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The Impact of Psychosocial, Clinical, and Neighborhood Factors on Inflammatory Outcomes Among African American Women

Malcolm Seth Bevel

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THE IMPACT OF PSYCHOSOCIAL, CLINICAL, AND NEIGHBORHOOD FACTORS ON
INFLAMMATORY OUTCOMES AMONG AFRICAN AMERICAN WOMEN

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DEDICATION

This thesis is dedicated to my lovely wife (Jazmine), parents (Henry and Daphne), brother (Kwame), friends and family (including my Lucky #3's Layla, Sole, and Khalil), and to my granddad-in-heaven (Henry Bevel II) who have constantly given me support, strength, and love during my academic pursuits.

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ABSTRACT

Inflammatory-related chronic diseases are disparagingly prevalent among African Americans in the United States, particularly in the Southeastern region. Access to community gardens shows promise in mitigating chronic disease outcomes, despite multiple barriers to physical activity and diet among underserved populations. We seek to determine if psychosocial or clinical factors mediate the association between the treatment effect of a healthy lifestyle intervention and inflammatory biomarker levels among African American women, respectively. We also seek to analyze the relationship between residing in a food desert/swamp and inflammatory biomarker levels, while gaining a qualitative perspective about community garden access among African American women. Quantitative data was obtained from the Sistas Inspiring Sistas Through Activity and Support (SISTAS) trial (N = 337), where we received biological, anthropometric, and demographic measures. Qualitative information came from key informative interviews (n = 15) to gain insight on the views of healthy food access among residents in county level-designated food deserts or swamps. We computed descriptive statistics using frequencies or means and standard deviations (STD) and conducted mediation analyses to evaluate if depression, percent body fat, or diastolic blood pressure mediates the effect of the association between participation in the SISTAS intervention and c-reactive protein (CRP) and interleukin-6 (IL6) levels. We also performed a mixed methods analysis to observe the impact of residing in a food desert or food swamp on CRP and IL6 levels, and then receive common themes on community garden access

among SISTAS participants. We found that depression, percent body fat, nor diastolic blood pressure mediated the effect of the treatment assignment of the SISTAS trial on CRP or IL-6, respectively. We also did not find a significantly increased risk of high CRP or IL-6 levels among women residing in food deserts or food swamps. Common themes from the key informative interviews included self-efficacy for the utilization of personal or community gardening. Other psychosocial and clinical factors should be analyzed for future mediation analyses, and unique resources such as community gardens also need to be considered for use in healthy lifestyle interventions to combat inflammatory-related health disparities among underserved populations.

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LIST OF SYMBOLS

Kg/m^2 Kilograms per meter squared.

mg/dL Milligrams per deciliter.

pg/dL Picogram per milliliter.

% Percentage.

n/N Sample size.

LIST OF ABBREVIATIONS

AA	African American
BrCA	Breast Cancer
BMI	Body Mass Index
CBPR	Community-Based Participatory Research
CESD-10	Center for Epidemiologic Studies Short Depression scale
CI	Confidence Interval
CRP	C-reactive Protein
DII	Dietary Inflammatory Index
EA	European American
IL-6	Interleukin-6
NHANES	National Health and Nutrition Examination Survey
OR	Odds Ratio
PA	Physical Activity
RR	Relative Risk
SC	South Carolina
STD	Standard Deviation
SISTAS	Sistas Inspiring Sistas Through Activity and Support
U.S.	United States

CHAPTER 1

INTRODUCTION

The objectives of this dissertation are two-fold: to evaluate how interventions for diet and physical activity (PA) behavior change are mediated by psychosocial or clinical factors, which can affect inflammation among a cohort of African American (AA) South Carolinian women participating in the Sistas Inspiring Sistas Through Activity and Support (SISTAS) study and to examine the acceptability of an alternative approach to diet and PA interventions through community gardening.

Racial health disparities (in regard to chronic disease morbidity and mortality) have remained persistent in the United States (U.S.). Conditions such as breast cancer occur at higher rates in AA adults compared to other races. AA women succumb to breast cancer at a higher rate than European-American (EA) women [1], and one of the most alarming health disparities in SC is associated with increased breast cancer mortality rates among AA women [2-3]. Specifically, hypertension, type 2 diabetes, stroke, and heart disease all depict a picture of disparaging morbidity and mortality outcomes among AA adults [4-7].

Investigators in the public health field seek to mitigate chronic disease outcomes through prevention strategies and early detection. Heart disease, diabetes, and breast cancer can be prevented through healthy diet and/or PA regimens [8-14]. Psychosocial factors, such as depression, can play an adverse role in chronic disease

management [15-20]. Also, clinical factors such as percent body fat or high diastolic blood pressure can exacerbate other conditions [21-22]. However, these particular categories of factors have seldom been studied in relation to healthy lifestyle interventions (e.g. fruit and vegetable intake, PA) focused solely on AA women [23].

Racial disparities exist as it pertains to inflammatory issues within the body. Specifically, AA adults deal with elevated inflammatory biomarker levels in the blood compared to whites. These rates are pronounced when they are facing depression [24-25], higher percent body fat [26-27], or high diastolic blood pressure [28-29], respectively. There has been a slight increase in breast cancer incidence rates among AA women from 2007-2014, and despite a gradual decline in breast cancer death rates in the same time period, AA women are still dying at a higher rate compared to other racial groups [30]. Issues behind the death rate disparity include later diagnoses of breast cancer and more aggressive forms of breast cancer among AA women compared to EA women [31]. Interventions geared towards diet and PA behavior change can mitigate chronic disease afflictions among under-resourced populations.

In brief, numerous CBPR based clinical trials have targeted AA men and women in regard to specific outcomes [32-35], including assessment of cancer risk knowledge [36] and reduction of cancer risk [37]. Statistically significant increases in colorectal cancer knowledge was shown in one study [32], while statistically significant decreases in weight, body mass index (BMI), and percent body fat occurred among participants recruited from five churches [36]. Only two studies used a CBPR approach to develop a breast cancer prevention intervention among AA women [38-39]; it is rare to find research studies involving gardening/community gardens utilizing the CBPR approach.

Despite epidemiologic evidence tying community gardens to living a healthier lifestyle, the focus of most of those studies in the U.S. were geared towards children or AA men [40-50]. One study found a significantly higher prevalence of (and preference to consume) fruits and vegetables grown in gardens among a small cohort of Latino elementary school students [40]. Another study involving a larger cohort of children showed that elevated fruit and vegetable intake was achieved if schools with a gardening intervention improved its involvement scores by multiple levels [41]. The current investigation proposes to focus on AA women as intervention targets. The main limitation among other previous studies is that the focus was solely on changing behavior given the populations used, as opposed to behavior change coupled with mediating factors in chronic disease outcomes.

Primary prevention should be the focal point in chronic disease health, as it is a vital component of improving statistics as well as improving population health, especially among underserved communities. This dissertation will give information on healthy lifestyle interventions and breast cancer among AA women in SC. We will study the benefits of lifestyle interventions for the primary prevention of breast cancer, while also considering how psychosocial factors play a possible mediating role in the relationship between interventions and breast cancer among an at-risk population. Given how previous research has shown how depression, percent body fat, and diastolic blood pressure all have played a specific role in inflammatory outcomes among AAs, and how living a healthier lifestyle (i.e. PA, diet) can mitigate said outcomes, this gives us the rationale to conduct a mediation analysis using information from an underserved population.

Specific Aims

Quantitative and qualitative data from the Cancer Prevention and Control Program {specifically the Sistas Inspiring Sistas Through Activity and Support (SISTAS) randomized controlled trial} will be used to examine the association between diet/PA behavior change, psychosocial factors, and chronic disease outcomes. The SISTAS project was a CBPR project aimed at promoting PA and healthy diet among obese AA women in South Carolina (SC).

The dataset includes information on women ages 18 years old and above during a 4-year period, consisting of demographics, anthropometric measures, and laboratory-derived data. The overall goal of the SISTAS study was to reduce biomarkers of inflammation, which have been linked to elevated chronic disease risk and mortality.

Therefore, the specific aims of this paper are:

1. Examine how depression mediates the treatment effect of a dietary and PA intervention on changes in AA women's inflammatory biomarkers over time.
2. Examine how clinical factors mediate the effect of a dietary and PA intervention on changes in AA women's inflammatory biomarkers over time.
3. Using an explanatory sequential design:
 - a) Examine how residing in a food desert or food swamp affects AA women's pro-inflammatory dietary habits and biomarkers (QUAN).

- b) Explore how residing/not residing in a food desert/swamp further explains AA women's pro-inflammatory diets and perceptions of community gardens as a way to improve their dietary needs (QUAL).

Although there has been an ample amount of research done in determining certain risk factors for chronic diseases among AA women, a concentrated effort to focus on healthy lifestyle changes can allow epidemiologists to conduct population-based preventive interventions geared towards reducing disease burdens. Given the fact that the southeastern US is host to higher rates of chronic disease, the state of SC is prime to study racial disparities associated with breast cancer. The focus should be on strategies to keep healthy persons from elevated inflammatory biomarkers through preventive measures, and this in return can potentially decrease the cost of medicinal treatments of chronic ailments.

A critical goal of this epidemiologic project is to significantly contribute to the body of work currently existing in regard to C-reactive protein (CRP) and interleukin-6 (IL-6) levels. This dissertation seeks to advocate for additional research among AA women to define how their behaviors can be potentially modified to improve other health outcomes. Development of concise and adequate healthy lifestyle guidelines specific to AA women will be vital in combating the comorbidities they suffer from. Results from this dissertation may offer a side to the story of chronic disease health that desperately needs to be told.

CHAPTER 2

LITERATURE REVIEW

Chronic Diseases

The rise of chronic diseases among adults in the U.S. led to an increased focus on these ailments by public health officials. Despite slight declines at various timepoints, the prevalence of hypertension, diabetes mellitus, and obesity has continued to rise in recent years [51]. Although the overall cancer prevalence rates are declining, there is still concern given that incidence rates and deaths are increasing [52]. The rates of the diseases previously mentioned are more pronounced in the AA community, hence the considerate focus on health disparities in this population in recent years. Over 40 percent of AAs have hypertension compared to EA (27.4%) [53], 12.7% of AAs have diabetes compared to 7.4% of EA [54], and almost 47% of AAs are obese compared to almost 38% of EA [55].

Although overall cancer death rates have significantly declined during 1999-2015 [56], the racial disparity among the incidence and mortality rates of certain cancer types are still particularly concerning. Prostate cancer, for example, adversely affects AA men more often than EA men [52]. The leading cause of cancer deaths among women is breast cancer, and although EA women have a slightly higher incidence of breast cancer compared to AA women (125.6 vs. 123.8; rates per 100,000), AA women have a higher mortality rate compared to EA women (28.7 vs. 20.3; rates per 100,000) [52].

Inflammation

Inflammation can be defined as the body's natural response to specific and abnormal traumas, including wounds, infections, or abnormal tissue [57]. Typical cases of acute inflammation are associated with infections or wounds that occur during a short period of time, while chronic inflammation presents for multiple reasons including leaving acute inflammation unchecked for prolonged periods of time [58]. Commonly known diseases that exhibit chronic inflammation include cardiovascular diseases, diabetes, allergies, and joint diseases (e.g. rheumatoid arthritis).

The two main types of chronic inflammation include *granulomatous inflammation* and *nonspecific proliferative inflammation*, with the main difference between the two being the type of tissue created at the damage site. Age, diet, stress, and smoking are just some of the risk factors associated with chronic inflammation; typical signs include pain, fatigue, depression, and frequent infections. Factors that can contribute to the mitigation of chronic inflammation via decreasing cytokines include a healthy diet (e.g. increase in fruits and vegetables, decrease in fats, fish oil consumption) and PA [58]. Despite the lack of effective laboratory measures to detect chronic inflammation, existing methods include serum protein electrophoresis [59] as well as blood tests to identify serum levels of CRP and cytokines like IL-6 [60-61].

CRP is a plasma protein in the petraxin family, with a single copy of itself in the human genome located on chromosome 1; it is typically regulated by cytokines such as IL-6 in response to inflammation [62]. Clyne and Olshaker reported that normal CRP levels are around 10 mg/L or less, while responses to inflammation after a 48-hour period can see levels reach as high as 400 mg/L. It has also been used as a measure to detect

infectious diseases presented by patients in the emergency department, such as appendicitis, pancreatitis, pneumonia, or urinary tract infections [63]. IL-6 is a cytokine acting as a mediator as it pertains to inflammatory response, regulating CRP. It consists of 212 amino acids located on chromosome 7p21 in the human genome, sending a signal while traveling to the liver when internal damage arises. The main importance of IL-6 lies within its response to inflammation: typically, the activation of IL-6 ceases when the internal trauma to tissue is mitigated [64].

Disparities in inflammation have been recently noted in the field of public health, with analyses geared towards stress markers at childhood to socioeconomic disadvantages in adulthood and several chronic diseases. Schmeer and Tarrence evaluated National Health and Nutrition Examination Survey (NHANES) data to determine how chronic stress played a role in low-grade inflammation among children, and they found a significantly elevated risk of inflammation among AA children (when at least one parent is foreign born) compared to white children [65]. Richman looked at psychosocial stress and CRP levels among adults sampled from NHANES data and found a significant association between inflammation levels and stress among middle-aged poor/non-poor AA adults compared to non-poor whites [66].

Depression and its relationship with inflammatory biomarkers have rarely been studied among the AA community, although the research done has been in the last 15 years . A cross-sectional study by Camacho and his team found a significant association between depressed AA adults and logIL-6 [67], and Deverts and her colleagues saw a significant relationship between depressive symptoms and future higher CRP levels among AA adults compared to whites [68]. Contrarily, Morris and her co-authors did not

find a significant association between depressive symptoms and CRP levels among AA adults [69]; Case and Stewart also found no relationship between serum CRP and varying levels of depression [70].

Overview of Breast Cancer and Inflammation

Symptoms that can lead to the detection of breast cancer include having a new lump in or around the breast (the most common sign), pain and/or irritation or dimpling of the breast, redness or flaky skin, or nipple discharge outside of breast milk [71]. The primary procedures for breast cancer screening includes self-exams, clinical breast exams, and mammograms; the best modality for detection being mammograms as regularly as possible [72]. Regular examinations, especially mammograms, are recommended to reduce the risk of breast cancer mortality. Self-exams and clinical exams consist of a basic physical examination of the breast to determine if any physical irregularities (e.g. lumps or change in size or shape) exist [72]. After any initial detection technique is used, a biopsy may be ordered by a physician to confirm any diagnoses. A biopsy consists of the surgical removal of tissue to locate cancerous cells in the body [73].

Through a plethora of epidemiologic research, risk factors (hereditary, environmental/lifestyle factors, hormonal/reproductive) have been found to be associated with breast cancer. Gene mutations in the BRCA1 and BRCA2 positions are the primary causes of hereditary breast cancer [74], therefore it is imperative to know one's genetic risk so then information on preventive measures can be disseminated properly. Any interruption in the p53 tumor suppressor gene is another common genetic cause of breast cancer [75]. A multitude of hormonal factors are related to an increased risk of breast

cancer, such late menopause, early menarche, obesity in postmenopausal women, lack of ability to breast feed, no full-term pregnancy before a certain age, elevated concentrations of estradiol, and hormone replacement therapy usage in women [76]. Obesity due to poor diet and exercise, as well as exposure to various contaminants, are also some factors associated with breast cancer [76].

There are modifiable and unmodifiable risk factors related to this carcinoma. Unchangeable factors that can lead to an increase in breast cancer risk include race, being female, age, family history, estrogen exposure (early menarche or late menopause), and breast density. There are several changeable risk factors including weight concerns, excessive alcohol consumption, smoking, intake of hormone replacement therapy, oral contraceptive use, diet, and exercise [77].

PA, Inflammation, and Breast Cancer

One of the most well-known protective factors in combating breast cancer is PA. As it can be defined in many ways, we observe that PA is bodily movement that expends energy [78]. It can consist of numerous tasks such as walking, water aerobics, playing basketball or tennis, weightlifting, yoga, or even heavy gardening [79]. Recommendations for main health benefits through PA among adults include performing at least 30 minutes of moderate-intensity aerobic activity in a five-day period, which can be broken up into 10-minute increments per day [80]. Various advantages of PA on a person's health status include weight control, risk reduction of chronic diseases (e.g. type-2 diabetes, specific cancers), improvement of bone/muscle strength and mood [79].

Despite the known positive effects of PA, not enough Americans are getting the recommended amount of PA they need [81]. Barriers to getting enough activity in

throughout a typical week can depend on specific ailments, but can include lack of time, child care issues, accessibility issues (e.g. walkable neighborhoods and parks), traffic concerns, lack of motivation, fear of being injured, and feeling tired [82-89]. These barriers also exist in minority communities, who suffer health disparities regarding various chronic diseases. Unique barriers to PA among AAs include concerns about hair care, multiple jobs, familial obligations, peer pressure, lack of social support, physical appearance concerns, high religiosity, and transportation issues [90-100]. Therefore, it is imperative to emphasize PA interventions to help combat ailments such as breast cancer.

An abundance of previous studies concluded that PA serves as a protective factor against breast cancer among women in general. Interventions, including home-based projects, have shown favorable outcomes when participants are physically active. One such intervention showed with an increase in PA minutes and intensity among intervention participants compared to controls, the intervention group showed better results in a fitness field test [101]. Others have produced findings such as reduced levels of sex hormones shown to be associated with breast cancer [102], reduced risk of breast cancer overall including among participants who simply walk [103], and dose-response relationships with reduced risk as PA levels increased [104].

Several prospective cohort studies either showed a significantly or marginally lower risk of breast cancer when women had consistently high recreational PA, vigorous PA, the highest output of kilojoules, reported jogging, or reported exercising at least once a week, respectively [105-110]. Two case-control studies found that women who reported either participating in recreational PA or having more than 161 metabolic equivalent (MET) hours/week per year were less likely to have breast cancer [111-112]; one did not

find a significantly reduced odds of breast cancer if women reported any lifetime PA across increasing quartiles {Quartile 2 = 0.91 (0.60–1.37), Quartile 3 = 0.91 (0.60–1.39), and Quartile 4 = 1.10 (0.73–1.67)} [113].

