9-2017

Geospatial Determinants of Increased Screening Mammography in U.S. Black Women

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Geospatial Determinants of Increased Screening Mammography in U.S. Black Women

by

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A Dissertation submitted in partial satisfaction of
the requirements for the degree
Doctor of Philosophy in Social Policy and Social Research

September 2017

Each person whose signature appears below certifies that this dissertation in his/her opinion is adequate, in scope and quality, as a dissertation for the degree Doctor of Philosophy.

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ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to the many people who have been a part of this project; there are too many to list here! Thank you for your encouragement, support, and advice. I am very thankful to have had the opportunity to study at LLU and learn from this inspiring community.

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ABBREVIATIONS

ACOG	American College of Obstetricians and Gynecologists
ACS	American Cancer Society (Chapters 1-4)
ACS	American Community Survey (Chapters 5 and 6)
BCDDP	Breast Cancer Detection Demonstration Project
BRFSS	Behavioral Risk Factor Surveillance System
CDC	Centers for Disease Control and Prevention
CRT	Critical Race Theory
DAHC	Dartmouth Atlas of Health Care
GIS	Geographic Information Systems
GWR	Geographically Weighted Regression
HMO	Health Maintenance Organization
HRR	Health Referral Region
HSA	Health Service Area
ICE	Index for Concentration at the Extremes
JAMA	Journal of the American Medical Association
LISA	Local Indicators of Spatial Association
MBASIC	Multi-level Biologic and Social Integrative Construct
NBCCEDP	National Breast and Cervical Cancer Early Detection Program
NHIS	National Health Interview Survey
NCI	National Cancer Institute
OLS	Ordinary Least Squares
SEER	Surveillance, Epidemiology, and End Results

SEM	Socioecological Model
SEP	Socioeconomic Position
SES	Socioeconomic Status
U.S.	United States of America
USPSTF	United States Preventive Services Task Force

ABSTRACT OF THE DISSERTATION

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by

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Doctor of Philosophy, Graduate program in Social Policy and Social Research
Loma Linda University, September 2017
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Black women have the highest mortality rate due to breast cancer compared to any other racial/ethnic group in the U.S. and are more likely to be diagnosed with late-stage breast cancer compared to White women. Though the causes of these disparities are multifactorial, early detection by mammography, in combination with improved treatment, is related to improved breast cancer survival outcomes. Recently, the rate of Black women reporting having had a screening mammogram in the last two years has increased, and by some accounts surpassed, that of White women. This dissertation assesses this change in mammography among Black women in order to help inform future policies impacting preventive health care, which can lead to early diagnoses, and thus improvements in women's health and reductions in the economic impact of treatment costs. The objective of the study was to identify factors, including geographic place and space, associated with the spatial variation of the increased screening mammography observed for Black women in the U.S. from 2008 to 2012. The central hypothesis was that the spatial distribution of the change in screening utilization is not random, and that the geospatial pattern of change is associated with changes in access to health care when controlling for education, income, demographic factors, and the larger ecological sociodemographic context. The central hypothesis was tested by pursuing the following aims: 1) Assess whether the geographic pattern of change from 2008-2012 of screening mammography among Black women in the U.S. is spatially clustered; and 2) Identify individual- and ecological-level factors associated with the geographic pattern of change from 2008-2012 of screening mammography among Black women in the U.S. Statistical software was used for assessing aspatial data, and Geographic Information Systems (GIS) was used for descriptive mapping and implementing spatial statistical analyses. Results indicate that changes in screening are not consistent across the U.S., Black and White women have increased and decreased screening in different regions, and the impact of variables associated with screening varies by location.

CHAPTER 1

INTRODUCTION

The purpose of this study was to identify factors that are associated with the increased screening mammography undertaken by Black[1] women in the U.S. from 2008 to 2012. This is a critical issue worthy of study because it has the potential to affect women's health care, which may help reduce breast cancer disparities Black women face, and ultimately save lives.

Though they have the same incidence rate of breast cancer compared to White women (DeSantis et al., 2015), Black women in the U.S. have the highest mortality rate compared to any other racial/ethnic group, and in recent years, the disparity between Black and White women's mortality rates has widened (American Cancer Society [ACS], 2011). Further, among those under age 50, the mortality rate of Black women is nearly twice that of Whites (Howlader et al., 2013). Black women across all ages are also more likely to be diagnosed with late-stage breast cancer than Whites (Deshpande et al., 2009; Elmore et al., 2005). Though the causes of these differences in breast cancer incidence and mortality between Black and White women are multifactorial, detecting the disease is key to treating it, and screening mammography is currently the best method for doing so. Despite this, policy guiding the delivery of mammograms is fraught with debate and conflicting recommendations that arguably disadvantage Black women under age 45,

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1 The term "Black" is used throughout this proposal instead of "African American" because the datasets to be analyzed for this study use the term "Black." In addition, this term more readily includes individuals from other countries, such as the Caribbean Islands, who live in the U.S. but may not identify as African American. Although I have adopted the use of "Black" for this proposal, when I cite and discuss other studies that explicitly use the term "African American" rather than "Black," I have kept the original phrasing.

who have a higher incidence rate of breast cancer compared to White women in this age range (ACS). Not only can a better understanding of factors associated with increased mammography by Black women lend insight into developing policy that furthers this preventive health care measure, but it may also help inform efforts to foster other health policies and practices through increased awareness of how they affect a population more generally.

Theoretical and Conceptual Framework

The differences in incidence and mortality rates of breast cancer between Black and White women in the U.S. are health disparities that reflect a lack of social justice in health. While race is a complex concept to use for delineating differences between people, it can be understood as a social construct that has come to reflect variations in experiences groups face at the societal level. As Braveman et al. (2011) point out, compared to Whites, Blacks as a group in the U.S. have long experienced less wealth, lower incomes, lower educational attainment, and under-representation in high occupational rank and financial and political power. Further, racial differences in socioeconomic status, neighborhood residential conditions, and medical care affect variations in disease (Williams & Jackson, 2005), and the experience of racial discrimination is associated with poorer physical and mental health (Williams, Neighbors, & Jackson, 2003).

According to Critical Race Theory (CRT), which is based on the principles of race equity and social justice, structural forces drive inequities, though individual mechanisms are disproportionately highlighted by most research and intervention practices (Ford & Airhihenbuwa, 2010). The persistence of health disparities is thus a form of structural violence, which is represented through social determinants of health, manifested as factors affecting ill health and barriers to health care access (Mukherjee, 2011). From a CRT lens, contemporary racism, which is implicit, subtle, and normalized through its integration in society and everyday life, must be eliminated in order to achieve health equity. One of the ways this may be approached is through knowledge production, incorporating and centering the voices of racial minority communities and valuing critical self-reflection and the transformation of existing hierarchies (Ford & Airhihenbuwa), bridging theory with practice. This is especially relevant for the problems associated with current policies affecting screening mammography, which are based on cancer research lacking minority representation as both researchers and research participants, and thus suggests a normative experience for all people regardless of race, despite incidence and mortality data to the contrary. Because the U.S. lacks uniform, evidence-based guidelines for screening mammography that take into account the different realities faced by the country's diverse population, it can lead to not only uncertainty about appropriate screening, but also lack of access to needed preventive care.

The most contentious issue at present is whether women under age 50 should undergo screening mammography, and if so, whether it should be annually or every two years. The United States Preventive Services Task Force (USPSTF), part of the Department of Health and Human Services, is responsible for reviewing scientific evidence for preventive care services and making recommendations that are not official federal policy, but are used by policymakers and industry professionals nationwide.

Contrary to its 2002 recommendations, the agency's 2009 and 2016 statements do not recommended routine screening mammography for women 40 to 49 years of age, but rather specify that the decision to screen should take individual patient context into account, and recommended biennial screening for women 50-74 years of age (Siu, 2016; United States Preventive Services Task Force [USPSTF], 2009). The update in 2009 was criticized by some as ignoring existing science and overemphasizing potential harms of the procedure (Hendrick & Helvie, 2011), and contrasted sharply with guidelines put forth by other organizations, such as the American Cancer Society (ACS), which, in 2014, suggested women receive mammograms every year beginning at age 40 (ACS, 2014). In 2015, however, the ACS amended its recommendation to advise women ages 45-54 at average risk of breast cancer to get screening mammograms every year, women 55 and older to get biennial screening, and women ages 40-44 to have the choice whether to screen (ACS, 2015).

Part of the theoretical background guiding this study encompasses the notion that multiple levels of influences affect health and health care, including not only public policy factors, community factors, institutional factors, interpersonal processes and primary groups, and intrapersonal factors (McLeroy, Bibeau, Steckler, & Glanz, 1988), but also geographic space and place (Arcaya, Brewster, Zigler, & Subramanian, 2012).

Research Questions

This study included three research objectives; the first two relate to analysis of the data, while the third is concerned with interpretation of the data. Research questions for each of the objectives are listed below.

1. What is the geographic pattern of change over time in screening mammography for Black women across the U.S. from 2008 to 2012?
2. Is this geographic pattern of change associated with particular ecological or individual level factors?
3. How can these findings be used to inform policy that promotes health equity?

The methodology for this study utilized Geographic Information Systems (GIS), which is "a computer system for capturing, storing, querying, analyzing, and displaying geospatial data" (Chang, 2012, p. 1) that has the important ability of integrating multiple layers of data from different sources with one another. Although still a relatively young field, GIS has been used to explore health concerns using similar methods as the ones proposed for this research, including both descriptive analyses and spatial statistics.

Benefits of the Study

One of the benefits of this study is that it contributes to existing literature regarding individual and ecological variables associated with screening mammography. While this is a widely debated topic, there is a lack of research seeking to determine why screening has increased among Black women in recent years. There is also a lack of research using GIS to gain insight into associations with differences over time in screening mammography, which is another benefit. Further, by providing a better understanding of how screening mammography has changed over time and space, this research may contribute to the development of future policy and practice aiming to increase breast cancer screening, and possibly other preventive health care measures.

