enforcement agency differences in crime collecting by utilizing only Part I crimes, the most serious and numerous of crimes recorded and where the FBI UCR has detailed collection and reporting of these crimes nationwide [22, 23]. Furthermore, due to differences in confidentiality rules protecting victims across the four cities several law enforcement agencies did not release certain crimes (rapes, domestic violence) at the address level. We removed all these crimes from all cities in our exposure but this approach may have led to misclassification of crime in this study. Overall, these crimes comprise a small percentage of all part I crimes, violent crime, and visible crime and the effect of removing these crimes may be small.

A final limitation of our neighborhood crime measurement involves the spatial units we defined as neighborhoods. Our neighborhood definitions were not respondent delineated neighborhood buffers or boundaries and we may miss capturing respondents' true neighborhoods. It is difficult to identify what people would define as their neighborhood but do to limitations of available data much research has used census and other administrative units. Census blocks are the smallest geographic unit where census data is available while census tracts are semi-permanent in their boundaries and generally homogeneous with respect to population, economic, and living conditions. This study used both areal units for analysis.

Conclusions

While there are clear limitations, this study on neighborhood crime and obesity adds to the literature examining risk factors for health of the social environment and in an ethnically and racially diverse group of diabetics. There have been no studies to date on associations between objective neighborhood crime and obesity in diabetics. This study found a modest association between higher crime and higher prevalent obesity in African-American women as well as an association between higher crime and lower obesity in Asian women. Certain race/ethnic groups and women may be particularly vulnerable to living in areas with high residential crime. More research in diverse study samples is needed to validate our findings and possible links between neighborhood crime and obesity through longitudinal studies.

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CHAPTER FIVE

Conclusion

CONCLUSION

Neighborhoods may matter for health but there has been far too little research on the social environment of neighborhoods. Limited research exists examining how the social environment may affect health in general populations and even less studies have been in chronically ill populations like diabetics. Crime is a salient feature of the social environment. It has been seen to influence physical activity and health care behaviors but more research is needed to examine these associations.

Due the high level of health management needs of diabetics, they may be particularly susceptible to barriers and obstacles of unsafe residential environments. Diabetics must adhere and follow strict guidelines for weight control that involve weight control through physical activity and a diabetic friendly diet high in healthy foods in addition to medication. Without strict adherence to these healthy behaviors, diabetics become at serious risk of diabetic morbidity and early mortality. Studies examining the residential influences on this clinically vulnerable population are warranted to avoid diabetes sequelae. An additional consideration for better understanding neighborhoods of diabetic involves their sociodemographic vulnerability. While diabetes is increasing nationally, diabetic populations tend to be poorer, older, and are disproportionately from minority groups. All these sociodemographic characteristics have been tied to poorer neighborhood environments perhaps putting diabetics at greater risk for the ill effects of living in unsafe residential neighborhoods.

In this work, both perceived and objective measures of neighborhood safety, including self-report of general neighborhood safety and recent violence as well as police-recorded crime incidents, were examined in a diverse sample of diabetics. The research found mixed cross-sectional associations between neighborhood safety and our outcomes of stress, physical activity, body mass index, and HbA1c (Hemoglobin A1c, glucose control).

In these studies, perceived crime was associated with body mass index (BMI) but not with stress, physical activity, or HbA1c. Perceptions of poor neighborhood safety from crime or self-report of neighborhood violence were associated with increased BMI after adjusting for individual level confounders. A larger increase in BMI was associated with self-report of neighborhood violence compared to reports of poor general safety in neighborhoods. Reports of recent violent neighborhood crime, but not general neighborhood safety, was also associated with diabetics who were extremely obese (BMI$\geq$35) after accounting for other sociodemographic characteristics of respondents.

For the second study examining police recorded crime and stress we determined that crime was associated with odds of high stress but only for African-American and Latino women. For African-American women, an increase in neighborhood crime rates for all crimes and many of our other categories of crime at either block level and census tract was associated with increased odds of everyday stress after we controlled for individual and neighborhood level characteristics. For Latina women we found an even more pronounced association of higher crime rate and higher odds of stress for all crime types at both spatial levels. African-American women consistently lived in neighborhoods with the highest rates of crimes compared to other women and compared to men. Latina women also had higher crime rates than Whites and Asian women but it is possible that crime may more adversely affect certain historically vulnerable

populations, like Latina women. No associations were found for White, Asian, or other race women or for men.

Very small associations were seen in our cross-sectional study examining crime and odds of obesity. We found that increase in crime was related to an increase in obesity for African-American women but with lower obesity for Asian women. The relationships were strongest at the tract level. For Asian women increase in census tract level crime was related to decreases in odds of obesity. While this may seem counterintuitive, it may be that the particular neighborhoods where Asian women live offer certain other counter benefits to high crime. In fact, Asians lived in areas with the consistent lowest crime rates in our studies and 57% of Asians lived in the least deprived neighborhoods, Quartile 1 and 2 in our neighborhood deprivation measures. No crime obesity associations or consistent associations were seen for White, Latina, or Other race women or men. These very moderate increases in obesity require further verification with other studies and with studies using longitudinal data.