The shortage of epidemiologic research on breast cancer geared towards AA women has drawn major concern among those in the public health field, as well as stakeholders in the AA community. Seldom do we find experimental studies performed with a focus on AA women, and the observational studies tend to have mixed results. Epidemiologic studies dealing with the association of PA and breast cancer risk among black women were from the PubMed [114] database using the following search terms: breast cancer, breast carcinoma, breast tumor, breast hyperplasia, breast neoplasm, black women, and African-American women. They were combined with these search terms: physical activity, physical fitness, exercise, physical exercise, light physical activity, light physical fitness, light physical exercise, light exercise, moderate physical activity, moderate physical fitness, moderate physical exercise, moderate exercise, vigorous physical activity, vigorous physical fitness, vigorous physical exercise, and vigorous exercise.

We decided on the PubMed search with the terms above to lay the foundation of the most relevant and recent research performed on PA and breast cancer risk among AA women. The search initially yielded 82 studies in the last 18 years that were considered eligible for further assessment. We excluded 72 studies because they 1) did not include AA women exclusively, and 2) did not include a population that was cancer-free at the beginning of the study; we ultimately focused on ten studies.

Two of the studies we focused on were designated as prospective cohort studies, while the remaining were case-control studies. Despite the lack of applicable clinical trials in almost two decades, some of these previous studies showed significant results. Nomura and her colleagues analyzed adherence data from the Black Women's Health Study, specifically if AA women were adhering to individual recommendations such as being physically active for at least 30 days. They also stratified PA by the number of hours and observed different levels of sedentary habits. They found a roughly 15% reduced risk of breast cancer when AA women adhered to the PA recommendations [115]. Similar results were discovered by Rosenberg and her team, analyzing vigorous exercise data and breast cancer overall (including estrogen receptor positive and negative cancer) from the Black Women's Health Study, respectively. They found that breast cancer risk among women who participated in vigorous exercise for greater than/equal to seven hours per week was 26% less compared to those who participated in vigorous exercise for less than one hour per week [116].

Eight case-control studies from our search produced mixed results; specifically, 63% of the case-control studies reviewed saw a significant reduction in breast cancer outcomes. Gong and her co-authors analyzed data from women participating in the African American Breast Cancer Epidemiology and Risk Consortium. They found a marginally significant reduced risk of breast cancer overall, including estrogen receptor positive breast cancer when AA women had recent vigorous exercise [117]. However, the decrease was not statistically significant among estrogen receptor negative breast cancer. Sanderson and her team used data from AA women in the Nashville Breast Health Study to determine if adult exercise had an association with breast cancer among women

depending on menopause status. They found a reduced odds among postmenopausal AA women, but it was not statistically significant [118].

Lu et al. conducted research on AA women who participated in the California Breast Cancer Survivorship Consortium; they did not find a significant risk of breast cancer among those who had recreational PA use [119]. Sedentary and PA data from the Southern Community Cohort Study was analyzed by Cohen and her colleagues, and they found a non-significant increased association of breast cancer and total PA among AA women [120]. Sheppard and her colleagues looked at vigorous PA activity and breast cancer data from AA women in the Washington, D.C. area. They found a significantly decreased risk of breast cancer among women who had more than two hours of PA per week, and the association was also found among postmenopausal women [121].

Ratnasinghe and his cohorts conducted an analysis on data from the Global Epidemiology Study, with participants from various ethnic backgrounds. They found a highly reduced odds of breast cancer among AA women who were in the highest tertile of PA [122]. Adams-Campbell and her team did a matched case-control analysis on data from the Black Women's Health Study. They looked at strenuous PA by the number of hours and did comparisons by age groups. They found a 40% significantly reduced odds of overall breast cancer among 21-year old and 30-year old AA women with more than seven hours of exercise per week [123]. The decrease odds of breast cancer were more pronounced among 40-year old postmenopausal AA women in this sample. Bernstein and her team used data from the Women's Contraceptive and Reproductive Experiences Study to determine if a significant association existed with increasing levels of lifetime

exercise activity. They found a 25% reduced odds of breast cancer if AA women had three or more hours a week in their lifetime [124].

We also decided on a PubMed search to continue strengthening the foundation of the most relevant and recent research performed on PA, inflammation and breast cancer risk among AA women. We used the previous terms from the search about PA and breast cancer including the following additional terms: inflammation, inflammatory, inflammation biomarkers, inflammatory biomarkers, CRP, IL6, c reactive protein, or interleukin 6. The search initially yielded 362 studies in the last 18 years that were considered eligible for further assessment. None of the studies were deemed relevant for review because they 1) did not include AA women exclusively, 2) did not include a population that was cancer-free at the beginning of the study, and 3) did not include inflammatory biomarkers in their analysis. Many of the studies reviewed included breast cancer survivors from a multi-ethnic population. Out of the survivor-based studies, we ultimately focused on four randomized controlled trials (RCTs) and one cross sectional study.

Half of the RCTs found significant associations between PA (specifically adherence to activities), inflammation, and inflammatory biomarkers of interest. Jones and her colleagues analyzed data from the Yale Exercise and Survivorship study; they found significantly reduced levels of IL-6 among women in the exercise group (regimens consisted of 150 minutes of supervised and unsupervised moderate aerobic exercise) compared to the control group [125]. Richi and her coauthors looked at outcomes among women in the Improving Physical Activity After Cancer Treatment (IMPAACT) study, where they participated in 26-week exercise sessions including whole body circuit and

flexibility training after receiving cancer treatment. They found reduced levels of CRP among women who received treatment in less than one year and who adhered to the 26-week program [126]. Conversely, Owusu and her team looked at the disparity of poor physical performance and inflammation among white and AA women before receiving treatment for their breast cancer. They found that AA women had higher IL-6 levels at baseline compared to white women, and they also found that women had an increased prevalence of poor physical performance when they had higher IL-6 levels or lower levels of PA per week [127].

Despite the strengths of the prospective cohort studies covered earlier, they also had a few limitations. Walking was the only piece of moderate-intensity PA covered in the Rosenberg analysis [116]; there are a plethora of other moderate-intensity activities information they could have captured in their population. The analysis by Nomura et al. lacked some information on breast cancer subtype, thus affecting the number of cases; the measures for their analysis were all based on self-report and can lead to various biases [115]. Some of the common weaknesses found in the case-control studies presented here include: recall bias due to self-reported PA, selection bias, differential misclassification due to lack of information on all types of PA (e.g. no information on non-recreational PA), lack of information on lifetime PA, lack of PA information 10 years prior to onset of breast cancer, and fairly low response rates [117-124]. Based on the literature presented here, the association between PA and breast cancer risk among AA women remains inconclusive. However, promise is shown due to evidence from cohort studies showing that PA reduces risk for breast cancer. The limitations in the aforementioned studies on PA and breast cancer among AA women provides the basis that more conclusive clinical

research is needed, so that underserved populations can receive the resources they not only need but yearn for as well.

Healthy Diet, Inflammation, and Breast Cancer

Another vital protective factor in combating breast cancer is consumption of a healthy diet. This has been articulated in several ways, but a healthy diet consists of receiving the proper nutrients for your body on daily basis; one main purpose for dieting is for weight loss among overweight/obese persons [128]. Promotion of a healthy diet typically includes an emphasis on high whole food intake, such as vegetables, fruits and whole grains. If meat products are a part of the plan, those are usually lean meats (e.g. poultry, fish, eggs, etc.); the main consideration for a healthy diet is portion control and reducing the intake of saturated and trans fats, sugar and sodium. Different plans include gluten-free diets, the DASH diet, Paleolithic diets, and plant-based. Other known advantages of a balanced healthy diet outside of nutrients include reduced risk of chronic diseases (e.g. hypertension, hypercholesterolemia, obesity, type-2 diabetes, cancer), proper digestion and bowel function, protection against infections, anti-inflammatory properties, and healthy-looking skin [129].

The American Heart Association recommends that adults get about five servings of vegetables per day, four servings of fruits per day, and six servings of grains per day [130]. However, it seems that Americans are also not consuming enough whole foods that are beneficial to one's body. Updated data from the 2013 Behavioral Risk Factor Surveillance System (BRFSS) showed that approximately 9% of adults met vegetable recommendations, and about 12% of adults met fruit recommendations [131]. Factors that contribute to the lack of whole food consumption among adults include the belief

that healthy foods have poor taste, skepticism about health messages backed by government entities, time pressure, “laziness” or “discipline” (from self-report), residing in lower socioeconomic areas, and emotional eating [132-136].

Persons in underserved populations share similar barriers, while distinct barriers addressed by AAs include the lack of grocery stores within a specific radius of their residence (i.e. food deserts), family tradition, cost, lack of knowledge on how to prepare/cook healthy foods, lack of transportation, concern of family members cooking a separate meal from everyone else, caretaking, or a lack of urgency to change one’s behavior [137-148]. Like PA, the unequivocal importance of diet interventions to help reduce the risk of breast cancer needs to be impressed upon the populations who need it the most.

Food deserts can be defined as specific geographical areas where residents live more than one mile from a supermarket in urban or suburban areas, and more than 10 miles from a supermarket in rural areas [149]. Food swamps are a unique version of food deserts, with the main difference being access to unhealthy, processed foods usually found at corner stores or fast-food restaurants [150-151]. Both areas are typically devoid of fresh produce, compared to areas with affluent residents. The USDA reported in 2009 that over 23 million Americans reside in food deserts [152], with higher prevalence rates shown mainly in the Southeastern region of the country (see Figure 2.1). In 2014 over 1 million South Carolinians were reported to reside in food deserts as well [153], even affecting more metropolitan counties than anticipated (see Figure 2.2).

Research has shown that unhealthy food options are heavily promoted in AA communities more often versus predominately white communities [154-162].

Conversely, other studies have shown that when access to healthy foods are provided to underserved minority populations, they are more inclined to consume it [163-164]. A common theory behind the disparities in food options (including the over-promotion of unhealthy foods in the AA community) can be traced back to the historic and resurging discriminatory practice of redlining in the U.S. Redlining is commonly known as the denial of services (e.g. insurance, banking, supermarkets) to residents of color, either by not building the needed resources in communities or neighborhoods of need or through the selective price gouging of goods [165-167]. The effects of this traditionally racist practice, along with other means of marginalization (e.g. gentrification), still arguably resonates throughout the country and transcends through generations of AAs particularly in the Southeast. Therefore, one could infer that disparities in access to healthy food options through the disenfranchisement of AA communities can be a probable augmenting factor to inflammation and chronic disease outcomes.

The benefits of consuming fruits and vegetables are still notable today, especially from the National Cancer Institute's "Five-A-Day" program. In brief, the program was created in the early 90's to promote the adult consumption of at least five servings of fruits and vegetables daily [168]. A multitude of studies have shown an inverse relationship between produce consumption and various cancers (e.g. esophagus, stomach, lung, colon, ovary) [169]. However, breast-cancer specific studies have shown mixed results. An intervention that emphasized the decrease in fat percentage found that women in the intervention group significantly consumed less dietary fat compared to the control group, and those in the intervention group also had a reduction in relapse breast cancer events [170]. Conversely, the intervention that emphasized daily targets of specific

serving goals of fruits, vegetables, and fiber, did not show a statistically significant decrease in relapse events among intervention participants compared to controls [171]. A pooled analysis of several cohort studies also produced nonsignificant results on fruit and vegetable intake and breast cancer risk [172], so the need for more conclusive results is unquestioned.

Similar to PA studies and breast cancer risk among AA women, there is a dearth in the literature in recent years as it pertains to diet and breast cancer risk among the same population. Epidemiologic studies dealing with the association of diet and breast cancer risk among black women were chosen for review from the PubMed [114] database using the previously listed search terms for breast cancer (see above). They were combined with these search terms: diet, dietary, nutrition, nutritional, diet regime, diet regimen, dietary regime, dietary regimen, diet fat reduction, dietary fat reduction, fruit, vegetable, fruit intake, vegetable intake, fruit and vegetable intake, low fat diet, fat free diet, fiber, fiber diet, whole foods, and whole foods diet.

Again, the PubMed search with the terms above was conducted to lay the groundwork of the most relevant research done recently with the association of diet and breast cancer risk among AA women. Six studies were of interest to us including two analyses of non-vegetarian food consumption to highlight how breast cancer risk can be affected when not following evidence-based recommendations. None of the studies we covered here were clinical trials, while four of them were cohort and the others were case-control in design. Boggs and her colleagues analyzed fruit and vegetable intake among participants in the Black Women's Health Study and found that AA women who consumed two or more servings per day had a significantly reduced risk of estrogen

receptor-negative/progesterone receptor-negative breast cancer compared to those who consumed less than four servings per week [173]. Conversely, the partially reduced risk of overall breast cancer was found among those who ate three or more servings of carrots per week.

Agurs-Collins and her fellow researchers also looked at data from the Black Women's Health Study, yet their focus was on two dietary patterns (Western vs. prudent). They defined a Western pattern as consuming unhealthy foods (e.g. processed meats, sweets) and a prudent diet consisted of healthier options (e.g. whole grains, fruits, vegetables). Although they did not find a statistically significant association between the prudent diet and breast cancer overall, they did show a significantly reduced risk among AA women consuming a prudent diet and who were diagnosed with estrogen receptor-negative breast cancer [174]. The lower risk of breast cancer was also observed among premenopausal AA women and those with a BMI less than 25 kg/m², respectively.

Conroy and her coauthors looked at the potential relationship between breast cancer and soy intake in the form of either beans or specific products such as miso, tofu, and vegetarian meat. However, they did not find a significantly reduced risk of breast cancer among AA women who were in the highest tertile of soy product consumption [175]. Genkinger et al. analyzed meat and dairy consumption data from the Black Women's Health Study; proper consumption of dairy products has benefits for bone health but can possibly modify how specific hormones influence the risk of breast cancer. However, they did not find a significant association between total or specific dairy or meat intake and breast cancer [176].

Chandran and her colleagues conducted two case-controls studies, focusing on non-whole food consumption and risk of breast cancer. One analysis found that breast cancer risk among premenopausal AA women increased when they consumed fast food five or more times a week compared to once a week or less; the increase was also shown among estrogen-reception positive breast cancer cases [177]. The other analysis showed a marginally significant elevated risk of breast cancer among AA women who consumed processed meats at the highest quartile [178].

Again, we ran a PubMed search to continue laying the foundation of the most relevant and recent research performed on diet, inflammation and breast cancer risk among AA women. We used the previous terms from the search about diet and breast cancer including the following additional terms: inflammation, inflammatory, inflammation biomarkers, inflammatory biomarkers, CRP, IL6, c reactive protein, or interleukin 6. The search initially yielded 989 studies in the last 18 years that were considered eligible for further assessment. None of the studies were deemed relevant for review because they 1) did not include AA women exclusively, 2) did not include a population that was cancer-free at the beginning of the study, and 3) did not include inflammatory biomarkers in their analysis. Again, multiple studies reviewed included breast cancer survivors from a multi-ethnic population. We decided to focus on one RCTs and two prospective cohort studies.

Han and her study team conducted a pilot study utilizing cognitive behavior theory and conducted five nutritional education sessions, including specific topics similar to what was covered in the SISTAS study (e.g. understanding food labels, eating colorful fruits and vegetables). They found a significantly reduced level of CRP among the

intervention participants compared to controls [179]; significance was not found with levels of IL-6. Villasenor and her cohorts looked at dietary fiber intake among a multi-ethnic cohort of breast cancer survivors in the Health, Eating, Activity, and Lifestyle (HEAL) study and found decreased levels of CRP when women were consuming more dietary fiber [180]. George and her co-authors looked at post-diagnosis diets among recent breast cancer survivors in the HEAL study and found a significantly reduced risk of CRP levels with better quality diets post-diagnosis [181].

The cohort studies had some strengths but there were limitations noted by the respective authors such as measurement errors due to factor analysis, misclassification of dietary intake, and lack of food intake data post diagnosis [173-175]. Similar to the conclusion drawn before about PA and breast cancer risk, the association between diet and breast cancer risk among AA women is not definitive considering the projects noted above. Although the design is stronger than the case-control analyses presented here, there is still a need for definitive proof of an association between healthy food intake and breast cancer risk among AA women. Conclusive evidence that can be disseminated to AA women directly can potentially aid in strengthening the growing desire to living a healthier lifestyle.

Community Garden Interventions

Gardening has been known as a long-standing staple of American culture, despite how this nation has recently gained the perception of a quick access, instant gratification-like society. A recent report has shown a positive outlook on gardening, including a substantial increase in household gardening from 2013-2018 [182]. The cultivation of plants for horticulture purposes has always been a potentially cheaper alternative to

purchasing produce (e.g. vegetables, fruits) in markets or grocery stores. Persons can purchase seed for various products, and depending on various aspects (e.g. season, rainfall, soil content, etc.), the seed can possibly produce copious amounts of food. In the Southern region of the U.S., the seasons play a key role in which fruits and vegetables can be grown adequately (see Table 2.1) [183]. Although the main ways of gardening include large plot gardening or small-pot plant gardens, community gardening is a modality of produce production that has seen a surge in popularity in recent years [184].

Community gardens (i.e. gardens located in various neighborhoods cultivated by a group of people with a purpose of providing nutritious whole foods) have been a vital part of a movement to live a healthier lifestyle. Their popularity seems to stem not only from the socioeconomic and empowering benefits they entail [184], but the health benefits resulting from physical fitness and diet. They are typically funded through grant and fundraisers, with approximately 18,000 gardens in the U.S. and Canada [185]. They have been on the rise on the West coast and Patriot Northeast regions of the U.S., respectively. For example, there are approximately 125 community gardens registered in Los Angeles County, California alone [186], while approximately 600 exist in New York City alone through the Green Thumb project [187]. However, there seems to be a shortage of gardens in the Southeast, specifically Columbia SC. Considering the chronic disease health disparities plaguing the AA community in the South alone, it is crucial to understand if alternative modalities to combating these ailments are feasible and acceptable in this specific community.

A preliminary search of epidemiologic studies through PubMed [114] involving community gardens and chronic disease outcomes among all populations yielded

approximately 100 studies in almost two decades. There has been limited research done on behavior changes among adults in nutrition interventions with community gardens. Interventions with gardens tend to focus on children more often [42, 188], including programs set at elementary schools [41, 189-190]. To our knowledge, interventions with gardens involving the AA adult population are rare. A quick search of community garden interventions and chronic disease outcomes among AAs only produced three studies that could have potentially been reviewed. Another PubMed search was done to look at community gardens and cancer prevention in the general population, and we initially found 132 studies in the last 18 years. After carefully observing them, we found no applicable studies because 1) they did not incorporate community gardens, 2) they did not include a population that was cancer-free at the beginning of the study, 3) many of the studies found were qualitative analyses of the feasibility of community gardens.