Significance

This research produced knowledge about how screening increased within a population facing disparities, despite contested policy and other factors that have previously been thought to discourage such screening. This is significant to policy because the results can be used to inform discussions regarding breast cancer screening recommendations that take into account the diversity of women in the U.S. Such recommendations may include efforts to create uniform guidelines across organizations in order to help women make educated decisions regarding their health care, or to create social programs that ensure access to care for those in need. Further, results of this study can be used in the transition from policy to practice to improve delivery of services for breast cancer screening, whether it involves a focus on individual factors, neighborhood variables, or considerations broader in scope. This research is also significant to practice in that it can provide additional information to health care professionals about the individuals and geographic contexts associated with the most and least screening, and thus how to effectively tailor communications with different patients. In addition, this study is significant to research, not only because the results can help guide the direction of future studies, but also because it demonstrates how GIS can be used to assess changes in the use of a preventive health care measure nation-wide, integrating and analyzing multiple types of data and different variables, including geographic space and place.

Although the rate of Black women undergoing screening mammography has risen in recent years, this population is more likely to be diagnosed with late-stage breast cancer than White women, and suffers a higher mortality rate due to breast cancer. By better understanding factors associated with this increase in screening, researchers, health care practitioners, and policy-makers can gain insight into the changes over time and space of a preventive health care measure that may help reduce breast cancer disparities, and ultimately save lives.

CHAPTER 2

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Overview

Breast cancer is the most common non-skin cancer in women in the U.S. (Davidson, 2016), and over the next twenty years, the number of women with breast cancer is expected to increase by a third (Robbins, Kumar, & Cotran, 2010). Across the U.S., the most common risk factors associated with this disease are the following: gender (about 99% of cases occur in women), age (about 75% of diagnoses are in women over fifty), and family history (about 20% of cases occur in women with a family history of breast cancer) (Davidson).

Although breast cancer is also the most common cancer among Black women in the U.S., representing 34% of all cancers that this group experiences (ACS, 2011), differences in disease incidence and mortality exist between this population and Whites in the U.S. For example, across all age groups, Black women are more likely to be diagnosed with late-stage breast cancer than White women (Deshpande et al., 2009; Elmore et al., 2005). Though Black women across all ages previously had lower incidence of breast cancer compared to White women, incidence rates have recently converged, and in many locations surpassed, that of White women (DeSantis et al., 2015). In addition, Black women also have a higher incidence rate for those ages 45 or younger (ACS), and breast cancer mortality rates are highest in Black women compared to any other racial/ethnic group. Indeed, in recent years, the disparity between Black and White women's mortality rates has widened (ACS). For women under age 50, the mortality rate of Black women is nearly twice that of Whites (Howlader et al., 2013).

While the causes of these differences in breast cancer incidence and mortality between Black and White women are multifactorial, detecting the disease is key to treating it. Traditionally, approaches to detecting breast cancer included breast self-examination, clinical breast examination by a health care professional, and screening mammography. However, in recent years, the efficacy of self-examination has come under scrutiny (Davidson, 2016). Using MRI technology to screen for breast cancer has been promoted for high-risk women, but has limited usefulness in the general population, and there is not enough evidence to support the effectiveness of other imaging tools, such as ultrasound and radionuclide techniques, in detecting the disease in asymptomatic women (Davidson). As such, screening mammography, whether using conventional film or digital technology, has persisted as the best measure of early detection. Indeed, in combination with improved treatment, early detection by mammography is related to improved breast cancer survival outcome (Kaplan, Malmgren, Atwood, and Calip, 2015). Since its introduction to the public in the 1960s, however, screening mammography has been subject to controversy in the social, political, and academic arenas, particularly with regard to younger women. Despite this, the number of women reporting having had a mammogram within the past two years has risen, and the rate of Black women receiving screening has recently met, and by some accounts surpassed, that of Whites (DeSantis et al., 2015; National for Health Statistics, 2014). Among older women, however, there is some debate as to whether screening has increased or decreased. While studies of self-reported mammography have found no statistically significant decreases in screening among older women since 2009 (Howard & Adams, 2012; Pace, He, & Keating, 2013; Yao, Bradley, & Miranda, 2014), those assessing Medicare claims did find declines

(Jiang, Hughes, Appleton, McGinty, & Duszak, 2015; Jiang, Hughes, & Duszak, 2015). Additionally, a study of Medicare fee-for-service women ages 65 and over reported that from 2007 to 2012, there was an overall decrease in screening, though some regions had increases; when separated by race, only Black women had an increase in screening nationally (Chang et al., 2016).

Discovering variables associated with Black women's increase in mammography in recent years provides better understanding of not only screening, but also how preventive health care practice can change over time and space more generally. This chapter reviews the literature on factors that may be associated with the increase, from 2008 to 2012, in Black women in the U.S. having had a mammogram in the last two years, as well as the conceptual framework and relevant methodologies for this study. First, however, historical policy development around screening mammography is presented.

Historical Policy Development

While mammograms had previously been used for diagnostic purposes, research outlining the first use of screening mammograms to detect breast cancer was published in 1961 (Gershon-Cohen & Berger). In 1963, the National Cancer Institute (NCI) funded a randomized control trial and found that compared to those in a control group, women ages 50-59 receiving annual screening mammograms had 40% fewer breast cancer deaths (Shapiro, Strax, & Venet, 1971). In the same year as the publication of this research, the National Cancer Act of 1971 was signed into law, granting $1.6 billion in funding for the first three years, and specifically allocating $90 million for cancer control programs that cooperated with state or private agencies (National Cancer Institute, 2015). One of the projects launched with this funding was the Breast Cancer Detection Demonstration Project (BCDDP), a five-year program of free screening mammography sponsored by the NCI and American Cancer Society (ACS). Although results of this project showed that 42% of the breast cancers in women ages 50-59 and 35.4% of those in women 40-49 were discovered using mammography alone, the project lacked a control group and thus mortality reduction from screening could not be assessed (Reynolds, 2015). During the BCDDP's tenure, debate began over screening mammography recommendations, and it continues today (Reynolds). A number of organizations, from government agencies to non-profit research and advocacy groups, issue screening guidelines and campaign for policy that affects public and private insurance coverage for this procedure.

The most contentious issue at present is whether women under age 50 should undergo screening mammography, and if so, whether it should be annually or every two years. The United States Preventive Services Task Force (USPSTF), part of the Department of Health and Human Services, is responsible for reviewing scientific evidence for preventive care services and making recommendations that are not official federal policy, but are used by policymakers and industry professionals nationwide. The USPSTF regularly reviews its recommendations, and the agency's last three guidelines, issued in 2002, 2009, and 2016 respectively, have received much attention. In 2002, the task force recommended screening mammography every one to two years for women 40 years and older (USPSTF, 2002). In 2009 and 2016, however, the group recommended biennial screening for women 50-74 years of age, and advised that the decision to screen women 40 to 49 years of age should take individual patient context into account (Siu, 2016; USPSTF, 2009). This 2009 update was criticized by some as ignoring existing science and overemphasizing potential harms of the procedure (Hendrick & Helvie, 2011), and contrasted sharply with guidelines put forth by other organizations, such as the ACS, which, in 2014, suggested women receive mammograms every year beginning at age 40 (ACS, 2014). In 2015, however, the ACS amended its recommendation to advise women ages 45-54 at average risk of breast cancer to get screening mammograms every year, women 55 and older to get biennial screening, and women ages 40-44 to have the choice whether to screen (ACS, 2015). As another example, the American Congress of Obstetricians and Gynecologists continues to recommend women receive annual mammograms beginning at age 40 (American Congress of Obstetricians and Gynecologists, 2016). As a result of the USPSTF's controversial position, the language of the Affordable Care Act of 2010 states that coverage for screening mammography must be in accordance with current USPSTF recommendations, other than those issued in 2009 (The Patient Protection and Affordable Care Act, 2010). Until USPSTF's 2016 recommendation was released, this effectively required new insurance plans to cover screening in accordance with the USPSTF's 2002 guidelines. A recent blog post from the Director of the Office on Women's Health from the U.S. Department of Health and Human Services notes that the 2016 USPSTF recommendation will not immediately impact coverage requirements because President Obama signed a bill in December 2015 that keeps mammography coverage the same thorough 2017 (Lee, 2016). Similarly, Medicare covers annual screening mammograms for women aged 40 and above, and women ages 35-39 are allowed one baseline mammogram (Centers for Medicare & Medicaid Services, 2015). The National Breast and Cervical Cancer Early Detection

Program (NBCCEDP), part of the Centers for Disease Control and Prevention (CDC), provides breast cancer screening to low-income, uninsured women, consistent with USPSTF 2009 recommendations (Lee et al., 2014). As such, the program's policy requires that only women ages 40 and above are screened, and at least 75% of the mammograms performed are for women 50 years and above, with no more than 25% for women 40-49 years old (Lee et al., 2014).

Ultimately, it is problematic that the U.S. lacks uniform, evidence-based guidelines for screening mammography that take into account the different realities faced by the country's diverse population. This policy problem (which may translate into provider confusion) can lead to not only uncertainty about appropriate screening, but also lack of access to needed preventive care. It is the result of several underlying societal values at work that tug against one another: science and secular rationality, humanitarian mores, and the legacy of racism. While contemporary American society values and encourages empirical research, debate, and discovery to benefit people's health, it also has a history of excluding racial minorities from research, both as investigators and as participants. For example, Black, Hispanic, and Native American/Alaskan faculty are underrepresented in academic medicine and the basic sciences, which is thought to affect the recruitment, mentoring, and retention of racial minority students, perpetuating the cycle throughout the health care system; in addition, underrepresented minority faculty are rarely positioned as Principal Investigators for NCI research and training grants (Rodríguez, Campbell, & Mouratidis, 2014). Further, in a review of cancer studies over the last twenty years, Chen et al. (2014) found that less than 2% of NCI-funded clinical trials had a primary emphasis on a racial minority population, and just 20% of randomized control studies published in high-impact oncology journals provided results on race.