In examining stress, the associations we found between police reported crime and stress were not seen in our analysis of perceived neighborhood safety. In our study of police reported crime we found that it was associated with higher stress for African-American and Latina women. There was no association between perceived neighborhood safety and high stress overall. Due to limitations in sample size for our perceived crime analysis we were not able to test for interactions of race and gender in that sample.

Our perceived crime analysis found an association between self-reported safety concerns and BMI and extreme obesity when controlling for race among other individual level factors in our analysis. We did not find this association, however, in our analysis of police recorded crime and obesity across all groups. The only associations seen were for African-Americans in the direction we expected but these associations were very small. Amongst Asian women we found that police recorded crime was associated with a decrease in BMI. One possible reason we found differences between perceived and police crime was timing of our outcome, BMI. In our perceived crime analysis BMI was collected after the survey while BMI was collected in a cross-sectional design in the police recorded crime analysis and may also have influenced our differing findings.

Our findings comparing perceived and objective measures of neighborhood safety support previous literature conclusions that both types of measures may have differing and/or independent relationships with health related outcomes.

Limitations of Research

There are several limitations to note concerning the research conducted. Our first limitation concerns the cross-sectional design of most of our studies. Our exposure, respondent sociodemographic characteristics, stress, and BMI were collected during the same timeframe for most of these studies. Our design limits the questions we can ask, types of analysis we were able to conduct, and provides barriers to arriving at causal conclusions in studying the relationship between neighborhood safety and diabetes related health measures.

A second limitation relates to identifiably issues that relate to neighborhood research. Individuals are not randomized into neighborhoods and people may self-select into

neighborhoods for numerous known and unknown reasons. In studies involving neighborhood exposures we may not be able to control for all known and unknown individual characteristics that may account for self-selection into neighborhood and with our outcomes. We attempted to control for as many individual level covariates that might bias estimates of our neighborhood safety and outcomes but residual confounding remains a limitation to our findings.

For this study, only crime documented by law enforcement officials was used as a measure of safety. Not all criminal incidents are reported and we may not be capturing all of the safety concerns that affect residents. In addition, there may be discrepancies in how law enforcement agencies may report or classify their crime. Furthermore, due to policies regarding confidentiality for victims of crimes certain serious violent crimes (i.e. rape, child abuse, domestic violence) locations for these crimes were not released at the address level and were not included in our crime measure across all cities. While the proportion of these crimes as compared to all part I crimes is small it remains a possibility that non-inclusion of these crimes may influence our findings.

A last limitation to this study is that the DISTANCE cohort (and the subsamples used to examine perceived and police recorded crime) are from a managed care plan sample that may have limited generalizability to other populations or the broader population. The participants in this diabetes cohort are part of a managed care plan whose members are certainly different than people of other health care plans and those without comprehensive health insurance. Care must be given in generalizing these findings to other population.

Although major issues surround arriving at causal relationships between neighborhood safety and health related factors among diabetics, these do not detract from the usefulness of studying these associations. Studies evaluating the associations of neighborhood crime and health related outcomes in diabetic and chronically ill populations are in their infancy and these studies provide exciting new road in the field of neighborhood research..

Discussion

These studies examining neighborhood safety and crime with health in diabetics contribute to the very small but growing neighborhood literature in diabetic populations. Identifying neighborhood risk factors, such as neighborhood safety, and the mechanisms influencing poor diabetic management may be essential to tackling a chronic disease with no current cure. Identification of contextual risk factors may lead to policy changes that may aid diabetics in better self-management practices. If improving or managing around neighborhood safety is a strong influence for decreasing stress, increasing physical activity and positively impacts BMI or HbA1c in diabetics, we may also focus on increasing safety through a variety of policies or interventions.

The United States has a fast growing rate of diabetes incidence and prevalence of this disease is growing. A better understanding of the environmental influences, mechanisms, and possible policy interventions available to tackle this growing disease and its complications is necessary. Ultimately, the goal of this research is to find ways to reduce the burden of diabetic sequelae in the general population as well as in specific sub groups who suffer the greatest share of diabetic morbidity and mortality.

Recommendations

This research on neighborhood safety and health related measures in diabetics can be useful to the growing field but more studies are needed. The literature has sparse studies using objective measures of neighborhood security and more studies of these measures alone and in combination with perceived neighborhood safety are necessary. Future longitudinal studies in diverse populations are also warranted. Longitudinal studies can more persuasively build a case for findings examining associations between neighborhood safety and diabetic health. Diverse populations are needed to evaluate any possible effect measure modification of sociodemographic associations between neighborhood safety and health.