Barnidge and her team conducted an intervention targeting AA men in a rural setting that disseminated nutritional education and looked at food access via gardens. They utilized the CBPR approach in the creation of Men on the Move Growing Communities (MOTMGC), with intervention components including nutrition education activities and the growth of 1800 pounds of food in two growing seasons. They found a significant odds reduction of hypertension among the intervention group {Odds ratio (OR) = 0.52, 95% CI = 0.38–0.71}, as well as an increased perception of whole food consumption when participants either had direct access to the educational pieces or access to the produce from the community garden [50]. Despite the previously mentioned findings, there still is a lack of evidence regarding community gardens and breast cancer risk among AA women. We only found one study after a preliminary search into the

association, and after careful review, we determined that there are no studies to date that focus on community gardens used in interventions as a method of implementing healthy lifestyle strategies to mitigate breast cancer risk among AA women.

Unity and member involvement in the AA community has been a part of its foundation in terms of addressing copious health issues. Considering the need for support systems for underserved persons in this country, and the possible differences in hormonal milieu among AA women in SC compared to women nationally, this gives us the distinct opportunity to consider the development of an innovative intervention and resource geared towards a specific population of AA women that are less likely to be included in breast cancer risk/mortality studies.

Table 2.1 List of Produce Typically Grown in the Southern region of the U.S.

	Vegetables	Fruits
Spring	Asparagus, broccoli, cabbage, collards, green beans, peppers, sweet potatoes	Blueberries, mangoes, oranges, peaches, strawberries
Summer	Asparagus, beets, cabbage, collards, cucumbers, okra, sweet potatoes, tomatoes	Apples, blueberries, cantaloupes, grapes, oranges, raspberries
Fall	Cabbage, collards, cucumbers, kale, okra, sweet potatoes, tomatoes	Apples, grapes, peaches
Winter	Collards, kale, lettuce, spinach	Apples, grapefruit, oranges

Table 2.2 Summary of Relevant Studies

Study	Purpose	Participants	Results	Limitations
Nomura et al., 2014 [51]	Examine adherence levels to PA/body composition cancer prevention recommendations; determine if association exists between adherence and BrCA risk	59,000 AA women in United States from the Black Women's Health Study; 1,827 incident cases through 2011; analytic cohort = 49,103 AA women	15% reduced risk of BrCa when AA women adhered to the PA recommendations (HR = 0.85; 95% CI = 0.74–0.97); decrease more pronounced with the time-varying score	Lack of BrCa subtype information; self-reported measures
Rosenberg et al., 2014 [52]	Assess association of vigorous exercise and BrCa risk among AA women and by estrogen-receptor status	59,000 AA women in United States from the Black Women's Health Study; 1,364 confirmed invasive BrCa cases in 2011; analytic cohort = 44,078 AA women	26% reduced BrCa risk among women who participated in vigorous exercise for greater than/equal to seven hours per (IRR = 0.76; 95% CI 0.57-0.96)	No validation data on hours/days of sitting, or on exercise at age 30, 21, or high school; walking was the only moderate-intensity activity information collected
Gong et al., 2016 [53]	Investigate PA/BrCa association overall and by tumor ER status in AA women	2482 ER+ BrCa cases, 1374 BrCa ER- cases, and	12% lower odds of BrCa overall (OR = 0.88, 95 % = CI 0.81–0.96) and for ER+	Self-reported PA; data were pooled from four studies with different PA assessments

		16,959 controls	cancer (OR 0.88, 95 % CI 0.80–0.98) when AA women reported recent vigorous PA	
Sanderson et al., 2015 [54]	Examine if an association exists between PA and postmenopausal AA women	2,614 incident BrCa cases; 2,306 controls	30% nonsignificant reduced odds among postmenopausal AA women (exercise OR = 0.70; 95% CI 0.40–1.10, p-value for trend = 0.07)	Self-reported PA, energy intake, current weight and height, and recall of weight at age 18; lack of information on other energy-related indicators (e.g. waist-hip ratio and percent body fat); No data collection on daily living and housework activities, or PA for more than 10 years; fairly low response rates among cases and controls
Lu et al., 2015 [55]	Assess relationship between pre-diagnosis recreational PA & mortality risk among BrCa survivors	1,112 AA women	Nonsignificant odds of BrCa among AA women who had recreational PA use (HR = 1.08; 95% CI = 0.82-1.44 for the highest vs. lowest activity level)	Self-reported PA; no data collection on PA diagnosis; lack of information on non-recreational PA for all 3 studies
Cohen et al., 2013 [56]	Investigate association between both sedentary and PA behaviors and BrCa among AA and white women	546 cases (374 among AA women) and 2,184 matched controls	Nonsignificant increased association of BrCa and total PA among AA women (OR = 1.14; 95% CI = 0.78–1.67)	Self-reported PA; different racial results likely due to differences in reporting errors; no lifetime PA level measurement; lack of power to examine effect modification by body size or hormone replacement therapy
Sheppard et al., 2011 [57]	Examine association between PA and BrCa among AA women in Washington, D.C.	199 AA women (97 cases and 102 controls)	64% decreased odds of BrCa among AA women with vigorous PA (> 2 hours/week in	Self-reported PA; selection bias; lack of temporal sequence due to case-control design

			the past year) (OR = 0.36; 95% CI = 0.17–0.75); 64% decreased odds of BrCa in women with a high versus low tertile of total activity (OR = 0.36; 95% CI = 0.16–0.79)	
Ratnasinghe, L.D., 2010 [58]	Assess relationship between combined recreational and occupational PA and BrCa risk using data from the Global Epidemiology Study	408 BrCA cases and 88 controls (AA women)	79% reduced odds of BrCa among AA women with PA more than 3 times/week (OR = 0.21; 95% CI = 0.11-0.39); 73% reduced odds of BrCa with more than 30 minutes of PA (OR = 0.27; 95% CI = 0.14-0.52); 75% reduced odds of BrCa with more than 150 minutes of PA per week (OR = 0.25; 95% CI = 0.14-0.52)	Self-reported PA (recall bias); selection bias; metabolic equivalent of energy expenditure (MET) values could not be calculated with data
Adams-Campbell et al., 2001 [59]	Investigate association between strenuous PA and BrCa risk at a young age using data from the Black	704 AA BrCa cases, 1408 controls	40% decreased odds of overall BrCa among AA women at age 21 with 7 or more hours of strenuous PA	Self-reported PA (recall bias); selection bias; differences in PA assessment; lack of information on all sources of PA (nondifferential misclassification)

	Women's Health Study		(OR = 0.60; 95% CI = 0.40-0.80); 50% decreased odds of pre-menopausal BrCa at age 21 with 7 or more hours of strenuous PA (OR = 0.50; 95% CI = 0.30-0.80); 40% decreased odds of overall BrCa among AA women at age 30 with 7 or more hours of strenuous PA (OR = 0.60; 95% CI = 0.30-0.90); 70% decreased odds of post-menopausal BrCa among AA women at age 40 with 7 or more hours of strenuous PA (OR = 0.30; 95% CI = 0.10-0.90)	
Bernstein et al., 2005 [60]	Examine relationship between lifetime and time- or age-specific measures of recreational PA and BrCa risk among white and AA women using	1605 AA cases, 1646 AA controls	25% reduced odds of invasive BrCa for lifetime PA when average activity was 3 or more hours/week (OR = 0.75; 95% CI = 0.61-0.93);	Self-reported PA (recall bias); selection bias; lack of occupational and household activity information

	data from the Women's Contraceptive and Reproductive Experiences Study		23% reduced odds of invasive BrCa for lifetime PA when MET hours were 15.2 or more per week (OR = 0.77; 95% CI = 0.62-0.95);	
Boggs et al., 2010 [87]	Assess association of fruit and vegetable intake (through a dietary pattern) and BrCa risk using data from the Black Women's Health Study	51,928 AA women aged 21–69 years	43% decreased risk of ER/PR negative BrCA with total vegetable consumption of 2 or more servings a day compared to less than 4/week (IRR = 0.57, 95% CI = 0.38 - 0.85)	Misclassification of long-term dietary intake; significant associations may be due to chance; likely that unknown factors accounted for partial associations
Agurs-Collins et al., 2009 [88]	Investigate the potential relationship between dietary patterns (Western vs. prudent) and BrCa risk using data from the Black Women's Health Study	50,778 participants	36% reduced risk of BrCa among AA women with prudent dietary pattern and a BMI <25 (IRR = 0.64; 95% CI = 0.43-0.93); 30% reduced risk of BrCa among premenopausal AA women on the prudent dietary pattern (IRR = 0.70; 95% CI = 0.52-	Measurement error with food frequency questionnaires; factor analysis, is subjective when deciding the food groups, number of factors, the method of rotation, and labeling of dietary patterns

			0.96; 48% reduced risk of ER – BrCa among AA women on the prudent dietary pattern (IRR = 0.52; 95% CI = 0.28-0.94)	
Conroy et al., 2013 [89]	Examine the possible effects of pre-diagnostic soy intake (e.g. soy beans, vegetarian meat) and BrCa mortality among the Multiethnic Cohort (MEC)	3,842 female BrCa cases (748 AA women)	Nonsignificant decreased risk of BrCa mortality among AA women who consumed soy products in the highest tertile (HR = 0.87; 95% CI = 0.46-1.64)	Study did not capture any potential post-diagnostic dietary changes; lack of post-diagnostic soy intake information from cases; potential misclassification; incomplete data on hormone receptor status; lack of data on subsequent BrCa treatment
Barnidge et al., 2015 [104]	Analyze the association between nutritional education/food access from community gardens and chronic disease outcomes using data from the Men on the Move Growing Communities (MOTMGC) intervention	Baseline: n = 397 intervention, 397 comparison Mid-intervention: n = 389 intervention, 303 comparison	48% decreased odds of hypertension among the intervention group (OR = 0.52, 95% CI = 0.38–0.71); Significant increased association between access to whole foods from a community garden and perceived whole food consumption (OR = 1.95, 95% CI = 1.20–3.15)	Contamination of comparison county (bias towards the null); cross-sectional design of the study; measurement bias; perceived fruit and vegetable consumption was self-reported (recall bias)

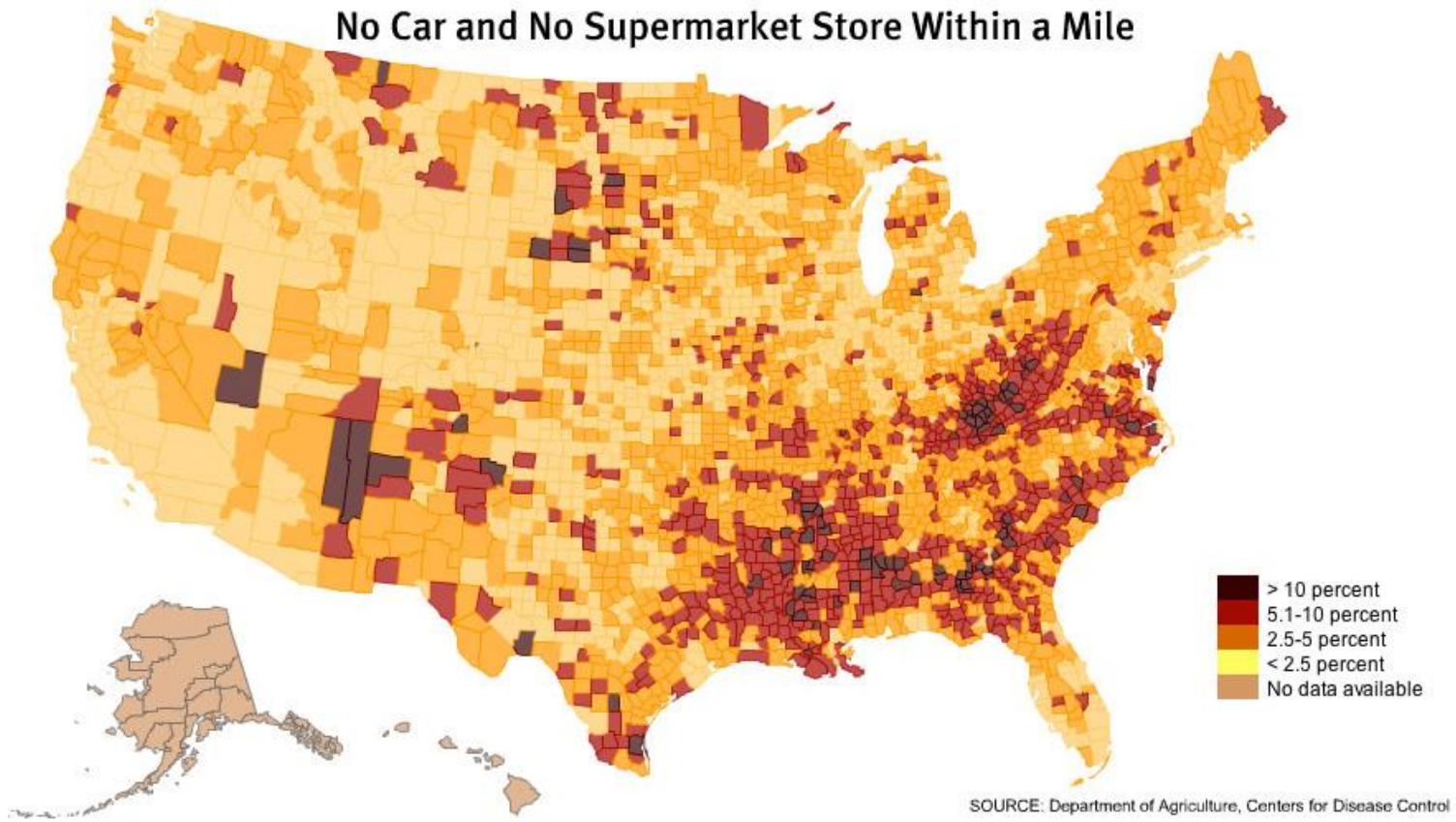


Figure 2.1 County-level map of food deserts in the U.S. (2009)

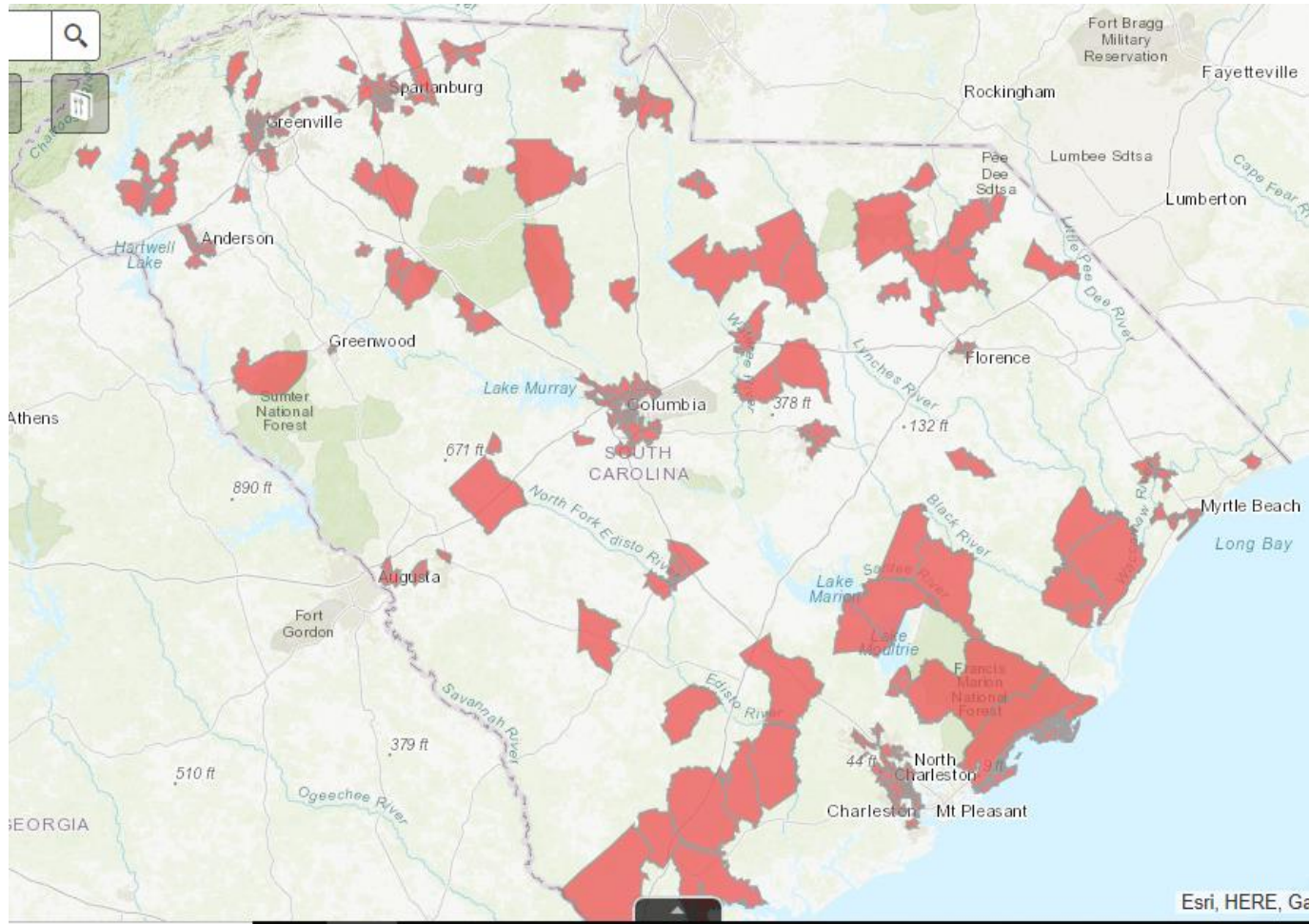


Figure 2.2 County level map of food desert areas in SC (2010)

CHAPTER 3

THE IMPACT OF DEPRESSION ON HEALTHY LIFESTYLE INTERVENTIONS AND INFLAMMATION: A MEDIATION ANALYSIS¹

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Abstract

Inflammatory-related chronic diseases are disparagingly prevalent among underserved minorities compared to European Americans (EAs). Despite the known protective factors, research on how psychosocial factors plays a role in participant's treatment assignment in clinical trials and inflammation among African American (AA) women is scarce. This study sought to determine if depression mediated the association between treatment assignment in the Sistas Inspiring Sistas Through Activity and Support (SISTAS) intervention and inflammatory biomarker levels. SISTAS was a one-year randomized controlled trial (RCT) to promote physical activity (PA) and healthy eating among AA women, utilizing the CBPR approach for recruitment and retention. Assessments on depression were obtained at baseline, along with anthropometric measures and blood draws to measure C-reactive protein (CRP) and interleukin-6 (IL-6). Women were randomized to the intervention (12 weekly classes and nine monthly booster sessions) or the delayed intervention groups, with follow-up clinic visits occurring at 12-week and 12-months after baseline. We received descriptive statistics through frequencies or means and standard deviations (STD) and conducted multiple regression analyses (including mediation analysis) to assess the relationship between the intervention arm of SISTAS, depression, and change in CRP/IL-6 levels over time. All steps in the test for mediation, including adjusting for potential confounders, were utilized via SAS version 9.4. Our sample (n = 337) were more likely to be middle-aged (mean age 50.1 years), have some college education, and be non-smokers. They also were morbidly obese (mean BMI > 39.0 kg/m²) with a DII score indicating they typically consumed a pro-inflammatory diet. Self-reported depression was not a mediator between

the SISTAS trial and chronic inflammation over time. Nevertheless, additional research should be conducted in this racially underserved population with an emphasis on a more pragmatic approach in order to further explain and combat inflammation and its related conditions.