This type of exclusion is similar to that which women have faced as potential research participants. In the past, clinical research was conducted mainly with men, which affected the efficacy of treatments used for women (National Research Council, 2001). Men were considered to be the norm for study, and women were excluded for a number of reasons, including the beliefs that their responses to treatment would not differ significantly, they would decrease the homogeneity of the sample and thus introduce additional study variables, and they needed to be protected from unethical practices (National Research Council, 2001). Only recently has the scientific community recognized that sex differences exist on the societal, whole organism, and cellular levels, and thus the lack of data that exists on conditions that manifest differently or necessitate different approaches for diagnosis and treatment between men and women (National Research Council).

Like the inclusion of women, the inclusion of racial minorities in research is important because scientific and academic study informs health care policy, which in turn influences health care practice. In the case of breast cancer health disparities, implicit racism and structural violence are reflected not only in Black women's underrepresentation in research, but also in the resultant exclusionary policies and practices.

Literature Review

Race/Ethnicity

The concept of race/ethnicity is complex, not only because the definitions of these terms themselves vary (Lee, 2009), but also because the social construction of race is often conflated with biological differences between people, and it can be difficult to separate the two within the literature on breast cancer health disparities. For instance, Daly and Olopade's (2015) review concludes that the mortality disparity between Black and White women is the result of two forces colliding: 1) differences in tumor biology and genomics, and 2) delays, misuse, and underuse of treatment for Black patients. Indeed, biomedical research can be conceptualized as divided between scientists who refute the notion that race has a biological basis, but see it as a proxy for social and historical experiences and differences between racialized groups, and scientists who consider race to be potentially biologically meaningful, such as via the idea that genetic variations between racial groups overlap with ancestral origin (Lee). While some researchers suggest adding genetic testing as part of a more precise risk evaluation of Blacks as a disparities subgroup, debate regarding the implications and ramifications of such testing on its usefulness for distinguishing groups continues (Fujimura & Rajagopalan, 2011; Santos, da Silva, & Gibbon, 2015). Currently, most published studies from both the biological and social sciences that use race/ethnicity as a factor in analysis draw on self-reported data.

A recent article and associated correspondence in the Journal of the American Medical Association (JAMA) highlight this issue: In their observational study of the proportion of breast cancers identified in Stage I among different racial/ethnic groups, Iqbal, Ginsburg, Rochon, Sun, and Narod (2015) found that Black women were less likely to be diagnosed with Stage I breast cancer and more likely to die with small-sized tumors than White women. Iqbal et al. conclude that the association of Black race/ethnicity with being diagnosed beyond Stage I "suggests that the stage disparity at diagnosis is not likely to be attributed to screening trends; rather, the paucity of stage I cancers appears to be explainable in large part by inherent biological factors" (p. 170). Rather than using biological or genetic data to distinguish between populations, however, these researchers used data on race/ethnicity gathered by the Surveillance, Epidemiology, and End Results (SEER) program. Responding to this article in a Letter to the Editor, Braun, Tsai, and Ucik (2015) question the conclusion of the study, noting "while racial/ethnic categories are important for monitoring disease incidence and mortality, these categories are genetically heterogeneous, change over time, and vary throughout the world…[and it is] thus problematic to draw conclusions about inherent differences among groups using fluctuating socio-political categories" (p. 1475). Braun et al. also argue that the article underestimates the role of other factors contributing to disparities, which are currently under avid debate, including those related to social and environmental variables.

Despite the complexity of using race as a concept for delineating differences between people, differences in tumor biology have been the subject of considerable study. For example, one type of breast cancer variant known as triple-negative, which has a poor prognosis, is found in higher incidence in African American and West African women compared to Whites (Ray & Polite, 2010). Triple-negative breast cancer is characterized by a tumor that lacks estrogen receptor (ER), progesterone receptor (PR), and human epidermal growth factor receptor type 2 (HER2) (Foulkes, Smith, Reis-Filho, 2010). Although a recent study found that triple-negative breast cancer was associated with particular immunohistochemical, genetic, and epigenetic profiles (Murria et al., 2015), the article did not include data on race/ethnicity. Other studies examining the relationship between genomics and race related to triple negative breast cancers are inconclusive (Daly & Olopade, 2015; Dietze, Sistrunk, Miranda-Carboni, O'Regan, & Seewaldt, 2015; Sturtz, Melley, Mamula, Shriver, & Ellsworth, 2014). Thus, though differences in the incidence of one breast cancer variant distinguished by tumor biology may be present among people self-identifying with different racial/ethnic groups, the existence and significance of differences between these groups at the cellular level remains unclear.

Variations in experience between groups at the societal level, however, clearly exist, even when- or perhaps as a result of its production as such- race/ethnicity is understood as a purely social construct. As Braveman et al. (2011) point out, compared to Whites, Blacks as a group in the U.S. have long experienced less wealth, lower incomes, lower educational attainment, and under-representation in high occupational rank and financial and political power. At the same time however, individuals within a single population distinguished by race must not be understood as homogenous. For example, according to Logan and Deane (2003):

> Black Americans of all ethnic backgrounds are highly segregated from whites and disadvantaged in comparison to them. Yet beneath this communality born of the color line are substantial differences between the majority of blacks with historical origins in slavery and in the rural South and new, growing minorities from the Caribbean and Africa (p. 12).

Despite the complex nature of the concept, for this dissertation, I will adopt a use of the term “race” that Lee (2009) describes: that which is not founded on genetic variance that exists between people, but rather “stands as a proxy for socio-cultural, economic, and particular historical processes and experiences. It is used to capture behavioral and structural differences between racialized groups” (p. 1184). Though race in this sense is not based on biology, racialized differences have been shown to affect health outcomes. For example, variations in disease are affected by racial differences in socioeconomic status (SES), neighborhood residential conditions, and medical care (Williams & Jackson, 2005), and the experience of racial discrimination is associated with poorer physical and mental health (Williams, Neighbors, & Jackson, 2003).

Health Disparities

The differences in incidence and mortality in breast cancer between Black and White women in the U.S. are considered health disparities affecting Black women. According to Braveman et al. (2011), health disparities are “systematic, plausibly avoidable health differences adversely affecting socially disadvantaged groups; they may reflect social disadvantage, but causality need not be established” (p. S149). In this way, health disparities are used to assess health equity, which is a commitment to reducing disparities, understood as social justice in health (Braveman et al., 2011). The principles underlying health equity include the following: all people should be valued equally; health has a particular value for both individuals and society; nondiscrimination and equality; rights to health and a standard of living adequate for health; health differences affecting socially disadvantaged groups are particularly problematic because they can impede the ability to overcome social disadvantage; and the determinants of health should be distributed fairly (Braveman et al.). Socially disadvantaged groups are those that, as a whole, systematically experience unfavorable social, economic, or political conditions due to their position in social hierarchies; differences between groups reflect social disadvantage when they determine a group's position in a social hierarchy (Braveman et al.). Once such factor that can affect health disparities is race/ethnicity.

Possible Determinants of Increased Screening Mammography

Given the problems with policy affecting breast cancer screening, it would be understandable if mammography rates for Black women in the U.S. were low. The aggregate rate of screening for Black women across the nation, however, has recently risen, and by some accounts surpassed, that of all other groups. Factors affecting this rise have not been well studied. However, because the screening rate of Black women was lower than that of White women in the past, lack of screening mammography was proposed as a contributing factor to the incidence and mortality disparities described earlier. As such, the focus of research has been factors affecting Black women's decision to screen, and the effects of interventions to increase screening.

Individual Factors

A number of individual-level variables have been considered for their influence on screening decisions, including age, income, education, marital status, access to health care, and attitudes and beliefs.

There are mixed results on the effect of age: One study found that African American women were more likely to have had a mammogram in the last year if they were aged 50 or above (Reiter & Linnan, 2011). O'Malley et al.'s (2001) study of Black and White women aged 52 and above in rural North Carolina, however, determined that physician recommendation for screening, which in turn indicates a woman being significantly more likely to have had a mammogram in the last two years, was negatively associated with increasing age. O'Malley et al. also reported that only 39% of women in the sample aged 75 and above reported receiving a physician recommendation for screening. Similarly, Jennings-Sanders (2008) discovered that a sample of African American women with a mean age of 75 had low self-efficacy regarding their ability to get a mammogram. In a sample of 99,615 younger women ages 18-39 receiving their first screening mammogram, African American women were more likely than White or Asian women to be under 35 years of age (Kapp, Walker, Haneuse, Buist, & Yankaskas, 2010). However, in a cohort of women who first had a screening mammogram before age 40 and then later underwent another follow-up screening between the ages of 40 and 45, African Americans were more likely than other groups to delay the timing until ages 43-45 compared to ages 40-42 (Kapp, Walker, Haneuse, & Yankaskas, 2011). African American women who have a doctor's recommendation are more likely to have had a mammogram before age 40 than those without (Bowie, Wells, Juon, Sydnor, & Rodriguez, 2008).

Other demographic factors may also influence women's breast cancer screening rates. Although O'Malley et al. (2001) found that White women reported more physician recommendations for screening than Black women, this difference was eliminated when controlling for educational attainment and family income, and lower family income and lower educational attainment were negatively associated with physician recommendation for all women. Indeed, other studies have found that for African American women, lower SES is a barrier to screening (Conway-Phillips & Millon-Underwood, 2009), and women with higher incomes are more likely to have mammograms before age 40 than those with low incomes (Bowie, Wells, Juon, Sydnor, & Rodriguez, 2008). African American women ages 40 and above with less than a high school education are less likely to have ever or recently had a mammogram compared to those with more than a high school diploma (Williams et al., 2008), while a study of women under 40 who had received screening mammograms found African American women were less likely than White or Asian women to have a college degree (Kapp et al., 2010). Compared to married women, African Americans ages 40 and above who had never married were less likely to have had a recent mammogram (Williams et al.).

Lack of access to health care, insurance, facilities, or providers are also barriers to screening for African American women (Conway-Phillips & Millon-Underwood, 2009; Reiter & Linnan, 2011; Young, Schwartz, & Booza, 2011). Likewise, having health insurance, making more medical care visits, and taking one or more medications was each positively associated with physician recommendation for screening in one study (O'Malley et al., 2001). In another study, African American women with private health insurance were more likely to have ever had a mammogram, and to have had a recent mammogram, compared to those with no insurance or public insurance, though women with public insurance were more likely to have been screened than those without any insurance (Williams et al., 2008). In two studies including women from different racial groups, the authors recognized the influence of public health interventions targeting underserved women on affecting screening mammography. Swan, Breen, Coates, Rimer, and Lee (2003) discovered that across racial groups, women ages 40 and above with no usual source of health care, and those with no health insurance, were among those least likely to have had a mammogram in the last two years. Between 1987 and 2000, however, rates of mammography increased even for women without a usual source of care, though the smallest gains were seen in those with private or military insurance, compared to public insurance. In a more recent study using data from 2004 to 2011, Holden, Chen, and Dagher (2015) found that among uninsured women, African Americans had higher odds of receiving mammograms than Whites; these racial differences persisted across income groups except in the highest one (at or above 400% of the federal poverty level), which contrasts with preventive service utilization in the general population. The researchers speculated that besides public health interventions, the cause of this might be due to a trend in movement away from rural areas toward metropolitan centers, which have a greater concentration of health care services and interventions.

In a review of the literature, Conway-Phillips and Millon-Underwood (2009) found that barriers to breast cancer screening for African American women include the following: cultural attitudes and beliefs, the belief that screening is unnecessary or harmful, fear of finding cancer, cancer fatalism, and prior negative experience. These findings are supported by a qualitative study utilizing four focus groups with total of 29 low-income African American women in Chicago ages 40 and above (Peek, Sayad, & Markwardt, 2008), which was not cited in the review. The authors of this study uncovered seven themes elucidating barriers to mammogram utilization: negative health care experiences, fear of the health care system, denial and repression, psychosocial issues, delays in seeking health care, poor health outcomes, and fatalism.

Negative health care experiences resulted from poor communication or misinformation, developed via either perceived disrespect or discrimination during previous health care experiences, or concern with negative interpersonal interactions with clinicians during the screening process (Peek, Sayad, & Markwardt, 2008). The failure of physicians to discuss the procedure is also a barrier to screening (Conway-Phillips and Millon-Underwood, 2009). Such gaps in the patient-provider relationship may be attributed in part to the scarcity of time most physicians have to spend with patients in the exam room, and the resulting lack of attention that they are able to give to this vulnerable population. In addition to problems with patient-physician communication, lack of trust in one's physician is also a barrier to screening for African American women (Young, Schwartz, & Booza, 2011). Peek, Sayad, and Markwardt found that women's fear of health care system is manifested not only as concern about unnecessary surgery, but also through general fear from mistrust. Likewise, a study of low-income African American women over age 40 in Washington, DC discovered that higher trust in one's health care provider was significantly associated with greater use of recommended preventive health services, after controlling or insurance status, primary care, and patient characteristics (O'Malley, Sheppard, Schwartz, & Mandelblatt, 2004). When mammograms were examined individually rather than as part of a suite of preventive health services, this study's researchers found a trend for higher level of trust being associated with increased mammography, though it was not significant.

The other five themes elucidated by Peek, Sayad, and Markwardt (2008) are related to one another. The first suggests that denial and repression of health symptoms due to uncertainty of potential illness are barriers to mammography because screening acknowledges vulnerability to disease and disability. At the same time, the following psychosocial issues are at work: fear of the effect of mastectomy on body image and in intimate partner relationships; spiritual beliefs that abdicate women's agency in prevention of breast cancer; and competing social demands that prioritize medical and other acute issues above preventive care. This factor was also reflected in the theme related to delays in seeking health care, which were cited as resulting from community cultural norms. Relatedly, the theme of poor health outcomes was ascribed to women's negative associations between prevention and disease, because of their experiences with others' late-stage diagnoses and poor health outcomes. The final theme of enhanced fatalism was similarly attributed to participants' experiences of breast cancer diagnosis being a death sentence. Together, these themes provide insight into some of the discussions of breast cancer and possible impediments to screening in the community. In addition, the themes reveal how Black women in the U.S., traditionally at the center of their families, often care for others before themselves.

In fact, Williams et al. (2008) recommends using a family-centered, rather than individual, approach to increase participation in screening because women frequently make decisions in the context of family responsibilities, and when the whole family is affected, Black women make decisions with the family. In this study of asymptomatic African American women aged 40 and above, Williams et al. found that women with a family history of cancer were 41% more likely to have ever had a screening mammogram, and 39% more likely to have had a mammogram within the last year, compared to those without a family history; the associations were significant even after adjustment for known predictors of screening. Interestingly, however, in a study of women under 40 who received mammograms, Kapp et al. (2010) found that compared to other groups, African American women were least likely to report a family history of breast cancer, and compared to White and Asian women, were more likely to report symptoms.

In a sample of White, Black, and Hispanic women ages 40 and above, religious service attendance was significantly associated with higher likelihood of recent breast cancer screening mammography (Leyva, Nguyen, Allen, Taplin, & Moser, 2014). Although religious service attendance was positively associated with social support, social support was not significantly associated with breast cancer screening, and thus it was not found to mediate the relationship of religiosity and mammography, though it did mediate other types of cancer screening. Likewise, racial identification did not moderate the relationship.

Ecological Factors

Ecological-level factors may also play a role in influencing changing rates of screening mammography. Rather than providing information about individuals, these variables offer aggregated values for geographic regions, such as neighborhoods or counties, providing a context to better understand the environment in which an individual lives.

This is important because geographic location affects health care access and quality. For example, in a study of access to cancer care in the U.S., researchers found that Native Americans, nonurban populations, and residents in the South (which include a high proportion of African Americans), have travel burdens to the nearest NCI Cancer Centers, considered de facto regionalized facilities (Onega et al., 2008). Similarly, a 2003 analysis showed the proportion of 65-69 year old women with Medicare receiving a mammogram in the last two years varied across the nation from 21 to 77 percent (Fisher & Wennberg). Trends in mortality due to breast cancer also vary widely by state; furthermore, these trends are less favorable to African American compared to White women: while death rates decreased in all states and Washington, DC for White women between 1975 and 2004, they declined in only 11 of 37 analyzed states for African Americans, remained level in 24 states, and actually increased in two (DeSantis, Jemal, Ward, & Thun, 2008). Mortality disparities similarly vary by county across the U.S. In 762 counties with enough data, researchers discovered the following trends from 1990 to 2009: 53.8% revealed unchanging disparities, 24% showed worsening Black/White disparities, 10.5% sustained racial equality, and 11.7% were moving away from high disparities toward greater equality; further, 3% demonstrated Black mortality rates better than the U.S. average (Rust et al. 2015).

Physical and Policy Environment

Baicker, Chandra, & Skinner (2005) argue that racial disparities in care are the result of geographic variations in care, as African Americans disproportionately live in areas with low-quality health care hospitals and providers; at the same time, however, these patterns of disparities are varied and inconsistent. Researchers have begun to study how differences in breast cancer health outcomes between geographic areas are related to other ecological factors. For example, Schootman, Jeffe, Lian, Gillanders, and Aft

(2009) attributed clusters of shorter- and longer-than-expected breast cancer survival rates for older women within two SEER areas to both individual and ecological factors. In this multilevel analysis, geographic differences in survival were accounted for by the individual-level factors of stage at diagnosis, and in one area, patient race, in addition to the ecological variable of census-tract poverty rate. Other individual factors, such as age, marital status, comorbidity, treatment factors, other tumor factors, utilization of medical care, and mammography use did not account for very much of the variance in survival rates. The authors suggest that census-tract poverty rate may affect geographic variation in survival rates because areas with higher poverty rates offer residents reduced access to healthy foods, generate increased psychosocial stress, and provide health care facilities with worse outcomes. Similarly, Feinglass, Rydzewski, and Yang (2015) recently found that about two-thirds of the differences in all-cause mortality among women diagnosed with breast cancer could be accounted for by the individual-level factors of insurance status, race, stage at diagnosis, and treatment modalities, while the remaining third could be attributed to the ecological factor of SES, as measured by census-based ZIP code level income and educational attainment.

While the studies cited above describe ecological factors associated with breast cancer mortality, there is less research on how these factors affect screening. In a review of the literature, however, Wheeler, Reeder-Hayes, and Carey (2013) outline how provider- and facility-level factors, which can also be considered ecological variables, contribute to racial variation in breast cancer treatment and outcomes, though they argue "health services characteristics are rarely considered in empirical analyses to confound or modify the effect of race" (p. 990) on these outcomes. At the same time, the structural and organizational factors of health systems affecting cancer care quality that these authors present may also impact mammography, as differences in access to care that vary by race may extend to cancer screening. These factors include the following: geographic location; distance to care; volume of patients; caseload severity; therapies available on site; specialist consultation; notification and reminder systems; stated commitment to quality improvement; incentive-based systems in place; facility type, practice setting, profit status, size; affiliations with cancer care organizations, research alliances, academic and teaching status; physician training and education; specialist-generalist collaboration; and physician gender, age, and race (Wheeler, Reeder-Hayes, & Carey, 2013). Supporting this assertion is Zenk, Tarlov, and Sun's (2006) exploration of Chicago facilities providing no-fee or low-fee screening mammography in 2004; they found that in general, mean distance and travel time decrease as neighborhood poverty increases. However, among neighborhoods with the highest proportion of residents in poverty, African American neighborhoods have longer travel distances and longer public transportation travel times compared to those areas with a smaller proportion of African Americans, though mean travel time by automobile does not differ (Zenk, Tarlov, & Sun, 2006). Thus, African American women in high poverty areas who rely on public transportation have poorer spatial access to facilities offering no-fee or low-fee mammograms.

Neighborhoods are an especially important ecological context. There are many aspects that contribute to a neighborhood environment, such as residents' demographic make-up, income, occupation, and spending on various goods and services. Independent of individual risk factors, health is also affected by a neighborhood's social environment, which can include local policies, discrimination and segregation, crime, disorder, community resources and support, collective efficacy, and social capital (Yen & Syme, 1999). Neighborhoods also have a built environment that is made up of physical attributes such as conditions affecting walkability and recreation, housing, and the presence or absence of various businesses and services, such as those that may influence health behaviors. Although the effects of neighborhood on cancer have been acknowledged conceptually, the study of how the social and built environments affect outcomes across the cancer continuum is a relatively new field, and directions and magnitudes of the associations discovered vary due to differences in neighborhood measures and geographic scales (Gomez et al., 2015). While population-level mammography screening has been taken into account as an environmental characteristic affecting diagnosis of breast cancer (Gomez et al.), there are few studies that explore how other neighborhood factors affect screening itself.