Introduction

Chronic inflammation, or the natural response to persistent internal damage including abnormal tissues [1], exhibits racial disparities in the United States (U.S.) [2-3]. Common blood markers to test for inflammation are C-reactive protein (CRP) and interleukin-6 (IL-6); CRP is a plasma protein from the petraxin family typically regulated by IL-6 (a cytokine) in response to wounds or infections [4-5]. Reported normal CRP levels for acute/general infections are about 5-10 mg/L but can rise as high as 400 mg/L [4] but levels at 3.0 mg/L or above can be considered a risk factor for cardiovascular disease (CVD) [6]. IL-6 levels have been reported to be around 1.8 pg/mL and the abnormal levels differ depending on the outcome of interest [7]. While these markers are usually used to detect short-term inflammatory responses like infections (e.g. urinary tract infections, pancreatitis, pneumonia), they can also be used to measure long-term inflammatory diseases [8].

Conditions related to inflammation (e.g. hypertension, type 2 diabetes, stroke, and heart disease) are affecting African Americans (AAs) at higher rates compared to their white counterparts [9-12], and these rates are still pronounced even in the Southeast. Specifically, hypertension (46% vs. 37%) and type-2 diabetes (18.2% vs. 12.3%) rates among South Carolinian (SC) AA women are still higher compared to SC white women

[13]. Also, AAs in the state are more likely to succumb to a stroke compared to whites and are at a higher risk of heart disease especially when living a sedentary lifestyle [14].

Increased physical activity (PA) and consuming a healthy diet (i.e. increased fruit and vegetable intake) have long been shown as protective factors against chronic diseases [15-21]. However, common psychosocial factors such as depression can adversely affect how one manages their chronic ailments [22-27]. Furthermore, epidemiologic research on the association between depression and inflammatory biomarkers among AA adults is lacking and inconclusive. A cross-sectional analysis found a significant positive relationship between depressive symptoms and logIL-6 among AAs, while a prospective analysis of the Coronary Artery Risk Development in Young Adults (CARDIA) Study revealed higher CRP levels when AA had higher scores of depressive symptoms after several years [28-29]. Conversely, a different cross-sectional study analyzing data from The Morehouse and Emory Team up to Eliminate Health Disparities (META-Health) Study and a prospective study analyzing NHANES found no significant associations between depression and CRP levels, respectively [30-31].

The purpose of this article was to examine if depression mediated the association between treatment assignment in the Sistas Inspiring Sistas Through Activity and Support (SISTAS) intervention sessions and changes of CRP/IL-6 levels over time. We hypothesized that we would find a significant association between treatment assignment and inflammation, and that depression would mediate this relationship, after controlling for chronic disease risk factors.

Methods and Materials

Study Population

Data was collected as a part of the SISTAS trial, which was a one-year randomized controlled trial (RCT) designed to promote diet and PA behavior change among AA women with the goal of attenuating chronic inflammation which is a key underlying biological mechanism for many chronic diseases including breast cancer, heart disease, and diabetes [32]. The cohort consisted of AA women at least 30 years old or older recruited from Florence and Columbia, SC between 2010 and 2015. All participants were free of breast cancer or known inflammatory conditions (rheumatoid arthritis, lupus) at baseline. The methods of the Sistas Inspiring Sistas Through Activity and Support (SISTAS) trial are detailed elsewhere [33]. Participants were eligible for the study if they were AA, had a BMI of 30 kg/m² or more, had to be physically able to exercise or walk and to be willing to be randomized and participate fully in the research study for one calendar year. Women were excluded if they had a previous cancer diagnosis (except non-melanoma skin cancer), and had any inflammatory-related diseases (e.g., lupus, rheumatoid arthritis). The final sample of eligible participants was 337 women.

Data Collection

The study team collected data at three different time points (before and after the 12-week intervention and at the end of one year of participation). Questionnaire data and anthropometric measurements were obtained, and blood samples were drawn at all three clinic visits (baseline, 3-month and 1 year). Questionnaires contained multiple sections

(e.g. healthy and lifestyle, everyday discrimination scale, Perceived Stress Scale (PSS), Depression Scale {CESD-10}) that were administered at each visit. Height, hip circumference, waist circumference, weight and percent body fat (including fat mass and fat free mass) were taken during the clinic visits by trained study staff.

Information obtained from the initial screenings included participant demographics, baseline anthropometric data, and basic health data. Demographic information included age, marital status (married, living with partner, widowed, divorced, separated, single/never married), educational status (high school or less, some college, completed college, post-graduate), employment status (full-time, part-time, retired, not employed), health insurance (Medicare, Medicaid, private, uninsured/self-pay, other), and smoking status (yes vs. no).

Symptomology of Depression

Depression was assessed via the Center for Epidemiologic Studies Depression Short Scale (CESD-10) where participants were asked on a scale from 0 (Rarely or none of the time) to 3 (All of the time) if they experienced depression in the previous week. The scores ranged from 0 to 30 with the standard cutoff score of ten, which signified the presence of significant depressive symptoms if women scored a ten or higher on the 10-item scale. Our CESD-10 scale was chosen from a previously validated study [34] among older adults in the US; the scale has also been validated among a national cohort of AA and Black Caribbean adults [35].

Laboratory and Inflammatory Markers

We collected blood samples from all eligible participants during clinic visits to analyze inflammatory markers [C - reactive protein (CRP), interleukin-6 (IL-6)]. Assays

were analyzed using venous blood received on the day of the clinic visits. Specific enzyme-linked immunosorbent assay kits were used to measure plasma CRP and IL-6 levels, respectively; all samples were run in duplicate (CRP: CV=3.9%, sensitivity = 0.022ng/ml; IL-6: CV=3.7%, sensitivity = 0.110 µg/ml.) [36].

Treatment assignment for the intervention was categorized as “Intervention” or “Control” from baseline to three months post-baseline, with the control group as the referent group. The primary outcomes for this analysis were changes in CRP or IL-6 during the same timeframe (continuous). Changes in depression scores (mediator of interest) was also continuous as we assessed using linear modeling to account for repeated measures within subjects.

Statistical Analyses

Descriptive statistics were computed using frequencies or means and standard deviations (STD). We conducted multiple linear regression analyses to assess the relationship between the effect of the treatment assignment of a dietary and PA intervention with the biological markers of inflammation, while adjusting for potential covariates. Mediation analyses also were conducted to determine if depression explains any underlying effects on dietary and PA intervention and inflammatory biomarkers. Model 1 was the crude analysis of the participant’s treatment assignment of the intervention on the respective outcomes, model 2 was the analysis testing if the mediator has any effects on the intervention alone, while model 3 tested if the mediator has effects on change on CRP/IL-6 alone, respectively. If significant findings were obtained from the first three models, then typically we would proceed to the full model (effect of the treatment assignment of the intervention on the respective outcomes, the mediating

variable of interest, and group of confounders significant via bivariate analyses) [37]. Pathway *c* signified the results from Step 1 (the regression analysis determining if X is a significant predictor for Y), pathway *a* signified the results from Step 2 (the regression analysis determining if X is a significant predictor for M), pathway *b* signified the results from Step 3 (the regression analysis determining if M is a significant predictor for Y), and pathway *c'* signified the results from Step 4 (the regression analysis determining if X is a significant predictor for M) [Figure 1].

Regression models for the mediation analysis were utilized via SAS software version 9.4 (Cary, North Carolina, United States), with age kept in all relevant models and potential confounders (marital status, education, employment status, smoking status, BMI) to be assessed via bivariate analyses. Statistical significance in the models were determined with the p-value (α) of 0.05.

Results

Table 1 illustrates the general demographics of the study population included in the regression analysis. Majority of participants at baseline were married, employed full time, had completed some college education, were not smokers, and perceived their health status as “good.” The average age was about 50 years old, their average BMI placed them as morbidly obese (39.0 kg/m^2), and the average inflammatory levels were distinctly high (CRP = 9.29 ± 17.8 ; IL-6 = 5.59 ± 24.2). After conducting bivariate analyses (not shown) we determined that age and BMI were the covariates of interest to be controlled for in the analysis. We did not see a significant difference in CRP or IL-6 levels over time between the treatment assignments (see Table 2).

Multiple regression results did not show that depression was significantly associated with either treatment assignment in the SISTAS healthy lifestyle intervention trial or inflammatory biomarkers over time in any of the models (Table 3). However, we see that age (p-value = 0.0009) and BMI (p-value = 0.02) were associated with depression, and BMI was significantly related to CRP (p-value <0.0001). Figure 2 depicted the association of the effect of treatment assignment on inflammatory biomarkers with depression in the causal pathway as the potential mediator. In the first mediation analysis, treatment assignment in the SISTAS trial did not significantly affect self-reported depression ($\beta_a = 0.31$, p-value = 0.53; path *a*) and CRP over time ($\beta_c = 1.28$, p-value = 0.27; path *c*), respectively. When treatment assignment in the trial and depression were included in the model, both treatment assignment ($\beta_{c'} = 0.10$, p-value = 0.29; path *c'*) and depression ($\beta_b = 0.11$, p-value = 0.40; path *b*) were still not associated with CRP. In the context of mediation, steps 1-3 were not satisfied, so we concluded that depression did not serve as a mediator in the relationship between treatment assignment in a healthy lifestyle intervention and CRP over time. In the second mediation analysis, treatment assignment in the SISTAS trial again did not significantly affect self-reported depression and IL-6 over time ($\beta_c = 2.25$, p-value = 0.34; path *c*), respectively. When treatment assignment in the trial and depression were included in the model for IL-6, again both treatment assignment ($\beta_{c'} = -0.43$, p-value = 0.30; path *c'*) and depression ($\beta_b = -0.42$, p-value = 0.11; path *b*) were nonsignificant. Based on this, we also confirmed that depression did not serve as a mediator in the relationship between treatment assignment in a healthy lifestyle intervention and IL-6 over time.

Discussion

This study aimed to determine if the association between treatment assignment in a healthy lifestyle intervention and inflammatory biomarker levels was mediated by self-reported depression over time. Our results indicated that depression did not mediate the effect of the treatment assignment in the SISTAS trial and CRP or IL-6 over time. This is the first study to our knowledge evaluating depression (measured by CESD score from the short scale) as a mediator in the healthy lifestyle/inflammation relationship among AA women in SC.

Findings from our analysis are markedly different compared to previous epidemiologic research that has focused on healthy lifestyle interventions and CRP and/or IL-6, respectively. One review showed multiple observational studies that showed the benefits of PA and reducing inflammation and inflammatory-related chronic diseases [38], a cross-sectional multi-site study showed lower concentrations of CRP and IL-6 when older adults exhibited high exercise levels [39], and some RCTs found significant decreases in CRP and/or IL-6 when women adhered to aerobic exercises and/or Mediterranean-based diets [40-41]. Our results, albeit nonsignificant, still add to the body of literature that has focused on healthy lifestyle interventions and psychosocial variables. Although the relationship between living a healthier lifestyle (e.g. weight loss treatment, proper diet) and depression is well known through meta-analyses and studies [42-46], others have not produced similar results [47].

Mediation-specific analyses with depression as the potential mediator have produced mixed results as well. Palmeira and his colleagues analyzed data from a cohort of women participating in long-term weight loss programs and although depression was

found to be a significant predictor for weight change, the inverse was not significant and therefore they concluded that depression was not a mediator between the intervention-weight loss relationship [48]. Pazzagli and her colleagues determined that depression measured by the CES–D mediated the association between weight loss and Health Related Quality of Life (HRQoL) among Italian adults [49]. It is important to note that BMI was a significant predictor in our analysis depending on the mediation model and biomarker of interest, which was in contrast to a review conducted by Gilbert and her team when they did not show a significant association of BMI and psychosocial factors among several observational studies [50].

Our study team determined elsewhere that contamination of the intervention in the SISTAS trial likely occurred due to women in the delayed intervention (i.e. control) group failing to wait to change their unhealthy habits as requested, despite being told upon recruitment that they would be offered the opportunity to attend intervention classroom sessions after their 12 month participation in the SISTAS trial officially ended [51]. It is also likely that some of the intervention women might have interacted with control women outside of the clinical sessions (e.g. women who attend the same church or who reside in the same geographical area) and could have spoken about the intervention material, subsequently encouraging the control women to implement a healthier lifestyle on their own. These aspects of contamination bias are feasible considering the evidence supporting the notion of readiness to change [52] and were confirmed via evidence of the control group’s significantly higher rate of weight loss (59.5%) compared to the intervention group (49.1%) [51]. Given this, one should consider alternative study designs when CBPR is used for recruitment and retention

purposes. The intervention also may have been affected by participant's environmental factors; for example, women residing in food deserts or areas without walkable neighborhood or easily accessible and affordable gyms often face barriers to change their behavior during the study period [53]. It is critical to comprehend the dynamic aspects between environment and treatment assignment within interventions among AA adults so then future interventions can be tailored properly to consider cultural and geographical aspects of their everyday lives.

Our study had several strengths. We were the first to our knowledge to examine depression as a mediating factor between intervention effects and inflammation on an underrepresented population not only who are rarely studied exclusively in epidemiologic research, but hampered by racial health disparities especially in rural and metropolitan SC. The prospective design allowed us to control for various biases seen in other observational designs. We also exhibited successfully high recruitment rates during the tenure of the trial and overall, despite potential drop-off when we moved from the rural to the metropolitan area [54-55].

We also recognize several limitations, starting with compliance issues among the delayed intervention group (weight loss in greater than 50%) that presents misclassification bias that distorts any association toward the null. Generalizability issues exist compared to AA women in other regions of the U.S. because some hormonal milieu differences within the group and between EA women may exist [56-59]. Baseline characteristics may differ between persons who volunteer to participate compared to those who do not so this presents the chance for volunteer/non-response bias. Most of our participants had some college experience (42.1%) at baseline [33] so it is likely they were

more willing to participate in the research project; this also may not be representative of all AA women in South Carolina (SC). Finally, inflammation was limited to only two biomarkers, despite them being the markers with a plethora of supporting literature on their correlation to numerous chronic diseases including cancer [60].

Conclusion

Depression did not mediate the effect of a healthy lifestyle program on inflammation among obese AA women in rural and metropolitan SC, yet BMI served as a predictor for depression and CRP. This is expected given the baseline characteristics among this population and how obese persons tend to exhibit various depressive symptoms. Considering our results, this allows us the opportunity to further evaluate the cultural differences and stigmas in how AA adults handle psychosocial issues in this country. Future research projects should consider more of a pragmatic randomized design to counter contamination concerns and to allow prospective persons, especially those who lack readily available resources, the flexibility to change their lifestyle choices as they clearly desire.

Table 3.1 Baseline Demographics of Study Population (n = 337)

Characteristic	Frequency (%)
Age (Mean ± STD)	50.1 ± 11.07
Marital Status	
Married	126 (37.5%)
Living with Partner	9 (2.70%)
Divorced	63 (18.8%)
Separated	28 (8.30%)
Single	91 (27.0%)
Widowed	19 (5.70%)
Education Status	
High school or less	70 (20.8%)
Some college	141 (42.0%)
Completed college	59 (17.6%)
Postgraduate	66 (19.6%)
Employment Status	
Full time	183 (54.5%)
Part time	38 (11.3%)
Retired/not employed	115 (34.2%)
Smoking Status	
Current	109 (32.4%)
Nonsmoker	227 (67.6%)
Perceived Health	
Excellent	10 (3.00%)
Very good	88 (26.1%)
Good	184 (54.6%)
Fair	52 (15.3%)
Poor	3 (1.00%)
Insurance	
Medicare	141 (42.0%)
Medicaid	44 (13.1%)
Private	22 (6.50%)
Uninsured/self-pay	62 (20.0%)
Other	67 (18.4%)
Characteristic	Mean ± STD
Body mass index (kg/m ²)	39.1 ± 7.4
Dietary Inflammatory Index score (DII)	0.56 ± 2.51
Center for Epidemiologic Studies Short Depression scale (CESD)	7.20 ± 5.15

Blood-C-reactive protein (CRP; mg/dL)	9.29 ± 17.8
Blood-Interleukin-6 (IL-6; pg/mL)	5.59 ± 24.2

Column percentages may not equal 100 because of rounding. Frequencies may not equal population total because of missing data.