One such analysis, using multilevel multivariable regression to assess 14,706 African American women 40-69 years of age between 1995-2001, found regular mammography use was associated with having health insurance, and increased with individual household income (Rosenberg, Wise, Palmer, Horton, & Adams-Campbell, 2005). Regular mammography use was also associated with neighborhood SES- as measured by median housing value and percentages of the following: households below the poverty level, residents 25 years old and above who completed college, people 16 years old and above with white collar occupations, households with non-salary income, and African American residents- however, the association was not significant after controlling for household income (Rosenberg et al.). In another study, 1,229 African

American and White women ages 40-79 were assessed for adherence to age-specific, 1996 ACS mammography guidelines from 1996-1998 (Dailey, Kasl, Holford, Calvocoressi, & Jones, 2007). Non-adherence in Whites was associated with the neighborhood-level SES variables of crowding and assets (as defined by the percentage of owner-occupied homes valued at $300,00 or more); non-adherence in African Americans was associated with the neighborhood-level SES variables of education and composite socioeconomic position (SEP) index, which is made up of median household income and percentages of the following: people in working class jobs (as defined as belonging to one of eight occupational categories consisting of mainly nonsupervisory employees from the 1990 U.S. Census); unemployed individuals; those living below poverty; people without high school education; and expensive homes (Dailey et al.). For both groups, associations with neighborhood SES were associated with regular screening independently of individual-level SES and other predictors of regular screening (Dailey et al.).

Local health practice signatures associated with mammography policy implementation and education may also have a role as an ecological factor affecting screening. For example, a study of African American women in Baltimore found that those with knowledge of mammogram guidelines had more than three times greater odds of having a mammogram before age 40 (Bowie, Wells, Juon, Sydnor, & Rodriguez, 2008). One of the most interesting policy questions affecting the screening changes observed between 2008 and 2012 is the effect of the more restrictive guidelines issued by the USPSTF in 2009. Several studies have found that screening mammography did not decrease after 2009 (Howard & Adams, 2012; Pace, He, & Keating, 2013; Yao, Bradley,

& Miranda, 2014), though Gray's (2016) paper reports that there was a reduction in screening prevalence. In a qualitative narrative inquiry specific to African Americans, Williams (2014) found that African American women diagnosed with breast cancer before age 40 believed the USPSTF's 2009 guidelines serve as a barrier to accessing screening, and thus early detection, for young women. Research by Habtes, et al. (2013) supports this idea. In this study, in which 85% of participants were African American, researchers conducted a retrospective chart review of patients diagnosed with breast cancer to model an equation estimating tumor sizes in order to predict disease stage at diagnosis and survival rates as though the patient had been screened according to different guidelines. They found that compared to those of the ACS, the 2009 USPSTF recommendations predicted later stages at diagnosis, and concluded that race and socioeconomics must be considered when practitioners discuss mammograms with patients, especially those at risk for developing breast cancer younger.

Social Environment

The social environment is another important ecological factor affecting screening. Gray (2014) describes social multipliers that have not only an effect a woman's own screening mammography, but also an indirect effect on her peers' behavior. She found that education was the strongest multiplier, so that efforts to promote mammography reach both the targeted women and their peer groups. Peer effects were also found among African Americans aged 40 and above, and Gray asserts that this may indicate "as the proportion of individuals with the same ethnic background (namely, black and other) in a geographic area increases, the effect of ethnicity on the peer group's screening rates becomes magnified" (p. 27).

Dean et al. (2014) also discuss the importance of social cohesion and collective efficacy on the diffusion of information, and thus the likelihood women hear health messages from others in the community. Their analysis of African American women over age 40 in Philadelphia concluded that individual women's perceptions of high collective efficacy, or the willingness of residents to intervene on behalf of the common good, were significantly associated with mammography use.

Programs designed to encourage screening mammography have effectively used social avenues to help disseminate their messaging. For example, a CDC-sponsored intervention in Alabama successfully led to increased screening rates of African Americans using a community-based approach and targeted motivational messaging (Fouad et al., 2010). In Georgia, the CDC implemented a radio campaign targeting low-income African American women, finding that it led to increased awareness of the NBCCEDP's breast cancer screening services (Hall, Rim, Johnson-Turbes, Vanderpool, & Kamalu, 2012).

Relevant Methodology and Conceptual Framework

Geographic Information Systems (GIS)

In addition to traditional aspatial statistical analyses, this study uses Geographic Information Systems (GIS) in order to better understand the increase, from 2008 to 2012, in Black women in the U.S. who report having had a mammogram in the last two years. To my knowledge, there are no prior studies exploring this phenomenon using GIS, which is "a computer system for capturing, storing, querying, analyzing, and displaying geospatial data" (Chang, 2012, p. 1) that has the important ability of integrating multiple layers of data from different sources with one another. GIS has been employed to study other health concerns using similar methods as those used in this dissertation, though the field is still relatively young. For example, Will, Nwaise, Schieb, and Zhong (2014) employed GIS to map preventable hypertension hospitalizations in Medicare beneficiaries from 2004-2009 by race, compare crude rates over time in White and Black Americans, and identify statistically significant clusters of counties with extreme rates. Khalid and Ali (2013) used GIS to perform global ordinary least squares (OLS) regression and local geographically weighted regression (GWR) in order to determine whether the incidence rates of common cancers in Saudi Arabia, from 1998 to 2004, were spatially correlated at the city level. Goovaerts et al., (2015) used logistic GWR in a study of factors associated with late-stage prostate cancer diagnosis in Florida.

GIS is also beginning to be used to explore breast cancer diagnosis and mortality. For example, using GWR, Tian, Wilson, and Zhan (2011) found how the relationship between mortality and racial disparities in late-stage breast cancer diagnosis varied across the state of Texas. In another study including the same researchers, GIS software was used to discover factors associated with racial disparities in breast cancer mortality in Texas census tracts (Tian, Goovaerts, Zhan, Chow, & Wilson, 2012).

GIS can also be used to understand screening through the concept of diffusion, which is "the process in which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 2003, p. 5). The diffusion paradigm has been used to better understand the necessary steps to achieving widespread dissemination of health-related innovations, such as those used in health promotion

(Oldenburg & Glanz, 2008). For example, the Division of Cancer Prevention and Control, part of the CDC, used diffusion of innovation to work with stakeholders to advocate for a comprehensive, nationwide approach to coordinate and integrate cancer prevention and control (Abed et al., 2000). In a review of studies evaluating diffusion of cancer control interventions across the cancer care continuum, including smoking cessation, healthy diet, mammography, cervical cancer screening, and control of cancer pain, Ellis et al. (2005) found that a single dissemination strategy to promote these interventions was not effective. However, they did find that the interventions of physician training, office reminders and prompts, patient reminders, removal of access barriers, and provision of social networks were effective in increasing the rate of mammography. In another study, Slater, Finnegan, and Madigan (2005) describe how, using a diffusion framework, a community-based trial that increased screening mammography was successfully adopted as an intervention for use throughout the state of Minnesota. In a different application of the diffusion paradigm, Cronin et al. (2005) used the framework to synthesize data from different sources to create a model of simulating screening mammography patterns for women representative of the U.S. population.

Since diffusion can be understood as a spatial process in regard to both physical and social distributions (Hägerstrand, 1968), mapping the distribution of innovations at different times can indicate spread over time and place. For example, using GIS, Casas, Delmelle, and Varela (2010) discovered that over time, diffusion of information about the health services available from a recently opened hospital in a disadvantaged neighborhood in Columbia occurred. Similarly, they found that the first-time patients served by this hospital diffused over time; that is, initially, the hospital served a cluster of patients around its location, but over time, those clusters grew outward from the hospital. In another study using GIS, researchers assessed the diffusion of HIV-related services and its impact on access to and utilization of HIV testing in rural Mozambique (Yao, Agadjanian, & Murray, 2014). They found that as services expanded over time, spatial barriers to their utilization declined in importance and spatial inequities decreased, though non-spatial variation, like level of education, remained.

Critical Race Theory (CRT)

One of the guiding theories behind this dissertation is Critical Race Theory (CRT). When considering the existence of breast cancer disparities faced by Black women in the U.S. as a failure in the administration of health equity, and thus social justice in health, the role of implicit racism and structural violence must be considered. According to CRT, which is based on the principles of race equity and social justice, structural forces drive inequities, though individual mechanisms are disproportionately highlighted by most research and intervention practices (Ford & Airhihenbuwa, 2010). CRT "is a framework that can be used to theorize, examine and challenge the ways race and racism implicitly and explicitly impact on social structures, practices and discourses" (Yosso, 2005, p. 70). Positioned as a part of critical postmodern theory, CRT does not assume universal truths, but instead "is based on the following assumptions: race is a social construction, race permeates all aspects of social life, and race-based ideology is threaded throughout society" (Ortiz & Jani, 2010, p. 176). Transdiciplinary in its approach, CRT operates primarily through knowledge production, incorporating and centering the voices of racial minority communities and valuing critical self-reflection and the transformation of existing hierarchies (Ford & Airhihenbuwa, 2010), thus bridging theory with practice. From a CRT lens, contemporary racism, which is implicit, subtle, and normalized through its integration in society and everyday life, must be eliminated in order to achieve health equity.

Building on this notion of racism, the persistence of health disparities can be seen as a form of structural violence, which Farmer (2004) describes as “violence exerted systematically- that is, indirectly- by everyone who belongs to a certain social order” (p. 307) and “the natural expression of a political and economic order that seems as old as slavery” (p. 317). Linking individual experience of illness to the structure of society, Farmer asserts that structural violence is embodied as adverse events experienced by people who are marginalized by poverty, racism, and / or gender inequality. Structural violence is thus represented through social determinants of health, manifested as factors affecting ill health and barriers to health care access (Mukherjee, 2011). The implicit racism and structural violence experienced by Black women in the U.S. via breast cancer incidence and mortality health disparities is also evident in breast cancer screening policy, which is based on cancer research lacking minority representation and thus meaningful translation into polices guiding screening.

As such, the breast cancer disparities affecting Black women could further be understood as the result of structural racism, which “refers to the totality of ways in which societies foster racial discrimination through mutually reinforcing systems of housing, education, employment, earnings, benefits, credit, media, health care, and criminal justice” (Bailey et al., 2017, p. 1453). One such form of structural racism, which is explored in this dissertation, is the residential segregation experienced by Black Americans, which has many effects, including health care access and quality.

Socioecological Model (SEM)

Part of the theoretical background guiding this study includes the notion that multiple levels of factors influence health, and this concept has been outlined in the literature in different ways. For example, Lynch and Rebbeck's (2013) Multi-level Biologic and Social Integrative Construct (MBASIC) proposes integrating the macroenvironment (including, for example, neighborhoods and policy), individual factors (such as behavior, exposure, and SES), and biology (for example, cellular biomarkers) in order to better identify the multifactorial relationships involved in cancer etiology. In McLeroy, Bibeau, Steckler, and Glanz's (1988) ecological model for health promotion, which in turn draws on work from Urie Bronfenbrenner and others, five levels of variables are proposed as influencing behavior: 1) intrapersonal factors; 2) interpersonal processes and primary groups; 3) institutional factors; 4) community factors; and 5) public policy factors.

In addition to considering individual and ecological factors, however, the role of geographical space and place is also important. Place is understood as consisting of geographical units, often defined by administrative boundaries, whereas space is used to define each data point according to its proximity to other data points regardless of geographical units (Arcaya, Brewster, Zigler, & Subramanian, 2012). Both space and place are to be integrated into analyses of area variations in health, according to Arcaya et al., because the results can indicate different conclusions; for example, spatial clustering may suggest spatially explicit processes at work, while the effects of place could imply policy factors in effect.

For this dissertation, I have synthesized these theories by integrating space and place into a framework that incorporates elements of the socioecological model (Oxendine, Goode, & Dunne, 2004) in order to locate the multiple levels of influence in place. In this model of Determinants of Health (Figure 1), the individual is affected by the interplay of biology and behavior, which in turn are influenced by the social and physical environments. At the same time, the physical environment affects, and is affected by, geographic place. There is also a circular effect of policies and interventions on these influences to the individual, access to quality health care, and place. In addition, each of these factors can influence, and be influenced by, space. The analyses in this dissertation incorporate variables from each of these factors in order to assess changes in screening mammography.

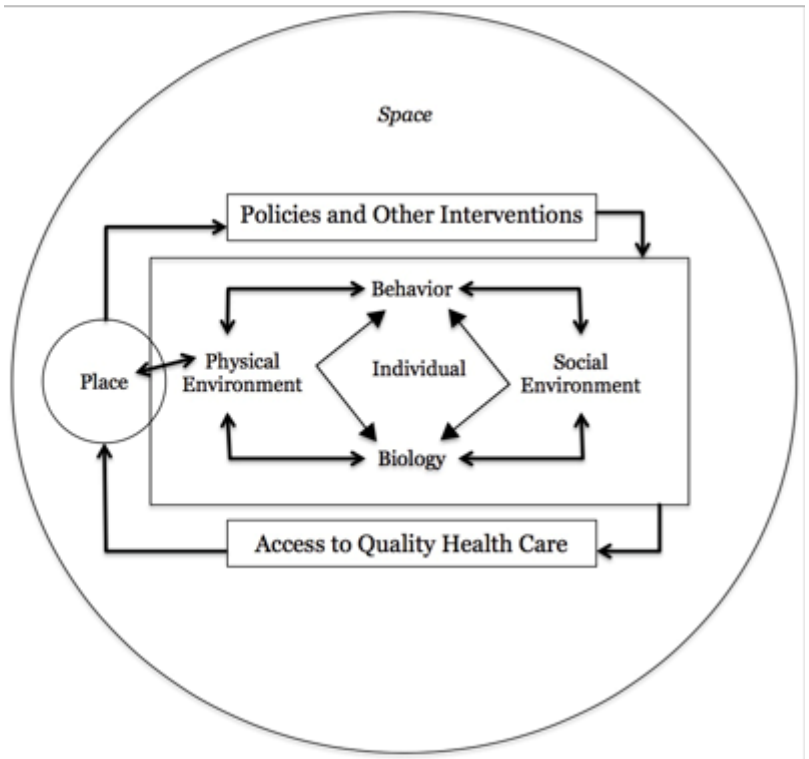

Figure 1. Determinants of Health

Conclusion

The number of women reporting having had a mammogram within the past two years rose from 2008 to 2012, and the rate of Black women undergoing screening has, by some accounts, surpassed that of White women. There are likely a number of influences that contribute to this change, including those visible at the level of the individual such as demographic factors, beliefs, problems with patient-physician communication, and lack of access to health care. Ecological variables, including neighborhood factors, social influences, and changes in mammography policies, as well as geographic space and place, also likely play roles. The premise of this work was that by integrating GIS, CRT, and SEM, I could discover factors associated with increases in screening mammography, and more generally, gain insight into how health practices can diffuse across time and space.

CHAPTER 3

METHODS

Health disparities in breast cancer incidence and mortality exist between Black and White women in the U.S. In particular, across all age groups, Black women have the same incidence rate of breast cancer compared to White women (DeSantis et al., 2015), but a higher mortality rate (ACS, 2011). However, Black women ages 45 and below have a higher incidence rate than Whites (ACS), and across all ages, are more likely to be diagnosed with late-stage breast cancer than White women (Deshpande et al., 2009; Elmore et al., 2005). Though the causes of disparities in breast cancer incidence and mortality between Black and White women are multifactorial, detecting the disease is key to treating it, and currently, early detection is best achieved through screening mammography. Unfortunately, however, screening mammography policy and recommendations are fraught with conflict, particularly with regard to younger women. Despite this, the number of women reporting having had a mammogram within the past two years has risen, and the rate of Black women receiving screening has recently met, and by some accounts surpassed, that of Whites (DeSantis et al.; National Center for Health Statistics, 2014). This trend, however, is not consistent across the U.S. Geographic location affects health care access and quality, and some argue that racial disparities in care are the result of geographic variations in care, as Black populations disproportionately live in areas with low-quality health care hospitals and providers, though these patterns are varied and inconsistent (Baicker, Chandra, & Skinner, 2005).

The aim of this chapter is to describe the methods I used in exploring the change, from 2008 to 2012, in the rates of Black women having had a mammogram in the last two years. The study hypothesis and objectives, variable measurement, research design, and strengths and limitations are presented.

Hypotheses and Objectives

Discovering factors associated with the increase in Black women's screening in recent years provides better understanding of not only mammography, but also how preventive health care practice can change over time and space more generally. This knowledge can then be used to inform policy related to preventive health care.

This study includes three research objectives; the first two relate to analysis of the data, while the third is concerned with interpretation of the data.

1. The first objective was to formally characterize the geographic pattern of change over time in mammography for Black women in order to assess whether the spatial distribution of screening utilization is random.
    a. The hypothesis for the first research objective was as follows: from 2008 to 2012, there is no difference in the geographic pattern of change in the percent of Black women reporting having had a mammogram in the last two years.
    b. The working hypothesis was that during this time period, there is a detectable geographic pattern of change in the percent of Black women reporting having had a mammogram in the last two years.
2. The second objective was to explore whether different types of factors are associated with the geographic pattern.

a. For the second research objective, the underlying hypothesis is as follows: the geospatial pattern of change in screening is associated with changes in access to health care when controlling for education, income, demographic factors, and the larger ecological sociodemographic context.

3. Finally, the third objective was to reflect upon how these findings can be used to inform policy that promotes health equity.

Measurement

Data was drawn from three sources, The Dartmouth Atlas of Health Care (http://www.dartmouthatlas.org/), The American Community Survey (https://www.census.gov/programs-surveys/acs/), and The Behavioral Risk Factor Surveillance System (BRFSS; http://www.cdc.gov/brfss/). Because this data was provided by research organizations that have taken responsibility for removing identifiers, Loma Linda University Institutional Review Board approval was not necessary for the study.

Data Sources

The Dartmouth Atlas of Health Care is a project based at The Dartmouth Institute for Health Policy and Clinical Practice, which utilizes Medicare data to provide information on the U.S. health care system. Integrating databases from the American Hospital Association, American Medical Association, U.S. Bureau of the Census, the Centers for Medicare and Medicaid Services, and the National Center for Health Statistics, the Atlas provides data to the public on services used by the Medicare population, ages 65 to 99, who are not enrolled in a risk-bearing health maintenance organization (HMO) (The Dartmouth Atlas of Health Care, 2015a).

The U.S. Census Bureau administers the American Community Survey every year through a random sample in all states, the District of Columbia, and Puerto Rico (U.S. Census Bureau, 2016). Sampling is based on housing unit addresses and residents of group quarters facilities; housing unit address samples are drawn from all counties in the U.S. (U.S. Census Bureau, 2014). From 2005-2010, the sample included about 2.9 million housing unit addresses per year, and in 2011, the sample was increased to 3.54 million addresses each year (U.S. Census Bureau, 2014). Researchers use a ratio estimation procedure and weight each sample person and housing unit record (U.S. Census Bureau, 2014). The data used in this study is based on 5-year estimates drawn from data collected during 60 months from 2008-2012.

The BRFSS was established by the U.S. Centers for Disease Control and Prevention (CDC); the survey collects information on the personal health behaviors of adults ages 18 and over in all 50 states as well as the District of Columbia and several U.S. territories, via telephone questionnaire (National Center for Chronic Disease Prevention and Health Promotion, 2014). Each state is responsible for conducting the interviews in its territory according to BRFSS protocols, choosing a sampling method that is appropriate for its territory and approved by the CDC; at least 4,000 interviews per state are conducted each year. For landlines, telephone numbers are drawn using disproportionate stratified sampling, where numbers are classified as either high or medium density. Information on the number of adults living in the household is collected and the interviewer must randomly select from the eligible adults. Cellular telephone respondents comprise a separate sample and are considered single adult households. These numbers are randomly selected and make up about 20% of completed interviews. Landline numbers are sampled based on geographic regions within states, as are cellular numbers beginning in 2013, though in the previous two years they were stratified only by state. In order to reduce the potential for bias in the sample, data is weighted in design and using iterative proportional fitting, utilizing age, sex, race, ethnicity, and region; since 2011, telephone ownership, education level, marital status, and home ownership were also included. The survey includes a set of questions asked each year by every state, a rotating set of questions asked by all states every other year, optional modules states may choose to ask, and any questions states may add that are specific to their health priorities.