Table 3.2 Adjusted Inflammatory Biomarker Mean Levels by Treatment Assignment at 12-week Follow-Up Timepoint

	Mean	Difference between Treatment Assignments	p-value
Outcome			
CRP (mg/l)			
Intervention	7.93		
Control	9.47	-1.54	0.15
IL-6 (pg/ml)			
Intervention	1.00		
Control	1.06	-0.06	0.55

*All models controlled for age and BMI

Table 3.3 SISTAS Intervention, Depression, and Inflammatory Biomarker Levels

Dependent Variables	Independent Variables	Regression		
		β	SE	p-value
CRP (Model 1)*				
	Treatment	1.28	1.15	0.27
CEDS score (Model 2)*				
	Treatment	0.31	0.50	0.53
CRP (Model 3)*				
	CEDS score	0.11	0.13	0.40
CRP (Model 4)*				
	Treatment	0.10	0.13	0.29

	CESD-score	1.22	1.15	0.43
IL-6 (Model 1)*				
	Treatment	2.25	2.34	0.34
CEDS score (Model 2)*				
	Treatment	0.31	0.50	0.53
IL-6 (Model 3)*				
	CEDS score	-0.42	0.26	0.11
IL-6 (Model 4)*				
	Treatment	-0.43	0.26	0.30
	CESD-score	2.43	2.34	0.10

*All models controlled for age and BMI

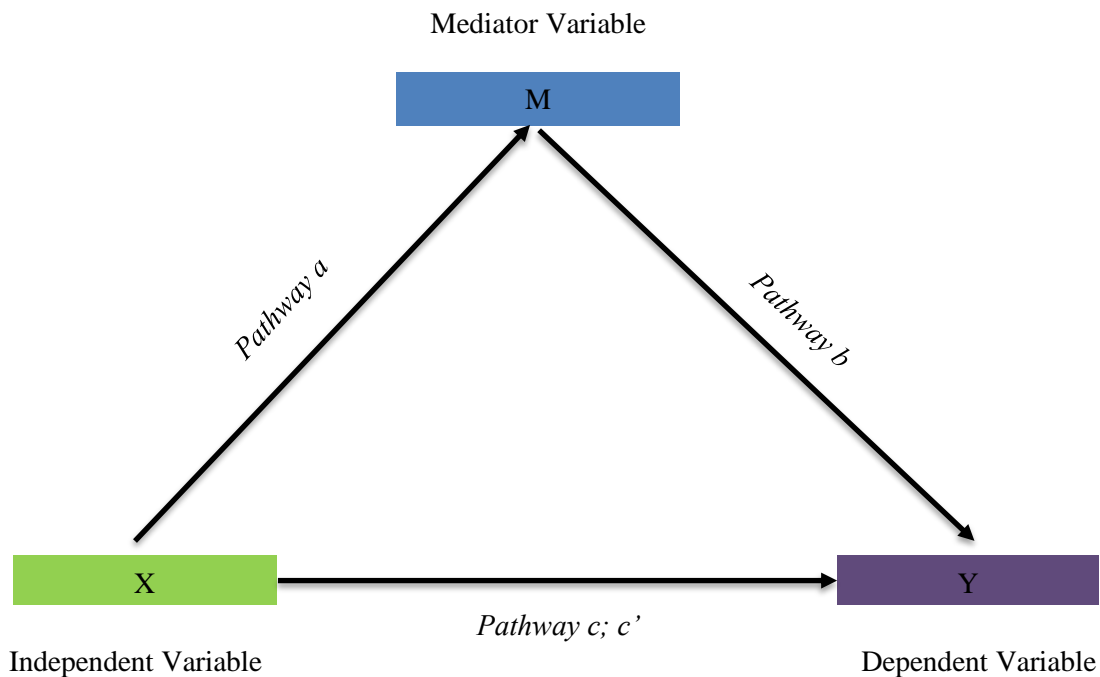


Figure 3.1 Testing for Mediation (four step pathways)

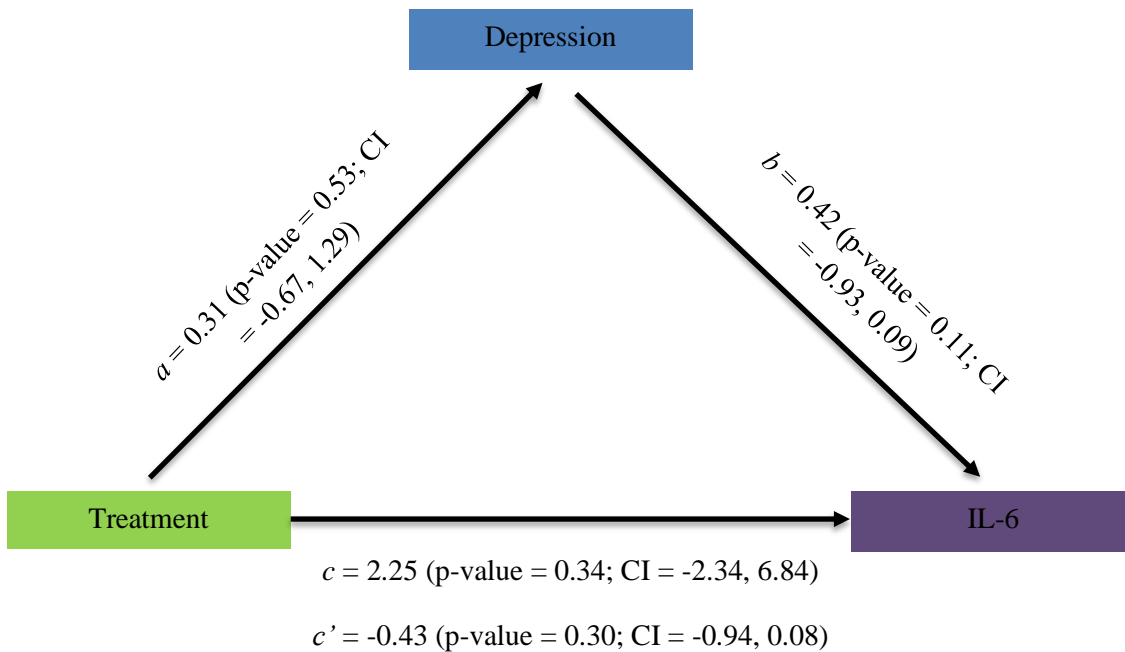
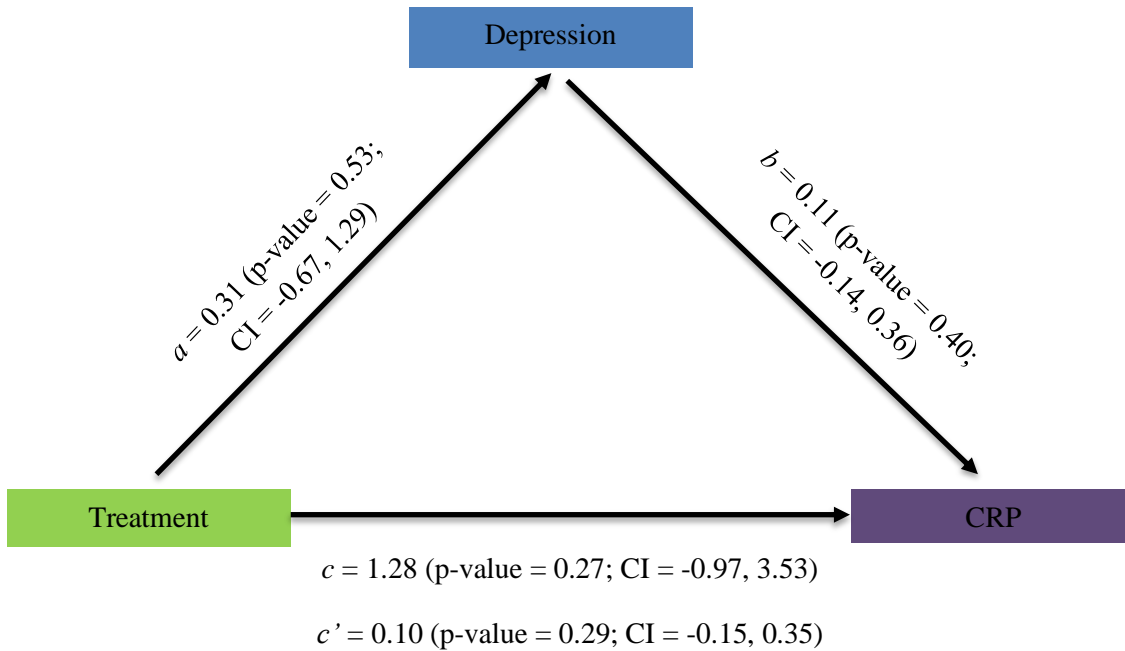


Figure 3.2 Adjusted mediation analysis of association between the SISTAS trial, depression, and inflammatory biomarkers {with p-values and 95% confidence intervals (CI)}

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CHAPTER 4

THE IMPACT OF CLINICAL FACTORS ON HEALTHY LIFESTYLE INTERVENTIONS AND INFLAMMATION: A MEDIATION ANALYSIS

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Abstract

Underserved minorities suffer from inflammatory-related chronic diseases at disparagingly higher rates compared to European Americans (EAs). Studies on how specific clinical factors play a role in participant's treatment assignment in clinical trials and inflammation among African American (AA) women is lacking, although common protective factors are still promoted nationwide. We analyzed if percent body fat or diastolic blood pressure mediated the association between treatment assignment in the Sistas Inspiring Sistas Through Activity and Support (SISTAS) intervention and inflammatory biomarker levels. SISTAS was a one-year randomized controlled trial (RCT) to promote diet and physical activity (PA) among AA women, utilizing the community-based participatory research (CBPR) approach for recruitment and retention. Anthropometric measures were obtained at baseline, along with blood draws to measure C-reactive protein (CRP) and interleukin-6 (IL-6). Women were randomized to the intervention (12 weekly classes and nine monthly booster sessions) or the delayed intervention groups, with follow-up clinic visits occurring at 12-week and 12-months after baseline. Descriptive statistics were obtained through frequencies or means and standard deviations (STD) and we conducted multiple regression analyses to assess the relationship (including mediation analysis) between the intervention arm of SISTAS, percent body fat or diastolic blood pressure, and change in CRP/IL-6 levels over time. Our sample (n = 337) were mostly middle-aged (mean age 50.1 years), had some college education, and were non-smokers. They also were morbidly obese (mean BMI > 39.0 kg/m²), had high diastolic blood pressure, and elevated percent body fat. Although we discovered that diastolic blood pressure was a significant predictor on CRP, and percent

body fat was a significant predictor for IL-6, diastolic blood pressure or percent body fat were not mediators between the SISTAS trial and chronic inflammation. Nevertheless, future research should be conducted in this racially underserved population with focus on a more pragmatic approach in study design in order to further extrapolate and combat inflammation and its related conditions.

Introduction

Chronic inflammation, defined as the body's prolonged response to internal damage including abnormal tissues [1], displays racial disparities in the United States (U.S.) [2-3]. C-reactive protein (CRP) and interleukin-6 (IL-6) are common blood markers to test for inflammation; CRP is a plasma protein from the petraxin family typically regulated by cytokines (i.e. IL-6) when wounds or infections arise in the body [4-5]. Normal CRP levels have been reported to be about 10 mg/L or less [4] but Collins and Dias have considered high-sensitivity CRP (hs-CRP) levels above 3.0 mg/L to be a risk factor for cardiovascular disease (CVD) [6]. Usual IL-6 levels are around 1.8 pg/mL and the abnormal levels differ depending on the outcome of interest such as rheumatoid arthritis or osteoporosis [7]. CRP and IL-6 are typically utilized to detect short-term inflammatory responses like infections (e.g. urinary tract infections, pancreatitis, pneumonia), they can also be used to measure long-term inflammatory diseases [8].

Diseases characterized by inflammation (e.g. hypertension, type 2 diabetes, stroke, and heart disease) adversely affect African Americans (AAs) at higher rates compared to their white counterparts [9-12], and these rates are still distinctly higher in the Southeast. Specifically, almost 46% of South Carolinian (SC) AAs have hypertension compared to less than 37% of whites, and 18.2% have diabetes compared to 12.3%,

respectively [13]. Stroke mortality rates are higher among SC blacks compared to whites and AAs are at a higher risk of heart disease especially when living a sedentary lifestyle [14].

A healthy diet (i.e. increased fruit and vegetable intake) and increased physical activity (PA) have been extensively researched in mitigating chronic disease outcomes [15-21]. However, common clinical factors such as percent body fat and diastolic blood pressure can adversely affect chronic disease management [22-23]. Furthermore, a dearth in the literature exists on the relationship between percent body fat, diastolic blood pressure, and inflammatory biomarkers among AA adults, respectively. A prospective study out of Washington, D.C. found a significant association with elevated CRP levels for those AA women with body fat $\geq 35.1\%$ [24], and among a multi-ethnic cohort out of Fort Worth, TX there were significant positive relationships found with increases in visceral adipose tissue (which is closely related to percent body fat) and inflammatory biomarkers among AA adults [25]. One cohort study recruiting AA participants from Philadelphia, PA found an elevated risk of high-sensitivity CRP and IL-6 when they experienced high blood pressure [26], and an analysis of the Multi-Ethnic Study of Atherosclerosis (MESA) study found that hypertensive AAs had increased CRP concentrations [27].

The purpose of this article was to examine if percent body fat or diastolic blood pressure mediated the association between treatment assignment in the Sistas Inspiring Sistas Through Activity and Support (SISTAS) intervention sessions and changes of CRP/IL-6 levels over time. We hypothesized that we would find a significant relationship between treatment assignment and inflammation, and that percent body fat or diastolic

blood pressure would mediate this association, after controlling for chronic disease risk factors.

Methods and Materials

Study Population

Data was collected as a part of the Sistas Inspiring Sistas Through Activity and Support (SISTAS) trial, a one-year randomized controlled trial (RCT) designed to emphasize diet and PA behavior change among AA women to mitigate chronic inflammation which is a key underlying biological mechanism for many chronic diseases including breast cancer, heart disease, and diabetes [28]. AA women aged at least 30 years old were recruited from Florence and Columbia, SC between 2010 and 2015. All participants were cancer-free and free from known inflammatory conditions (rheumatoid arthritis, lupus) at baseline. The methods of the SISTAS trial are detailed elsewhere [29]. Eligible women were selected for the study if they were AA, had a body mass index (BMI) of 30 kg/m² or more, had to be physically able to exercise or walk and to be willing to be randomized and participate fully in the research study for one calendar year. Women with previous cancer diagnoses (except non-melanoma skin cancer) or any inflammatory-related diseases (e.g., lupus, rheumatoid arthritis) were excluded from participation. The final sample of eligible participants was 337 women.

Data Collection

The study team collected data at clinic visits which occurred at baseline, after the 12-week intervention, and at the end of one year of participation. Information from questionnaire data, anthropometric measurements, and drawn blood samples also were

collected at the clinic visits. Questionnaires contained multiple sections [e.g. healthy and lifestyle, everyday discrimination scale, Perceived Stress Scale (PSS), Depression Scale (CESD-10)] that were administered at each visit. The PSS is a 14-item survey designed to determine a person's perceived stress levels in their daily lives, while the CESD-10 is a previously validated, shortened version of the 20-item survey that measures depressive symptoms among groups such as sadness, guilt, and suicidal ideation [30-31]. Height, weight, waist/hip circumference, percent body fat (including fat mass and fat free mass), and blood pressure were taken during the clinic visits by trained study staff.

Initial screening data included participant demographics, baseline anthropometric data, and basic health data. Demographic information included age, marital status (married, living with partner, widowed, divorced, separated, single/never married), educational status (high school or less, some college, completed college, post-graduate), employment status (full-time, part-time, retired, not employed), health insurance (Medicare, Medicaid, private, uninsured/self-pay, other), and smoking status (yes vs. no).

Anthropometric measures

Our trained staff collected percent body fat and blood pressure, along with other measurements, via bioelectrical impedance assessment (BIA) [32] during the clinic visits. A Tanita TBF 300A® electronic scale (precise to 0.1 kg and 0.1% fat) was utilized to receive fat mass and weight, and height was determined through a stadiometer to the closest cm.

Laboratory and Inflammatory Markers

We collected blood samples from all eligible participants during clinic visits to analyze inflammatory markers [CRP and IL-6]. Assays were analyzed using venous

blood received on the day of the clinic visits. Specific enzyme-linked immunosorbent assay kits were used to measure plasma CRP and IL-6 levels, respectively; all samples were run in duplicate (CRP: CV=3.9%, sensitivity = 0.022ng/ml; IL-6: CV=3.7%, sensitivity = 0.110 μ g/ml.) [33].

Treatment assignment under the SISTAS trial was categorized as “Intervention” or “Control” from baseline to 12 weeks with the control group being the reference group. The primary outcomes for this analysis were changes in CRP or IL-6 (continuous variables) during the same timeframe Percent body fat or diastolic blood pressure (mediators of interest) were continuous variables as we assessed their change over time using linear modeling to account for repeated measures within subjects.

Statistical Analyses

Descriptive statistics were computed using frequencies or means and standard deviations (STD). We conducted multiple linear regression analyses to examine the association between the effect of the treatment assignment of a dietary and PA intervention with the biological markers of inflammation, adjusted for potential covariates. Mediation analyses also were conducted to determine if percent body fat or diastolic blood pressure explains any underlying effects on dietary and PA intervention and inflammatory biomarkers. Model 1 was the crude analysis of the treatment assignment of the intervention on the respective outcomes, model 2 was the analysis testing if the mediator has any effects on the intervention alone, while model 3 tested if the mediator has effects on change on CRP/IL-6 alone, respectively. If significant findings were obtained from the first three models, then we would proceed to the full model (effect of the treatment assignment of the intervention on the respective outcomes,

the mediating variable of interest, and group of confounders significant via bivariate analyses) [34]. Pathway *c* signified the results from Step 1 (the regression analysis determining if the independent variable X is a significant predictor for the dependent variable Y), pathway *a* signified the results from Step 2 (the regression analysis determining if the independent variable X is a significant predictor for the mediating variable M), pathway *b* signified the results from Step 3 (the regression analysis determining if the mediating variable M is a significant predictor for the dependent variable Y), and pathway *c'* signified the results from Step 4 (the regression analysis determining if the independent variable X and mediating variable M are significant predictors for the dependent variable Y) [Figure 1].

Regression models were utilized via SAS software version 9.4 (Cary, North Carolina, United States) with potential confounders (age, BMI, education, employment status, smoking status) to be assessed via bivariate analyses first and age kept in all relevant models. Statistical significance in the models were determined with the p-value

Results

Table 1 depicts the general demographics of the study population included in the regression analysis. The majority of participants at baseline were employed full time, had completed some college education, were married, were not smokers, and perceived their health status as “good.” The average age was approximately 50 years old, their average BMI placed them as morbidly obese (39.0 kg/m^2), and the average inflammatory levels among all participants were markedly high ($\text{CRP} = 9.29 \pm 17.8$; $\text{IL-6} = 5.59 \pm 24.2$).

After conducting bivariate analyses (not shown) we determined that age and BMI were

the significant covariates included in the analysis. We did not see a significant change in CRP or IL-6 levels over time between the treatment assignments (see Table 2).

An examination of the multiple regression results did not show that percent body fat was significantly associated with either treatment assignment in the SISTAS healthy lifestyle intervention trial or CRP over time (Table 3). However, percent body fat was significantly related to IL-6 over time (p value = 0.004). We also saw that BMI was associated with IL-6 (p-value <.0001) and percent body fat (p-value <.0001); age may have been marginally significant for IL-6 depending on the model in the analysis. In addition to the regression results, we did not find that diastolic blood pressure was significantly associated with either treatment assignment in the SISTAS healthy lifestyle or IL-6 over time (see Table 4). We did find that it was significantly related to CRP over time (Model 3 p-value = 0.02, Model 4 p-value = 0.01). We also found that BMI was a significant predictor for CRP (p-value <.0001).