Geographic Units

The geographic location of women was analyzed at the county level for the BRFSS dataset. Dartmouth Atlas of Health Care data was also analyzed at the county level, as well as two additional geographic units. Hospital service area (HSA) is a measure used by The Dartmouth Atlas of Health Care (2015b) to distinguish local health care markets, as some patients may attend hospitals outside of the counties in which they reside. Each HSA includes ZIP codes representing Medicare residents who are hospitalized most in the area; there are 3,436 HSAs. The third measure used is hospital referral region (HRR), also created by The Dartmouth Atlas of Health Care, which distinguishes regional health care markets for care that requires services from a major referral center. Each HRR includes HSAs representing residents who are referred most for major cardiovascular surgery and neurosurgery; there are 306 HRRs. The Dartmouth Atlas of Health Care provided geographic boundary files for use in Geographic Information Systems (GIS) software.

Dependent Variable

Three dependent variables were used in this dissertation. In Chapter 4, the dependent variable was the difference, between 2008 and 2012, in the average percent of female Medicare enrollees ages 67-69 having had a mammogram in the last two years. For all women, Black women, and White women, respectively, the average percent reported in 2008 was subtracted from the figure for 2012 in order to create a variable describing the percent change during this time period. In Chapter 5, the dependent variable also draws upon the difference in screening among Medicare enrollees ages 67-69 having had a mammogram in the last two years, but is translated into a dichotomous variable to represent whether there was an increase in screening, or not. For these two chapters, data for this variable was drawn from The Dartmouth Atlas of Health Care. In Chapter 6, the dependent variable is derived from the BRFSS dataset, and is a dichotomous variable representing whether a woman had, or did not have, a mammogram in the last two years.

Independent Variables

Independent variables can be categorized into two types: ecological and individual.

Ecological

Ecological factors are understood as those for which values are available at the geographical level, rather than at the individual person level. They provide a context to better understand the environment in which an individual lives, but do not necessarily represent the characteristics of that individual. For example, a woman with health insurance may be living in a county that is 80% male and 75% uninsured. Although the majority of the population in this county does not represent the woman in terms of these two factors, recognizing the environment in which she lives is important to consider in addition to her individual characteristics, in order to better understand her health care.

This contextual data was drawn from the American Community Survey, as it is designed to represent the population. The following county-level variables were used: median age; percentage of the population age 25 and over with a high school diploma, GED, or alternative only (not including those with any higher education); percentage of the population age 15 and over who are married (except separated); and percentage of the female civilian non-institutionalized population with health insurance coverage.

In addition, data on race and income from the American Community Survey were used to calculate two Index for Concentration at the Extremes (ICE) variables. ICE was developed by Massey (2001) to estimate the proportional (im)balance between two groups within a local area, instead of separate effects, which can also lead to problems with multicollinearity. The variable provides a quantification of the concentration of privilege in an area on a continuum from -1 (most deprived) to 1 (most privileged). While Massey proposed the measure for use with income disparity, Krieger, Waterman, Gryparis, and Coull (2015) have introduced it for use with the polarization that exists due to race/ethnicity. Understanding race as a social construct, $ICE_{race/ethnicity}$ is important since racial residential segregation affects health care (White, Haas, & Williams, 2012). Based on previous studies (Feldman, Waterman, Coull & Krieger; 2015; Krieger, Singh, & Waterman, 2016; Krieger, Waterman, Spasojevic, Li, Maduro, & Van Wye, 2016) and defining the cutoffs for low income at the 20th income percentile and high income at the 80th percentile, these measures were calculated, for each county, as follows:

$$ICE_{income} = \frac{(Number\ of\ households\ earning \geq \$100{,}000) - (Number\ of\ households\ earning < \$25{,}000)}{Total\ number\ of\ households\ in\ county\ with\ income\ data}$$

$$ICE_{race/ethnicity} = \frac{(White\ non{-}Hispanic\ population) - (Black\ non{-}Hispanic\ population)}{Total\ population\ in\ county\ with\ race/\ ethnicity\ data}$$

Individual

Individual level factors were not used for analysis with the Dartmouth Atlas of Health Care dataset. However, a number of individual level factors were used with the BRFSS dataset, as they were items included in the BRFSS surveys. These variables are listed below.

Age

Respondents were asked, “What is your age?” Values range from 18-99 years.

Ethnicity

This question, which asks respondents, “Are you Hispanic or Latino?” is in addition to an item focusing on race, which is used in distinguishing the sample population and asks, “Which one of these groups would you say best represents your race?” Values include White, Black or African American, Asian, Native Hawaiian or Other Pacific Islander, American Indian/Alaska Native, Other, Don’t know/not sure, and Multiracial but preferred race not asked.

Education

Respondents were queried, “What is the highest grade or year of school you completed?” Values include the following: Never attended school or only kindergarten, Grades 1 through 8 (Elementary), Grades 9 through 11 (Some high school), Grade 12 or GED (High school graduate), College 1 year to 3 years (Some college or technical school), and College 4 years or more (College graduate).

Employment Status

The survey questions, “Are you currently: ___” with the following options: Employed for wages, Self-employed, Out of work for more than one year, Out of work for less than one year, A homemaker, A student, Retired, and Unable to work.

Income

Respondents were asked, “Is your annual household income from all sources: ___” with the following response options: Less than $10,000; $10,000 to less than $15,000; $15,000 to less than $20,000; $20,000 to less than $25,000; $25,000 to less than $35,000; $35,000 to less than $50,000; $50,000 to less than $75,000; and $75,000 or more.

Marital Status

Respondents were questioned whether they are married, divorced, widowed, separated, never married, or a member of an unmarried couple.

Health Care Access

The BRFSS survey asks four questions regarding health care access: 1) "Do you have any kind of health care coverage, including health insurance, prepaid plans such as HMOs, or government plans such as Medicare?" 2) "Do you have one person you think of as your personal doctor or health care provider?" 3) "Was there a time in the past 12 months when you needed to see a doctor but could not because of cost?" and 4) "About how long has it been since you last visited a doctor for a routine checkup?"

Research Design

Sample Selection

This study utilizes a serial cross-sectional design. For analyses using The Dartmouth Atlas of Health Care, the sample includes Medicare beneficiaries ages 67-69 except those in geographic regions with counts of fewer than 11 patients; these are excluded from the data set to protect patient confidentiality (The Dartmouth Atlas of Health Care, 2015b). For analyses using the BRFSS dataset, the sample is considered representative of the U.S. population over age 18.

Data Analysis

Both aspatial and spatial data are used in this dissertation. For aspatial analyses, SPSS Version 24 (IBM Corp.) and HLM 7.01 (Raudenbush, Bryk, & Congdon, 2013) were used. Spatial data analyses utilized GIS, which is "a computer system for capturing, storing, querying, analyzing, and displaying geospatial data" (Chang, 2012, p. 1) that has the important ability of integrating multiple layers of data from different sources with one another. The software used for analyses include ArcGIS for Desktop (Esri, 2014), GeoDa (Anselin, Syabri, & Kho, 2006), and SpaceStat (BioMedware, 2014). Three primary datasets were used in this study: county BRFSS data, county Dartmouth Atlas data, and HRR Dartmouth Atlas data.

Phase I

The first phase of the study answered the following question: What is the geographic pattern of change over time in screening mammography for Black women across the U.S. from 2008 to 2012? In order to accomplish this, the Dartmouth Atlas data by HRR was assessed using descriptive mapping. The overall distribution of change was shown using box plots and box maps, which reveal where data points fall in the quartiles of a distribution and identify outliers. Using ArcGIS, raw change values were also shown on chloropleth maps, which use different color shades to indicate values for the given areas.

This phase also included pattern analysis of the dataset in order to assess the probability that the spatial distribution of change by area is random, which can later be used to help identify potential causes and predict future trends. This kind of spatial analysis is based on Tobler's First Law of Geography, which asserts that things that are closer in space are more related to one another than to things that are further apart. When near things are in fact more related, they are considered to exhibit positive spatial autocorrelation. Negative spatial autocorrelation is seen when high values correlate with low values, while zero spatial autocorrelation represents complete random distribution of values. In order to assess the spatial autocorrelation of change values as a whole across the U.S., Global Moran's I was used. Next, Local Indicators of Spatial Association (LISA), or Local Moran's I, was used to identify local clusters of feature locations with similar change values as well as spatial outliers, also indicating whether any low value of change occurs in an broader area of high change values, and vice versa.

Phase II

The second phase of the study explored the following question: Is the geographic pattern of change associated with particular ecological or individual level factors? In order to accomplish this, aspatial and spatial statistics were used to explore correlations, better understand key factors, and attempt to predict unknown values. With the Dartmouth dataset, forward stepwise (Likelihood Ratio) aspatial logistic regression was performed first, using the ecological variables described above, for Black and White women, respectively. Before analysis, the assumptions of the method were considered and addressed, and after analysis, variable signs, coefficients, redundancy, residuals, and goodness of fit were checked. Following this, Geographically-Weighted Regression (GWR) was conducted. GWR runs regressions for each location in the model individually, allowing model coefficients to vary by region instead of remaining static for the entire study area (Mitchell). Thus, each geographic feature is assigned unique coefficients for every variable. Coefficient values were mapped to show the areas in which the variable has a significant impact on the model, and in which direction. For the BRFSS dataset, multilevel logistic regression was conducted, nesting individual variables within the community context.