Figure 1 denoted the first mediation analysis of the effect of the treatment assignment of the intervention on inflammatory biomarkers with percent body fat in the causal pathway as the potential mediator. The first step showed that treatment assignment in the SISTAS trial did not significantly affect percent body fat ($\beta_a = -0.09$, p-value = 0.84; path *a*) and CRP over time ($\beta_c = 1.28$, p-value = 0.27; path *c*), respectively. Both treatment assignment ($\beta_{c'} = 1.29$, p-value = 0.26; path *c'*) and percent body fat ($\beta_b = 0.11$, p-value = 0.47; path *b*) still remained not associated with CRP when both variables were included in the model. In the context of mediation, steps 1-3 were not satisfied, so we concluded that percent body fat did not serve as a mediator in the relationship between treatment assignment in a healthy lifestyle intervention and CRP over time. In the second

mediation analysis, treatment assignment in the SISTAS trial again did not significantly affect self-reported percent body fat and IL-6 over time ($\beta_c = 2.25$, p-value = 0.34; path c), respectively. When treatment assignment in the trial and percent body fat were included in the model for IL-6, treatment assignment ($\beta_{c'} = 2.19$, p-value = 0.34; path c') still remained nonsignificant but percent body fat ($\beta_b = -0.89$, p-value = 0.004; path b) was determined to be associated with IL-6. Nevertheless, we also confirmed that percent body fat did not serve as a mediator in the relationship between treatment assignment in a healthy lifestyle intervention and IL-6 over time.

The relationship of the treatment assignment on inflammatory biomarkers with diastolic blood pressure in the causal pathway as the potential mediator was in Figure 2. Treatment assignment in the SISTAS trial did not significantly affect diastolic blood pressure ($\beta_a = 1.07$, p-value = 0.36; path a) and CRP over time ($\beta_c = 1.28$, p-value = 0.27; path c) in the third mediation analysis. When treatment assignment in the trial and diastolic blood pressure were included in the model for CRP, treatment assignment ($\beta_{c'} = 1.50$, p-value = 0.19; path c') remained nonsignificant but diastolic blood pressure ($\beta_b = -0.13$, p-value = 0.02; path b) was statistically related to CRP. Although step 3 was satisfied in the context of mediation, steps 1 and 2 were not conditions that were statistically met. Therefore, diastolic blood pressure did not serve as a mediator in the relationship between treatment assignment in a healthy lifestyle intervention and CRP over time. In the fourth mediation analysis, treatment assignment in the SISTAS trial again did not significantly affect diastolic blood pressure and IL-6 over time ($\beta_c = 2.25$, p-value = 0.34; path c), respectively. When treatment assignment in the trial and diastolic blood pressure were included in the model for IL-6, both treatment assignment ($\beta_{c'} =$

2.24, p-value = 0.34; path c') and diastolic blood pressure ($\beta_b = 0.04$, p-value = 0.75; path b) still remained nonsignificant. Therefore, we also did not determine that diastolic blood pressure was a mediator in the relationship between treatment assignment in a healthy lifestyle intervention and IL-6 over time.

Discussion

This study evaluated if percent body fat or diastolic blood pressure mediated the relationship between treatment assignment in a healthy lifestyle intervention and inflammatory biomarker levels over time. Our results revealed that neither percent body fat nor diastolic blood pressure mediated the effect of the treatment assignment in the SISTAS trial and CRP or IL-6 over time. This is the first study to our knowledge examining percent body fat or diastolic blood pressure as mediators in the healthy lifestyle/inflammation association among AA women in SC.

There were stark contrasts between our analysis and prior research done on healthy lifestyle interventions and CRP and/or IL-6, respectively. One review contained multiple observational studies that highlighted the benefits of exercise and inflammation reduction [35], a cross-sectional multi-site study showed decreased CRP and IL-6 concentrations when older adults exhibited high exercise levels [36], and two RCTs that discovered significant decreases in CRP and/or IL-6 when women adhered to Mediterranean-based diets and/or aerobic exercises [37-38]. The connection between PA/diet and body fat has previously shown strong associations [39-43], as has healthy lifestyle changes and blood pressure [44-45]; however, other reviews on blood pressure did not find the same association [46].

Mediation-specific analyses with percent body fat or blood pressure as potential mediators have produced mixed results as well. Zeng and colleagues determined that percent body fat measured by bioelectric impedance analysis (BIA) was a significant predictor for cardiovascular risk factors instead of BMI among hospitalized Chinese adults, but they did not evaluate for full mediation [47]. Beydoun and her colleagues analyzed National Health and Nutrition Examination Survey (NHANES) data from obese adult men and women about their diet quality and metabolic disturbances, and they found that percent body fat mediated the association between the disturbances and their Healthy Eating Index surrounding dairy products [48]. A systematic review of prospective cohort studies by The Global Burden of Metabolic Risk Factors for Chronic Diseases Collaboration determined that blood pressure served as a significant mediator for coronary heart disease (CHD) and stroke compared to glucose and cholesterol [49].

Although our study team told delayed intervention participants upon recruitment that they would be offered the opportunity to attend intervention classroom sessions when their participation in the SISTAS trial was complete after one year, we still discovered that contamination bias likely occurred. Some of the intervention women may have interacted with delayed intervention (i.e. control) women outside of the clinical sessions (e.g. women who attend the same church or who reside in the same geographical area) and could have spoken about the intervention material, subsequently encouraging the control women to implement a healthier lifestyle on their own [50].

It also is very likely that women in the control group decided not to wait to change their unhealthy habits as requested by the SISTAS team. These facets of contamination are viable because evidence showed the control group significantly lost

weight at a higher rate (59.5%) compared to the intervention group (49.1%) at any timepoint of the trial [50], and considering the evidence supporting the notion of readiness to change [51]. Researchers should think about implementing other study designs when CBPR is used for recruitment and retention purposes. Environmental barriers (e.g. women residing in areas without walkable neighborhood or food deserts) also may have affected participant adherence of the intervention during the study period [52]. It is imperative to understand the unique aspects of environmental factors and treatment assignments within interventions among AA adults so then future interventions can be customized properly to consider cultural and geographical aspects of their everyday lives.

Our study had several limitations, starting with generalizability issues because AA women in general exhibit hormonal milieu differences within the group and compared to EA women [53-56]. There were compliance issues among the control group (over 50% had weight loss) that presents misclassification bias that distorts our association toward the null. We only examined two biomarkers of inflammation which does not represent the full gamut of inflammatory biomarkers, despite CRP and IL-6 being the markers with a plethora of supporting literature on their correlation to numerous chronic diseases including cancer [57]. Volunteer/non-response bias was likely present because baseline characteristics may differ between persons who volunteer to participate compared to those who do not. Finally, the majority of women in our sample had some college experience (42.1%) at baseline [29] so it is likely they were more willing to participate in SISTAS and thus may not be representative of all AA women in South Carolina (SC).

Nevertheless, the analysis exhibited some strengths. We were the first, to our knowledge, to evaluate specific clinical factors as potential mediators between intervention effects and inflammation on an underrepresented population not only who are rarely studied exclusively in epidemiologic research, but hampered by racial health disparities especially in rural and metropolitan SC. We also had high recruitment rates overall and during the tenure of the trial, despite potential drop-off when we moved from the rural to the metropolitan area [58-59], and the prospective nature of the SISTAS study mitigated other biases often seen in other observational designs.

Conclusion

Diastolic blood pressure was a significant predictor on CRP, and percent body fat was a significant predictor for IL-6 among obese AA women in rural and metropolitan SC, respectively. Regardless, neither clinical factor fully nor partially mediated the effect of the SISTAS trial on inflammation. BMI served as a predictor for both biomarkers and fat percent depending on the specific model; this is expected considering the baseline characteristics among these women coupled with the pathways associated with BMI, fat percent, and inflammation. Our study gives us the chance to further examine the cultural differences and stigmas surrounding AA adults dealing with blood pressure or body fat issues in this country. A pragmatic randomized design should be considered for future studies to mitigate contamination bias and to allow excited participants, especially those who do not have access to necessary resources, the ability to change their lifestyle choices as they clearly desire.

Table 4.1 Baseline Demographics of Study Population (n = 337)

Characteristic	Frequency (%)
Age (Mean ± STD)	50.1 ± 11.07
Marital Status	
Married	126 (37.5%)
Living with Partner	9 (2.70%)
Divorced	63 (18.8%)
Separated	28 (8.30%)
Single	91 (27.0%)
Widowed	19 (5.70%)
Education Status	
High school or less	70 (20.8%)
Some college	141 (42.0%)
Completed college	59 (17.6%)
Postgraduate	66 (19.6%)
Employment Status	
Full time	183 (54.5%)
Part time	38 (11.3%)
Retired/not employed	115 (34.2%)
Smoking Status	
Current	109 (32.4%)
Nonsmoker	227 (67.6%)
Perceived Health	
Excellent	10 (3.00%)
Very good	88 (26.1%)
Good	184 (54.6%)
Fair	52 (15.3%)
Poor	3 (1.00%)
Insurance	
Medicare	141 (42.0%)
Medicaid	44 (13.1%)
Private	22 (6.50%)
Uninsured/self-pay	62 (20.0%)
Other	67 (18.4%)
Characteristic	Mean ± STD
Body mass index (kg/m ²)	39.1 ± 7.4
Dietary Inflammatory Index score (DII)	0.56 ± 2.51
Percent Body Fat (%)	46.2 ± 5.63

Diastolic Blood Pressure	84.1 ± 13.7
Blood-C-reactive protein (CRP; mg/dL)	9.29 ± 17.8
Blood-Interleukin-6 (IL-6; pg/mL)	5.59 ± 24.2

Column percentages may not equal 100 because of rounding. Frequencies may not equal population total because of missing data.

Table 4.2 Adjusted Inflammatory Biomarker Mean Levels by Treatment Assignment at 12-week Follow-Up Timepoint

	Mean	Difference between Treatment Assignments	p-value
Outcome			
CRP (mg/l)			
Intervention	7.93		
Control	9.47	-1.54	0.15
IL-6 (pg/ml)			
Intervention	1.00		
Control	1.06	-0.06	0.55

*All models controlled for age and BMI

Table 4.3 SISTAS Intervention, Percent Body Fat, and Inflammatory Biomarker Levels

Dependent Variables	Independent Variables	Regression		
		β	SE	p-value
CRP (Model 1)*				
	Treatment	1.28	1.15	0.27
Fat % (Model 2)*				
	Treatment	-0.09	0.42	0.84
CRP (Model 3)*				
	Fat %	0.11	0.15	0.47
CRP (Model 4)*				
	Treatment	1.29	1.15	0.26
	Fat %	0.11	0.15	0.46

IL-6 (Model 1)*				
	Treatment	2.25	2.34	0.34
Fat % (Model 2)*				
	Treatment	-0.09	0.42	0.84
IL-6 (Model 3)*				
	Fat %	-0.89	0.30	0.004
IL-6 (Model 4)*				
	Treatment	2.19	2.31	0.34
	Fat %	-0.89	0.30	0.004

*All models controlled for age and BMI

Table 4.4 SISTAS Intervention, Diastolic Blood Pressure, and Inflammatory Biomarker Levels

Dependent Variables	Independent Variables	Regression		
		β	SE	p-value
CRP (Model 1)**				
	Treatment	1.28	1.15	0.27
BP (Model 2)**				
	Treatment	1.07	1.17	0.36
CRP (Model 3)**				
	BP	-0.13	0.05	0.02
CRP (Model 4)**				
	Treatment	1.50	1.14	0.19
	BP	-0.14	0.05	0.01
IL-6 (Model 1)**				
	Treatment	2.25	2.34	0.34
BP (Model 2)**				

	Treatment	1.07	1.17	0.36
IL-6 (Model 3)**				
	BP	0.04	0.11	0.75
IL-6 (Model 4)**				
	Treatment	2.24	2.36	0.34
	BP	0.03	0.11	0.80

**All models controlled for age and BMI

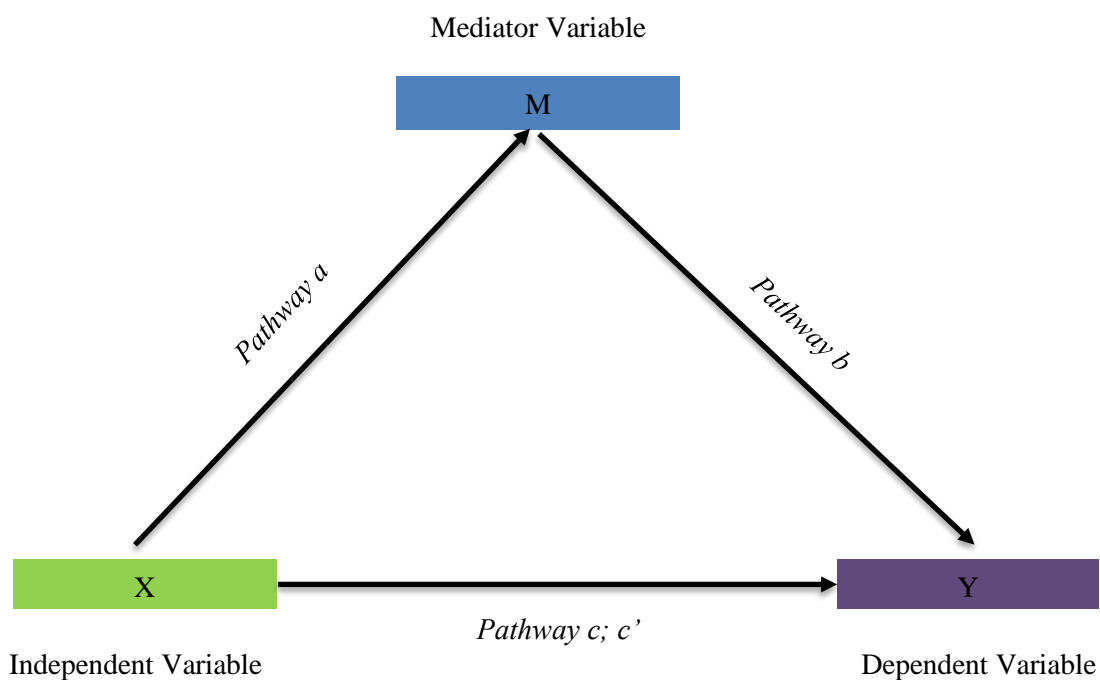


Figure 4.1 Testing for Mediation (four step pathways)

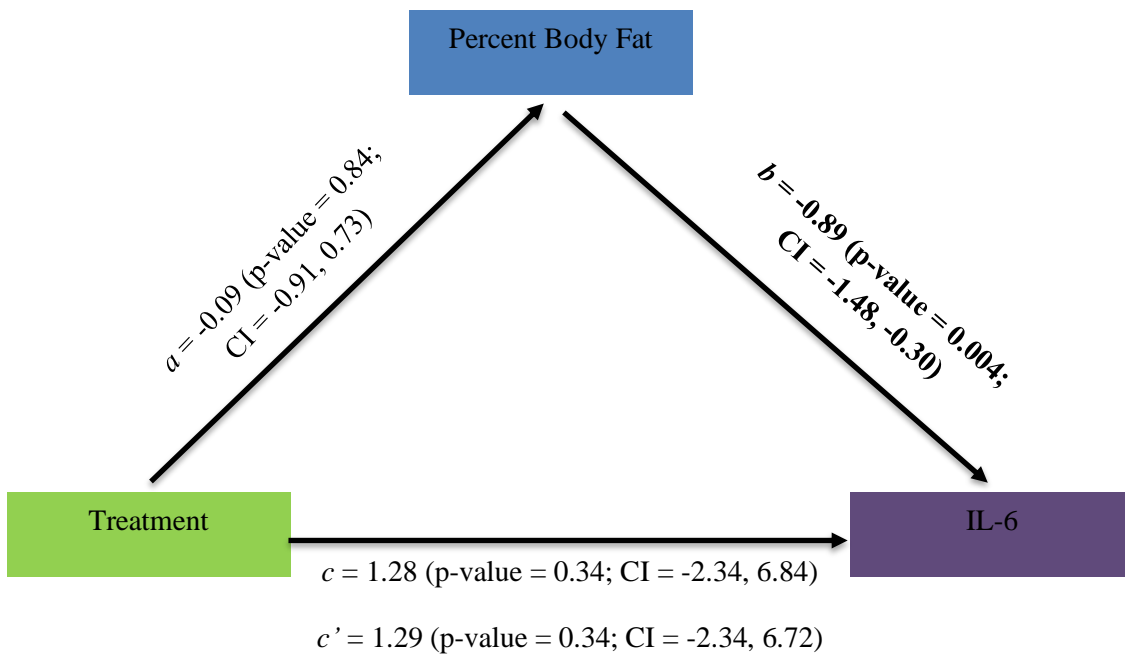
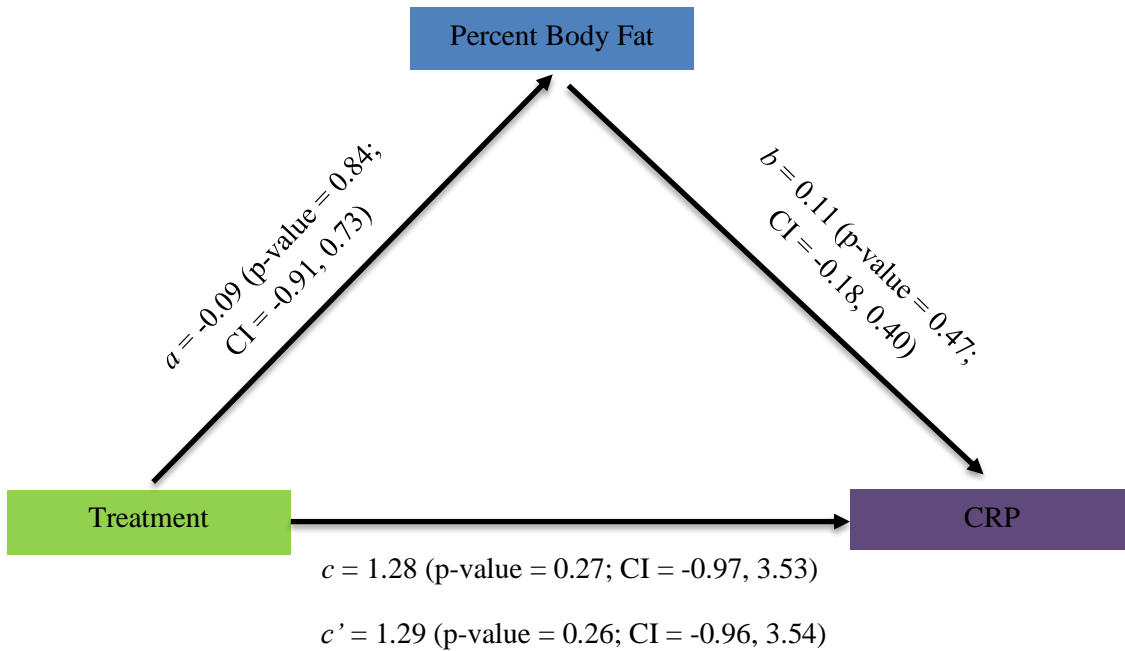


Figure 4.2 Adjusted mediation analysis of association between the SISTAS trial, percent body fat, and inflammatory biomarkers {with p-values and 95% confidence intervals (CI)}

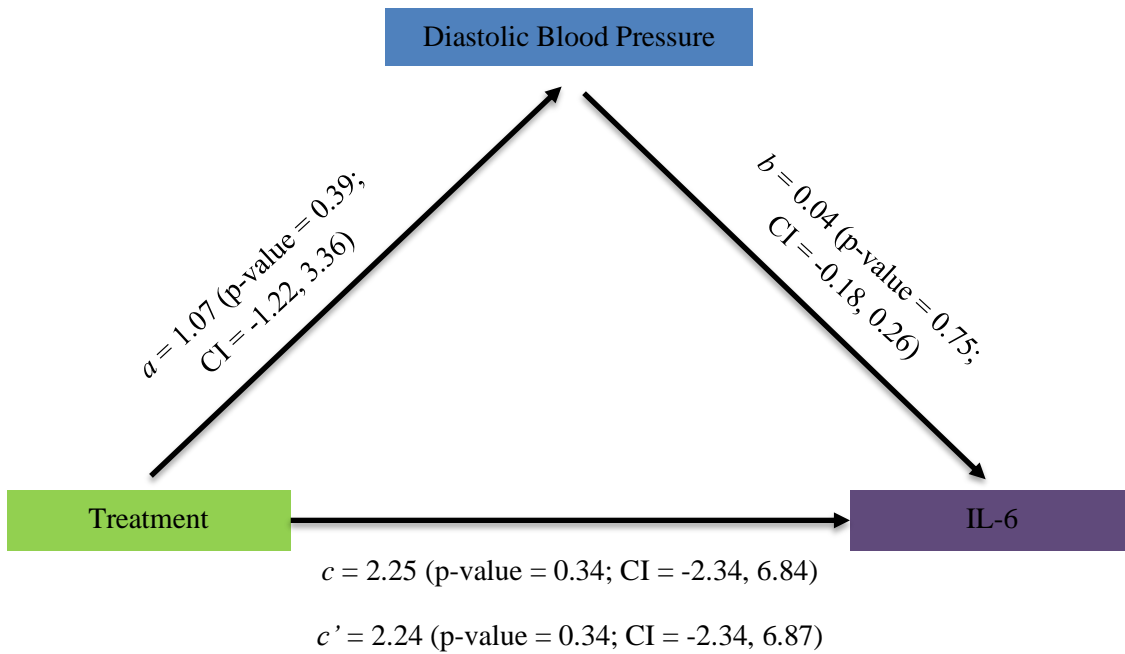
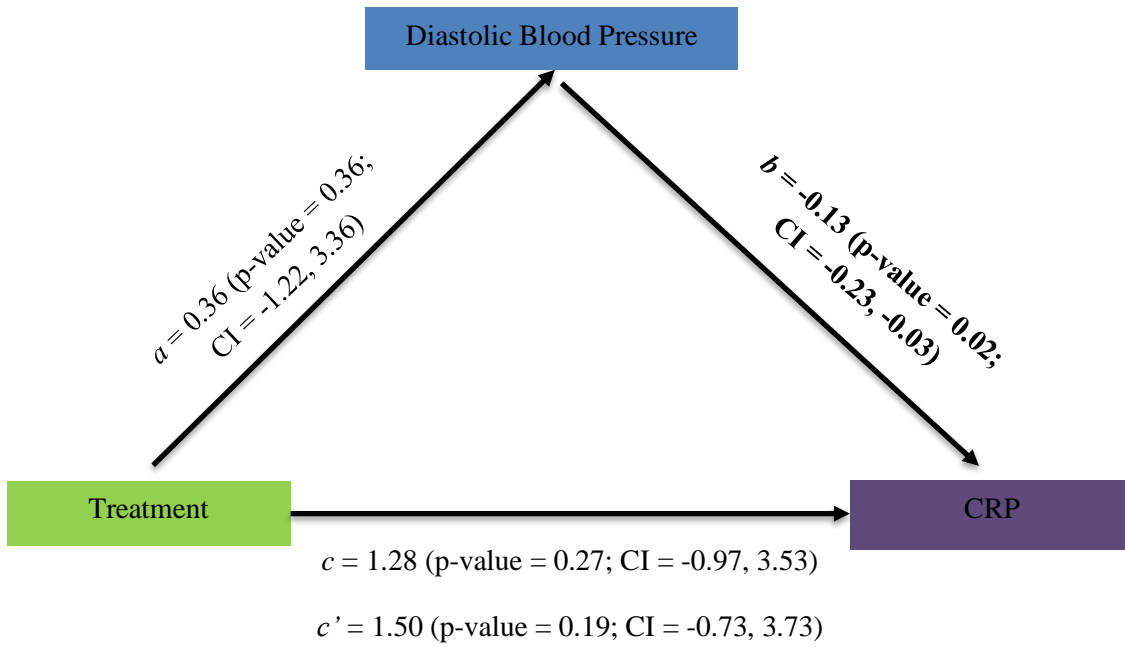


Figure 4.3 Adjusted mediation analysis of association between the SISTAS trial, diastolic blood pressure, and inflammatory biomarkers {with p-values and 95% confidence intervals (CI)}

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CHAPTER 5

TO PLANT OR NOT TO PLANT: A MIXED METHODS ANALYSIS OF THE ROLE OF FOOD SWAMPS AND DESERTS ON INFLAMMATION AND COMMUNITY GARDENING AMONG AFRICAN AMERICAN WOMEN IN SOUTH CAROLINA

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Abstract

Many chronic diseases are considered to be inflammatory-related and are unfavorably prevalent among the African American (AA) community. Although physical activity (PA) and a healthy diet have been previously cited as protective factors in various trials, they are seldom studied in relation to food deserts/swamps, community garden interventions, and inflammatory outcomes among underserved populations. We utilized a two-phase mixed-methods approach to examine the association of residing in a food desert or food swamp and AA women's inflammatory biomarkers, and explored their knowledge and beliefs on food availability in their environment (including gardening and community gardening) and its impact on healthy lifestyle goals. Secondary data was derived from the Sistas Inspiring Sistas Through Activity and Support (SISTAS) trial, using demographic and inflammatory biomarker information of the cohort of obese AA women. Primary data was collected via key informative interviews (n = 15) to cover items such as health beliefs, social support, knowledge of chronic diseases, and current knowledge of personal and community gardening, respectively. We conducted logistic regression analyses to evaluate the relationship between residing in a food desert/swamp and varying levels of inflammatory biomarkers while adjusting for possible confounders. Transcripts of the interviews were analyzed and interpreted using thematic analysis via NVivo, with multiple reviews of each transcript allowing us proper identification and differences of themes among participants. After controlling for age and body mass index (BMI), we found non-significant slightly higher risks of high inflammatory biomarker levels among women residing in food deserts/swamps (CRP = 1.18, 95% confidence interval (CI) = 0.82-1.77). Common themes identified from the interviews included the

desire for healthier food choices, the lack of knowledge on personal and/or community gardening, and self-efficacy of both personal and community gardening. The benefits of gardening highlight its feasibility and acceptability for healthy lifestyle promotion in underserved populations who suffer from health and resource disparities.

Introduction

Racial health disparities in the United States (U.S.) are still persistent as it pertains to many inflammation-based chronic diseases, including heart disease, diabetes, and cancer [1-3]. Common blood markers such as C - reactive protein (CRP) and interleukin-6 (IL-6) have been vital for inflammation testing. CRP is a plasma protein from the petraxin family typically regulated by cytokines (i.e. IL-6) when wounds or infections arise in the body [4-5]. Irregular levels of CRP and IL-6 can vary depending on the conditions activating each respective marker with normal CRP levels of approximately 5-10 mg/L [4] and 5.0 pg/mL for IL-6 [6]. Although CRP and IL-6 are usually used in hospital settings to detect short-term inflammatory responses (e.g. urinary tract infections, pancreatitis, pneumonia), there has been a recent push to use them for long-term inflammatory disease measurement [7].

Diseases such as hypertension, heart disease, type 2 diabetes, and stroke have been shown to be related to inflammation but adversely affect African American (AA) adults at higher rates compared to their white counterparts [8-11], with the rates particularly higher in the Southeast. Specifically, almost 46% of South Carolinian (SC) AAs have hypertension compared to less than 37% of whites, and 18.2% have diabetes compared to 12.3% [12]. Stroke death rates are higher among SC AAs compared to

whites and AAs are at a higher risk of heart disease especially when living a sedentary lifestyle [13].

Physical activity (PA) and healthy eating have been associated with a reduction in numerous chronic disease outcomes [14-20]. One key barrier to accessing a healthy lifestyle (i.e. PA and diet) is residing in a food desert or food swamp [21]. Food deserts and food swamps are geographical regions where persons live more than one mile from a supermarket and are devoid of healthy food options, with the unique difference of swamps having more pro-inflammatory food options (e.g., corner stores, fast-food restaurants). [22-24]. While some studies have shown a larger promotion of unhealthy food options in AA communities compared to predominately white communities [25-33], others have shown that underserved populations are more willing to consume healthy foods when given access to it [34-35].

A unique resource that can improve access to healthy foods in communities of color are community gardens. Although they span across the country, there was a surge of gardens built mainly in the Patriot Northeast and West Coast regions of the U.S., despite the strong agrarian culture in the South and a longer growing season. Conversely, food deserts/swamps mainly exist in the Southeastern region where chronic disease rates are the highest among AA adults. Literature on the relationship between access to healthy foods, community gardens, and inflammatory-related chronic disease risk among AA adults is scarce. A cross-sectional analysis with an intervention targeting AA men in rural Missouri provided nutritional education activities and food access via community gardens in two growing seasons. They found a statistically significant 48% reduction in the odds of having hypertension among the intervention group as well as an

increased perception of whole food consumption when participants either had direct access to the educational activities or access to the produce from the community garden [36]. Despite the previously mentioned findings, there still is a lack of evidence regarding community gardens and chronic disease risk among AA women.

The purpose of this explanatory sequential, mixed methods study was two-fold: 1) to examine how residing in a food desert or swamp is associated with AA women's dietary inflammation levels, and to explore how residing/not residing in a food desert/swamp explains AA women's pro-inflammatory diets and perceptions of community gardens as a way to improve their dietary needs. We hypothesized that we would find a significant relationship between residence in a food desert/swamp and inflammation after controlling for specific confounders in the quantitative analysis. For the subsequent qualitative analysis, we anticipated emergent culturally specific themes and barriers that would help explain our quantitative findings.

Methods and Materials

Study Population

In brief, an explanatory-sequential mixed methods design consists of the collection and analysis of quantitative data first, followed by the collection and analysis of qualitative data (e.g. interviews, focus groups) in order to illustrate themes that may be related to the results of the quantitative analysis [37]. We applied a constructivist worldview approach to the study which allowed us to create broad questions focusing on specific contexts in where participants live and/or work to allow participants to formulate social meanings in their responses[42]. Secondary quantitative data was received from

the SISTAS trial, a one-year randomized controlled trial (RCT) that promoted diet and PA behavior change among AA women to alleviate internal chronic inflammation which is a principal biological mechanism for many chronic diseases including breast cancer, heart disease, and diabetes [38]. Using a community-based participatory research (CBPR) approach, we AA women ages 30 years old or older were recruited from Florence and Columbia, SC between 2010 and 2015. Women were free from cancer, rheumatoid arthritis, lupus, and other known inflammatory conditions at baseline. The methods of the Sistas Inspiring Sistas Through Activity and Support (SISTAS) trial are detailed elsewhere [39]. Eligible women were chosen for the study if they had a body mass index (BMI) of 30 kg/m² or more, had to be physically able to exercise or walk and to be willing to be randomized and participate fully in the research study for one calendar year. Women were excluded from participation if they had any previous cancer diagnoses except non-melanoma skin cancer or any aforementioned inflammatory-related diseases. The final sample of participants was 337 women.

Data Collection

The SISTAS study team collected data at three clinic visits: baseline, after the 12-week intervention, and at the end of one year of participation. Information collected included questionnaire data, anthropometric measurements, and drawn blood samples. Questionnaires contained multiple sections (e.g. healthy and lifestyle, everyday discrimination scale) that were administered at the three follow-up visits, respectively. Height, weight, waist/hip circumference, percent body fat (including fat mass and fat free mass), and blood pressure were taken during the clinic visits by trained study staff.

Initial screening data included participant demographics including baseline anthropometric data and basic health data. Demographic information included age, marital status (married, living with partner, widowed, divorced, separated, single/never married), educational status (high school or less, some college, completed college, post-graduate), employment status (full-time, part-time, retired, not employed), health insurance (Medicare, Medicaid, private, uninsured/self-pay, other), and smoking status (yes vs. no). Physical street addresses were collected at baseline and checked throughout the study period; census tract data was used as the cross-link variable for geocoding each participant to determine if they resided in a food desert or food swamp and appended to their de-identified record. Women were excluded from the current study if they did not have baseline inflammatory biomarker data, if they had missing addresses, or there was a post office box listed as their permanent address (final n = 295).

Key Informative Interviews

Primary data was collected via key informative telephone interviews with a target sample size of 15 AA women. Specifically, we recruited women from the intervention and delayed intervention groups depending on their food desert/swamp status. We contacted the former SISTAS participants via telephone to confirm their eligibility for the interviews. Participants were eligible if they were ages 30 and older, a former SISTAS trial participant between the years 2010 and 2016, if they resided at the geocoded address given from the SISTAS screening, if they described residing in an area that did not have a grocery store/supermarket close to them, and if they described residing in an area that had more unhealthy food options (e.g. corner stores, fast-food restaurants) than healthier options. After confirming their eligibility, we set up an appointment time for the

telephone interview on a later date. On the day of the interview, we read to them an overview of the study procedures and proceeded to audio record the interview. Interviews were transcribed verbatim with all identifying information to be deleted from the transcripts. Pilot interviews (n = 2) were conducted with X to determine the quality of the interview guide, and to make any potential changes in order to improve the interview experience and type of data collected.

Interview Questions

We developed a model to provide the theoretical framework for this project adapted from the Health Belief Model (HBM) and the PEN-3 model. The Health Belief Model includes four main dimensions: 1) perceived susceptibility; 2) perceived severity; 3) perceived benefits, and 4) perceived barriers [40]. The three primary domains of the PEN-3 model include: 1) cultural identity; 2) relationships; and 3) cultural empowerment [41].

Questions developed included health beliefs, social support, knowledge of chronic diseases, quality of life, financial burden of purchasing fresh produce, time constraints with exercise, current knowledge of gardening, and knowledge of community gardens (Table 1). In order to allow participants to give additional information, the semi-structured interview questions were open-ended. We also collected demographic characteristics using a close-ended questionnaire following the interview. Participants received a \$15 gift card for completing the questionnaire and interview.

Laboratory and Inflammatory Markers

We analyzed blood samples from all eligible participants during clinic visits to evaluate inflammatory markers [C - reactive protein (CRP) and interleukin 6 (IL-6)]. Assays were analyzed using venous blood received on the day of the clinic visits. Specific enzyme-linked immunosorbent assay kits were used to measure plasma CRP and IL-6 levels, respectively; all samples were run in duplicate (CRP: CV=3.9%, sensitivity = 0.022ng/ml; IL-6: CV=3.7%, sensitivity = 0.110 µg/ml.) [43]. The current analysis only looked at baseline levels of CRP and IL-6 as our respective outcome variables.

Statistical Analyses

Descriptive statistics were computed using frequencies or means and standard deviations (STD) for both primary and secondary data. CRP levels less than or equal to 3 mg/dL were categorized as “normal/low” while levels higher than 3mg/dL were considered “high;” IL-6 levels less than or equal to 3.5 mg/dL were categorized as “normal/low” while levels higher than 3.5 mg/dL were considered “high.” We categorized baseline CRP and IL-6 levels based on previously reported parameters [44-46]. We conducted a logistic regression analysis to examine the association between residing in a food desert or food swamp with biological markers of inflammation, while adjusting for potential covariates. Regression models were utilized via SAS version 9.4, with potential confounders (age, marital status, education, employment status, insurance, smoking status) to be assessed via bivariate analyses first and age kept in all relevant models. After conducting bivariate analyses (not shown) we determined that age and BMI were the covariates of interest that would be controlled for in the analysis. Statistical

significance in the models was determined with the Wald statistic at an alpha level (p-value) of 0.05; crude and full analyses were obtained. Transcripts were analyzed and interpreted using thematic analysis via NVivo; identification of themes and differences among participants occurred through multiple reviews of each transcript.

Out of the 295 SISTAS participants that were geocoded to determine their food access status, 130 women resided in a food desert or food swamp. We utilized the intervention status as it was denoted in the database and how they were coded for each individual (1 = intervention and 0 = delayed intervention). We contacted 76 women via telephone to determine if they were interested in participating in the informative interviews. Forty-six women (60.5%) were unable to be reached after multiple call attempts. Fifteen women (19.7%) either refused to participate or were ineligible due to having a changed number or had a post office box listed as their primary address. Fifteen agreed to participate in the key informative interviews after eligibility screening phone calls were completed.

Results

Phase 1: Quantitative Results

Table 2 depicts the general demographics of the study population included in the regression analysis. Most participants at baseline were employed full time, had completed some college education, were married, were not smokers, and perceived their health status as “good.” The average age was almost 50 years old, their average BMI placed them as morbidly obese (38.9 kg/m²), and the average inflammatory levels were noticeably high at baseline (CRP = 9.30; IL-6 = 5.82).

Table 3 shows the crude and adjusted association of residing in a food desert/food swamp and CRP/IL-6 levels, respectively. Compared to women not residing in a food desert or swamp, the risk of higher CRP or IL-6 levels was slightly higher among women living in a designated food desert or swamp area, respectively. However, the initial findings were not supported statistically {crude CRP risk = 1.20, 95% confidence interval (CI) = 0.82-1.77; crude IL-6 risk = 1.16, 95% confidence interval (CI) = 0.82-1.64}. After we adjusted for age and BMI, the risk ratios were only marginally attenuated and still the risk of higher inflammatory biomarker levels among women living in food deserts/swamps were still not statistically significant {adjusted CRP risk = 1.18, 95% confidence interval (CI) = 0.81-1.72; adjusted IL-6 risk = 1.10, 95% confidence interval (CI) = 0.81-1.50}. BMI was found to be significantly associated with both high CRP (p-value <0.0001) and IL-6 (p-value < 0.0001) levels, while age was significantly related to high IL-6 levels (0.03).

Phase 2: Qualitative Results

Five themes emerged from the informative interviews: chronic disease awareness, healthy lifestyle interventions, living a healthier lifestyle, self-efficacy of personal gardening, and self-efficacy of community gardening. These themes and subthemes are explained in more detail below.

Chronic Disease Awareness

Interview participants self-reported they were diagnosed with chronic diseases such as hypertension, diabetes mellitus II, or hypercholesteremia even after their participation in the SISTAS trial. They also indicated medications were used to mitigate

the adverse effects of their conditions. The increased risk of getting a chronic disease was a common subtheme recognized among women, while another subtheme was how their respective chronic diseases affected their overall quality of life (QOL). One participant said of her mental illness “I’ve now since been on disability. I have points or times where it knocks me down, and then I can go awhile, and everything will be ok. Sometimes, little things...ok like now I have a cold I’ve been sick for about two and a half weeks...and sometimes my immune system is so bad that the least little thing will turn into something big. It’s just trying...sometimes the depression or whatever will be worse. It’s mostly controlled by medication, but um...sometimes it doesn’t work.” (P0094)

Healthy Lifestyle Interventions

There was a perceived direct benefit of overall participation in the SISTAS trial as well as other healthy lifestyle programs, with education and social support among fellow participants of SISTAS being the specific subthemes they all indicated was the main advantage of participating in healthy lifestyle trials.

Living a Healthier Lifestyle

Participants indicated perceived support from family and friends as a subtheme with one woman stating, “they all want me to live longer.” (P0085) Fast food restaurants were the common sources of unhealthy food options that study participants stated were near their residence. One participant said, “It’s cheaper (to eat out) because it’s just the two of us now. It’s just cheaper to go buy something instead of turning the stove on.” (P0083). Another subtheme was participants ate meals both in and outside their respective homes while the subtheme of familial traditions when eating in the home

mainly consisted of cooking traditional Southern dishes (e.g. macaroni and cheese, collard greens, baked chicken) around major holidays. One woman said of her aunt that “she prepares a lot of the meals for the family and she tries to prepare them healthier by cutting back on the salt, and she doesn’t do the desserts as often.” (P0086) Interestingly, women also indicated that community influence on what foods were offered did not impact what they ate on a weekly basis. Better marketing of healthy food options was a subtheme that participants believed that their community could and should provide, with one of the women suggesting “I guess they could offer, maybe in their weekly papers that they give us, they might want to offer healthier advertisements about certain food items. I guess that could help.” (P0084)

Self-efficacy of Personal Gardening

Gardening experience was a common subtheme among all participants, and it varied depending on the type of gardening done by the respondents. There were indicators of past firsthand involvement with personal gardening, yet no current knowledge of gardening overall among our sample. Perceived benefits to gardening was a subtheme, and it included personal knowledge of the produce grown and eating healthier produce compared to supermarket options. One respondent said of personal gardening “I like gardening, I like putting my hands in the dirt. I like thinking about the fact that what I’m doing will produce something in the future, and it gives me guilt-free eating. I like guilt-free eating (i.e. eating and not feeling bad about what I’m consuming).” (P0087) Perceived risks of personal gardening also was a subtheme, with specific risks including environmental issues, cost of maintenance, and lack of

convenience compared to purchasing at the grocery store. Nevertheless, women indicated self-efficacy of personal gardening if the opportunity presented itself.

Self-efficacy of Community Gardening

Past secondhand knowledge of community gardening was a subtheme our participants indicated, yet they also indicated no current knowledge whatsoever. Lack of access to an area for women to grow their own fruits and vegetables was another subtheme, but they still indicated perceived benefits to community gardening including specific subthemes (e.g. the consumption of healthier produce and interpersonal benefits). Management and age concerns were the only perceived risks indicated among our respondents, and they expressed self-efficacy of community gardening if they had the resources to garden in this manner.

Discussion

We utilized an explanatory sequential mixed methods analysis to understand the relationship between residing in a food desert/swamp and dietary inflammation, and healthy lifestyle practices, including gardening. We did not find significantly elevated risks of high levels of CRP or IL-6 among women residing in food deserts/swamps compared to women not residing in resource-devoid areas. There was a lack of variability in food desert/swamp status among SISTAS participants and considering the extremely high obesity levels in our sample and the correlation between obesity, adipose tissue, and inflammation levels [47], this may explain the nonsignificant results. Respondents from the telephone interview highlighted several critical themes including educational benefits of the SISTAS trial, familial support, lack of current knowledge on personal and

community gardening, and self-efficacy of personal and community gardening. We hypothesized that due to the participants seemingly not being affected by pro-inflammatory foods outside their homes (i.e. subtheme of lack of influence of unhealthy food choices), this further explains why there was no significant risk of high inflammation levels based on food desert/food swamp status. Their indication of eating in and outside the home, as opposed to eating out more often, also offers insight to the nonsignificant results (see Table 4).

Results from previous quantitative studies looking at food deserts and inflammatory biomarker levels or chronic disease outcomes have been mixed. A longitudinal study out of Emory University found that persons residing in food deserts have a higher risk of hs-CRP (p -value = 0.014) and prevalence of cardiovascular disease (CVD) compared to those not residing in food deserts [48]. A recent analysis of the National Health and Nutrition Examination Survey (NHANES) data showed that people residing in food deserts had higher odds of chronic kidney disease (CKD) but it was not statistically significant; those same residents had significantly lower fruit and vegetable intake [49]. Similarities between the sample in the NHANES study and our quantitative analysis include utilizing Census tract data to geocode addresses for food desert status and our respective samples had higher than normal BMI levels at baseline.

Prior work on food factors and its relationship to inflammation or inflammatory-related outcomes have mainly focused on food insecurity, access, or other factors contributing to food desert status {e.g. individual income, socioeconomic status (SES)}. A cross-sectional analysis of residents dealing with household food insecurity in Canada found a significantly lower prevalence of produce consumption and higher prevalence of

diabetes [50]. A different study utilizing NHANES data showed that higher levels of food insecurity were related to higher dietary inflammatory index (DII) scores, including a dose-response relationship per food security status [51]. Results from the Atherosclerosis Risk in Communities (ARIC) Study showed an elevated prevalence of obesity and overweight status when adults were in proximity to convenience stores (stores with limited food selection including healthy produce) and a decreased prevalence of obesity and overweight status when they were close to supermarkets [52]; however, other studies have not shown similar results [53-54].

Previous studies conducting interviews or focus groups about healthier lifestyles among AA adults echoed some of what was discovered in our analysis. In previously published work the majority of their participants highlighted themes included eating out at restaurants, outside sources of influence affecting dietary habits, support from family or friends in living a healthier lifestyle, culture and traditions around eating in general, educational benefits to healthy lifestyle programs, and better marketing strategies [55-60]. Although most of the qualitative studies alone included AA men and women, the research solely focusing on AA women, including mixed methods analyses, was sparse.

Our study has several strengths. This is the first study to our knowledge to conduct a mixed methods analysis of biomarker data based on food access status from an intervention along with the qualitative perceptions about healthy lifestyle interventions and the acceptability of personal and community gardening from AA women in South Carolina (SC). We focused on a population not only plagued by health disparities especially in rural and metropolitan SC but who are rarely studied exclusively in epidemiologic research. We also recognize several limitations, starting with the lack of

generalizability to AA women in other regions of the U.S. because regional differences may present some hormonal milieu variations. Volunteer/non-response bias may be present because baseline characteristics may be different between persons who volunteer to participate compared to those who do not. We previously reported that the majority of our participants at baseline had some college experience (42.1%) [39] so it is likely they were more willing to participate in a research project, but it may not be representative of all AA women in SC. We did not look at inflammation risk over time compared to previous studies, and while we were unable to use the total population from the SISTAS trial, we still retained the majority for analysis (87.5%).

Conclusion

AA women residing in food deserts or food swamps did not have a significantly higher risk of high inflammatory biomarker levels at baseline of the SISTAS trial, but among the subsample interviewed, the women believed that they needed better access to healthier food options, and they would be self-efficacious in regard to gardening. Considering the lack of access of healthy foods among millions of Americans in the South/Southeast, the disparity of food access and chronic disease rates in the same regions among AAs, and the deficiency of community garden clinical trials and their relationship with chronic disease outcomes among AA adults, community gardening could be a viable tool that needs to be studied further to combat health outcomes among a population that truly desires to live an abundant life.

Table 5.1 Interview Guide for Key Informative Interviews

	HBM	PEN-3 Model
1. Could you tell us about yourself briefly? (general information about background, job if employed, medical conditions)	NA	NA
2. Have you taken any medications? Why or why not?	X	NA
3. Did you feel that you were at a higher or lower risk for getting a chronic disease? Why or why not?	X	NA
4. Did you feel that getting a chronic disease was severe to the point of it affecting your life overall? Why or why not?	X	NA
5. What barriers do you have in managing your specific condition?	X	NA
6. What do you see as the benefit of participating in healthy lifestyle programs, like the SISTAS program, if any?	X	X
7. Tell me about the persons or extended family that are likely to be supportive of you living a healthy lifestyle.		X
8. Tell me about the persons or extended family that are not likely to be supportive of you living a healthy lifestyle.		X
9. Tell me about what types of foods and restaurants you have in your community.		X
10. Do you eat out more often than cook at home now? Why or why not?		X
11. Can you tell me about your eating/cooking experiences, including family traditions and/or recipes?		X
12. How does what your community has to offer impact how you choose what you eat on a daily and weekly basis?	X	X

13. What are some ways your community could provide more healthy food options?		X
14. What do you know about gardening or what have been your experiences with gardening?		X
15. In your opinion, what do you think are the benefits or good things to having access to your own garden?	X	
16. What do you think are the drawbacks or negatives to having access to your own garden?	X	
17. Thinking about the benefits and drawbacks, how likely would you be to use your own garden?	X	X
18. How likely would your friends or family be to utilize a garden?	X	X
19. What do you know about community gardens or what has been your experience with community gardening?		X
20. What types of gardens or opportunities to access places to grow your own fruits or vegetables do you have in your own community?		X
21. In your opinion, what do you think are the benefits or good things to having access to a community garden?	X	
22. What do you think are the drawbacks or negatives to having access to a community garden?	X	
23. Thinking about the benefits and drawbacks, how likely would you be to use a community garden?	X	X
24. How likely would your friends or family be to utilize a community garden?	X	X

Table 5.2 Baseline Demographics of Study Population (n = 295)

Characteristic	Frequency (%)
Age (Mean ± STD)	50.0± 11.19
Marital Status	
Married	107 (36.3%)
Living with Partner	8 (2.70%)
Divorced	56 (19.0%)
Separated	27 (9.10%)
Single	82 (27.8%)
Widowed	15 (5.10%)
Education Status	
High school or less	63 (21.4%)
Some college	126 (42.7%)
Completed college	51 (17.3%)
Postgraduate	55 (18.6%)
Employment Status	
Full time	161 (54.6%)
Part time	35 (11.9%)
Retired/not employed	99 (33.5%)
Smoking Status*	
Current	99 (33.6%)
Nonsmoker	195 (66.1%)
Perceived Health	
Excellent	9 (3.00%)
Very good	77 (26.1%)
Good	161 (54.6%)
Fair	45 (15.3%)
Poor	3 (1.00%)
Characteristic	Mean ± STD
Body mass index (kg/m ²)	38.9 ± 7.4
C-reactive protein (CRP; mg/dL)	9.30 ± 18.4
Interleukin-6 (IL-6; pg/mL)	5.82 ± 25.3

*Missing values

Column percentages may not equal 100 because of rounding. Frequencies may not equal population total because of missing data.

Table 5.3 Relative Risk (RR) of Inflammatory Biomarker Levels According to Food Desert/Swamp Residence at Baseline

	Frequency (%)	Crude RR (95% CI)	Adjusted* RR (95% CI)
Reside in Food Desert/Swamp			
Yes	130 (44.1)		
No	165 (55.9)		
CRP			
Normal/Low	76	1.00 (ref)	1.00 (ref)
High	219	1.20 (0.82-1.77)	1.18 (0.81-1.72)
IL-6			
Normal/Low	88	1.00 (ref)	1.00 (ref)
High	207	1.16 (0.82-1.64)	1.10 (0.81-1.50)

*Adjusted for age and BMI

Table 5.4 Joint Display of Quantitative Results Indicating Mixed Attitudes about Communal Impact on Eating Habits

Quantitative Results		Qualitative Results	
Phase I Adjusted RR		Phase II Key Informative Interview Quotes	
		Corresponding with item	Not corresponding with item
CRP	1.00 (ref)		
Normal/Low			
High	1.18 (0.81-1.72)	“Because when you’re in a rush and you got dinner (to cook) and you got grandchildren and you got people calling you saying ‘take me to the store’ and this and that...you hit the fast food restaurant for convenience.”	“It’s just a variety where I am so I don’t have a problem driving to different food grocery stores. It depends on what I want to use on the menu for the week.”
IL-6			
Normal/Low	1.00 (ref)	“It really doesn’t; I’m at a point right now where it’s a struggle for me to eat. I don’t have an appetite for anything in particular.”	“I don’t think it really does because I don’t eat out that much.”
High	1.10 (0.81-1.50)	“What impacts what I eat on a daily or weekly basis	“I’m not going to say for me it’s a great impact because I have a choice; being that I work & I just recently received a food stamp stipend that allows

	<p>is how much money I have. That's gonna impact what restaurant I go to.”</p> <p>“It's the only place I have to go...there's no place else for me to get anything to eat. I have to stop at one of those places (fast food restaurants) because I'm passing those places every day.”</p> <p>“It doesn't because I don't eat that stuff (unhealthy foods) on a daily basis. The library down the street started the farmer's market on the first Monday of the month.”</p> <p>“You know, on our side of town, if you want to eat anything different besides fast food you pretty much gotta travel to do that.”</p> <p>me to go to the grocery store a little more. Even before I got the food stamp benefits, I was already buying salad fixins' when I could.”</p> <p>“It doesn't really impact what I eat on a weekly basis, because if I want something, we have a farmer's market...you can always get fresh stuff. It's not near me but it's still available to me.”</p> <p>“A whole lot; I have a choice to go some places that always serves a meat and eggs for breakfast, & I would prefer doing that instead of go to like McDonalds or Hardees and get the full biscuit and not throw the bread away.”</p>
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CHAPTER 6

CONCLUSION

This dissertation focused on psychosocial, clinical, and neighborhood factors and their respective associations with inflammation among an underserved population in metropolitan and rural SC. Despite the overall nonsignificant results, certain quantitative associations were found to be significant in the mediation analyses as well as pivotal qualitative themes and subthemes obtained in the interviews. This is promising as it gives us unique insight on certain biologically plausible mechanisms within AA women, specific influences (or lack thereof) on their personal decisions, and what they considered to be missing elements from their neighborhoods, elements that may be essential in combating food access issues.

Our work allowed us to supplement the current body of literature on depression, percent body fat, diastolic blood pressure, food desert/swamp access, and inflammation among AA women. The continued future focus of the health disparities these women face can offset the paucity of research among this population. We were also able to address a particular taboo issue (re: depression) within the AA community. Future studies should consider other psychosocial factors (e.g. stress, discrimination) that may mediate treatment effects of healthy lifestyle interventions on chronic disease risk. Finally, the evidence we found from the qualitative piece can serve as the foundation for future community-garden-based interventions for AA adults at risk for inflammatory-related

chronic diseases. Resources such as greenhouse-based community gardens can be created and operationalized in order to give these women current firsthand knowledge of basic agricultural skills. The access to fresh produce plus the knowledge of gardening can potentially reinforce the lessons that epidemiologists pass along to AA women who, contrary to certain societal portrayals, seem to yearn to actively live a healthier lifestyle.

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APPENDIX A

KEY INFORMATIVE INTERVIEW QUESTIONS

The following list of questions was used as an outline for the focus group questions.

Where appropriate, the interviewees were asked to expand upon their answers.

1. Could you tell us about yourself briefly (general information about background, job if employed, medications)?
2. Have you taken any medications? Why or why not?
3. Did you feel that you were at a higher or lower risk for getting a chronic disease? Why or why not?
4. Did you feel that getting a chronic disease was severe to the point of it affecting your life overall? Why or why not?
5. What barriers did you have in managing your specific condition?
6. What do you see as the benefit of participating in healthy lifestyle programs, like the SISTAS program, if any?
7. Tell me about the persons or extended family that are likely to be supportive of you living a healthy lifestyle?
8. Tell me about the persons or extended family that are not likely to be supportive of you living a healthy lifestyle?
9. Tell me about what types of foods and restaurants you have in your community?
10. Do you eat out more often than cook at home now? Why or why not?

11. Can you tell me about your eating/cooking experiences, including family traditions and/or recipes?
12. How does what your community has to offer impact how you choose what you eat on a daily and weekly basis?
13. What are some ways your community could provide more healthy food options?
14. What do you know about gardening or what have been your experiences with gardening?
15. In your opinion, what do you think are the benefits or good things to having access to your own garden?
16. What do you think are the drawbacks or negatives to having access to your own garden?
17. Thinking about the benefits and drawbacks, how likely would you be to use your own garden?
18. How likely would your friends or family be to utilize a garden?
19. What do you know about community gardens or what has been your experience with community gardening?
20. What types of gardens or opportunities to access places to grow your own fruits or vegetables do you have in your own community?
21. In your opinion, what do you think are the benefits or good things to having access to a community garden?
22. What do you think are the drawbacks or negatives to having access to a community garden?

23. Thinking about the benefits and drawbacks, how likely would you be to use a community garden?

24. How likely would your friends or family be to utilize a community garden?