Strengths and Limitations

One of the limitations of this study is that it is not longitudinal, but rather makes use of serial cross-sectional data. Thus, the response of a single participant in 2008 regarding her screening behavior cannot be directly compared to her response in 2012, making the determination of causality difficult. This type of data would be very valuable in helping to determine factors leading to changes in mammography. As such, results of the analyses are incomplete, as not all factors affecting changes in screening behavior will be addressed. Despite this, one of the strengths of this study is that it contributes to existing literature regarding variables associated with screening, which is a topic fraught with debate, though there is no published research, to my knowledge, seeking to determine why screening has increased in Black women during this time period. In addition, to my knowledge, there is no prior research using GIS to gain insight into associations in differences over time in screening mammography, which is another strength. Importantly, this research advances the study of preventive health care by operationalizing a socioecological perspective that also incorporates the concepts of space and place. Further, by better understanding how mammography may have diffused over time and space, this research may inform the development of future policy and practice aiming to increase screening among women, and possibly other preventive health care measures.

The datasets used in this research also have benefits and drawbacks. One limitation of the BRFSS dataset is that it relies on self-reported responses, which can be inaccurate. However, it is strong in that the sample used is representative of each state's population (Division of Health Informatics and Surveillance, 2013). At the same time, then, the Dartmouth dataset is strong because it does not rely on self-report data, but rather is made up of reports from hospitals, physicians, other health care providers, and various agencies. In addition, it is designed to provide data on all female Medicare recipients ages 67-69 who are not enrolled in a risk-bearing HMO. A downside of this data set, however, is the narrow age range represented, which does not allow us to understand patterns of mammography for younger women- a challenge since Black women often present with a pattern of breast cancer that occurs at younger ages.

As a final note on the strengths of this dissertation, research findings can be displayed visually on maps, an opportunity that offers lay community members easier access to study findings as compared to traditional reports. As such, future efforts to affect preventive health care can build upon both the findings of, and the methods utilized in, this study in order to improve the health of vulnerable communities and help reduce related health disparities.

CHAPTER 4

GEOGRAPHIC PATTERNS OF CHANGE OVER TIME IN MAMMOGRAPHY: DIFFERENCES BETWEEN BLACK AND WHITE U.S. MEDICARE ENROLEES

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Keywords:

Breast cancer

Mammography

Geographic information systems (GIS)

Black/African American

Health disparities

This paper was published in Cancer Epidemiology 46 (2017): 57–65.

Abstract

U.S. Black women have higher breast cancer mortality compared to White women while their rate of ever having a mammogram has become equal to or slightly surpassed that of Whites. We mapped the distribution of change in screening mammography for Black and White female Medicare enrollees ages 67–69 from 2008 to 2012 by hospital referral region across the contiguous U.S., performed cluster analysis to assess spatial autocorrelation, and examined the screening differences between these groups in 2008 and 2012 respectively. Changes in screening mammography are not consistent across the U.S.: Black and White women have increased and decreased their use of mammography in different regions and Black women's change patterns vary more widely.

Introduction

In previous years, U.S. Black women had lower incidence rates of breast cancer compared to Whites, but recently, the rates have converged [1]. Black women also had a lower breast cancer mortality rate than Whites in the past; however, in the 1980s, Black women's breast cancer mortality rate became higher than any other racial/ethnic group, and the disparity between Black and White women's mortality rates has since widened [1]. This difference in mortality is likely due to 1) the fact that Black women across all ages are more likely to be diagnosed with late-stage breast cancer than Whites [2,3]; and/or 2) Black women receiving poorer quality of care compared to Whites once diagnosed.

Some argue that racial disparities in care are the result of geographic variations in care, as Black people disproportionately live in areas with low-quality healthcare; at the same time, however, these patterns of disparities are varied and inconsistent [4]. For example, trends in breast cancer mortality vary widely by state: while death rates decreased in all states for White women between 1975 and 2004, they declined in less than one third of the states analyzed for Black women, and increased in two [5]. Similarly, from 1990 to 2009, breast cancer mortality disparities between Black and White women worsened in 24% of 762 U.S. counties with enough data to be studied [6]. City-level disparities also exist: from 2005 to 2007, the mortality rates of non-Hispanic Black women were higher than those of non-Hispanic White women in the majority of 24 large U.S. cities, which may be related to income differences and racial segregation [7].

The role of increased screening mammography in reducing breast cancer mortality among women is under debate [8–10]; however, screening mammography is the best method currently available for detecting breast cancer early. In combination with improved treatment, early detection by mammography is related to improved breast cancer survival outcomes [11].

In recent years, Black women have had equal or slightly higher rates of ever having had a mammogram compared to Whites [12,13]. However, though the overall gap between these groups has closed across the nation as a whole, screening rates vary by geographic location. For example, a recent analysis found the proportion of Black women ages 45 and above receiving a mammogram in the last two years ranged from 68 to 89 percent (by state), and that of Whites from 66 to 86 percent [1]. In another study, researchers found the proportion of 65–69 year old women with Medicare receiving a mammogram in the last two years ranged from 21 to 77 percent across the nation (by hospital referral region) [14]. The main aim of this study was to assess geographic variations in U.S. screening mammography using small area analysis. Examining the changes in screening that took place over time by geographic area, and comparing between Black and White women, offers additional insight into national screening trends. We argue that by exploring the issue of screening mammography utilization from a spatial perspective, the effects of race, place, and healthcare geography can be simultaneously taken into account. Our specific objective was to formally assess the geographic pattern of change in mammography utilization for Black and White female Medicare enrollees ages 67–69 from 2008 to 2012 across the contiguous U.S.

Methods

The study population included Black and White female Medicare enrollees ages 67–69. Data was obtained from The Dartmouth Atlas of Health Care (DAHC), a project based at The Dartmouth Institute for Health Policy and Clinical Practice, which utilizes Medicare data to provide information on the U.S. healthcare system. Integrating multiple databases, DAHC offers data on services used by the Medicare population, ages 65 to 99, who are not enrolled in a risk-bearing health maintenance organization (HMO) [15]. However, data on mammography is available only for women ages 67–69.

Utilization data on mammography screening are available at the hospital service area (HSA) level, a geographic unit developed by DAHC scientists to distinguish local healthcare markets, made up of ZIP codes representing Medicare residents who are hospitalized most in the area [16]. Because patients may attend hospitals outside of the counties in which they reside, this geographic unit is based on healthcare delivery rather than administrative boundaries, which is useful for understanding healthcare access and related processes. A total of 3436 HSAs across the U.S. are defined in DAHC. However, in order to obtain more stable estimates, our analyses were implemented at the hospital referral region (HRR), a larger geographic unit also created by DAHC scientists, with boundaries that remain the same across time. The 306 HRRs defined for the U.S. are made up of HSAs and distinguish regional healthcare markets for care that requires services from a major referral center. As HRRs are large and built as catchment areas around hospitals, their design partially alleviates the consequences of underlying population variability. Since the distributions for mammography rates in 2008 and 2012 for all women, Black women, and White women respectively (Figs. 1–3) exhibited distributional symmetry and had few outliers, we did not conduct further smoothing. After assessing the underlying population sizes, we concluded that the outliers for White women (Medicare enrollees ages 67–69) in 2012 were not likely due to small population numbers, which ranged from 2429 to 14,120. No outliers were detected for 2008 in the White population. The distributions for Black women had more outliers, which were associated with small population sizes. In 2008, the mean population size associated with the five outlier regions for Black women was 69.6 (SD = 50.8), and in 2012 was 75.3 (SD = 56.7) for eight outlier regions. As a result, the 11 unique regions representing outlier mammography rates for Black women were excluded from the spatial cluster analysis of the change in mammography utilization. Following the DAHC approach, HRRs with fewer than 11 patients reported in the DAHC dataset were not included in the analyses [15].

Box maps and matching box plots were used to describe the variations in screening utilization changes over time (2008 and 2012). Global clustering of the outcome variable across the contiguous U.S. was assessed through the Moran's I statistic [17]. By comparing the value of each feature to the mean value and accounting for the values of neighboring features, this test measures spatial autocorrelation [18], or the degree to which the distribution of screening values is dependent on the distribution of neighboring HRRs in space. Anselin's Local Indicators of Spatial Association (LISA) metric, or Local Moran's I, was used to identify local clusters of feature locations with similar utilization changes and spatial outliers. In order to do this, LISA calculates local Moran's I values, and analyzes how individual locations affect the global value [19]. For Global Moran's I and LISA analyses, we used a spatial weights matrix generated using a

K- nearest neighbor conceptualization of spatial relationships with eight neighbors, applying row standardization, and Euclidean distances. All descriptive mapping and spatial clustering analyses were implemented using ArcGIS version 10.3 [20].

In addition, Disparity Statistics were implemented to assess the absolute and relative differences in screening rates between Black and White women, both in 2008 and 2012 [21,22]. These analyses measured the significance of the absolute differences between the two groups in 2008 and in 2012 respectively, as well as the rate ratios (relative differences) of these measures, while accounting for multiple testing due to the presence of multiple spatial units. These Disparity Statistics were implemented using SpaceStat Version 4 [23].

Results

A total of 247 HRRs (see Table 1) had sufficient data to be included in the analyses; HRRs with insufficient data were the same for Black and White women.

Figs. 1–3 display the geographic distributions of screening rates and changes in screening utilization overall, for Black women, and for White women, respectively.

Table 1. Female Medicare enrollees ages 67–69.

		Black	White
2008			
	Total n in analyses	176,818	1,708,607
	Mean (SD) by HRR	716 *(1034)*	6917 *(5827)*
	Minimum by HRR	23	1010
	Maximum by HRR	6330	36,563
2012			
	Total n in analyses	196,074	1,834,775
	Mean (SD) by HRR	794 *(1157)*	7428 *(6355)*
	Minimum by HRR	18	1115
	Maximum by HRR	7281	38,235

Figure 1. Box Maps and Matching Box Plots for Overall Female Medicare Beneficiaries Ages 67–69 by Hospital Referral Region (HRR): Average Percent Reporting Having Had a Mammogram in the Last Two Years, 2008 (A), 2012 (B); and Change in the Proportion (%) of Those Reporting Having Had a Mammogram in the Last Two Years, 2008 and 2012 (C). State lines provided for reference only. Regions in map C with an increase in screening are denoted with a star, as not all changes measuring above the 75th percentile were positive.

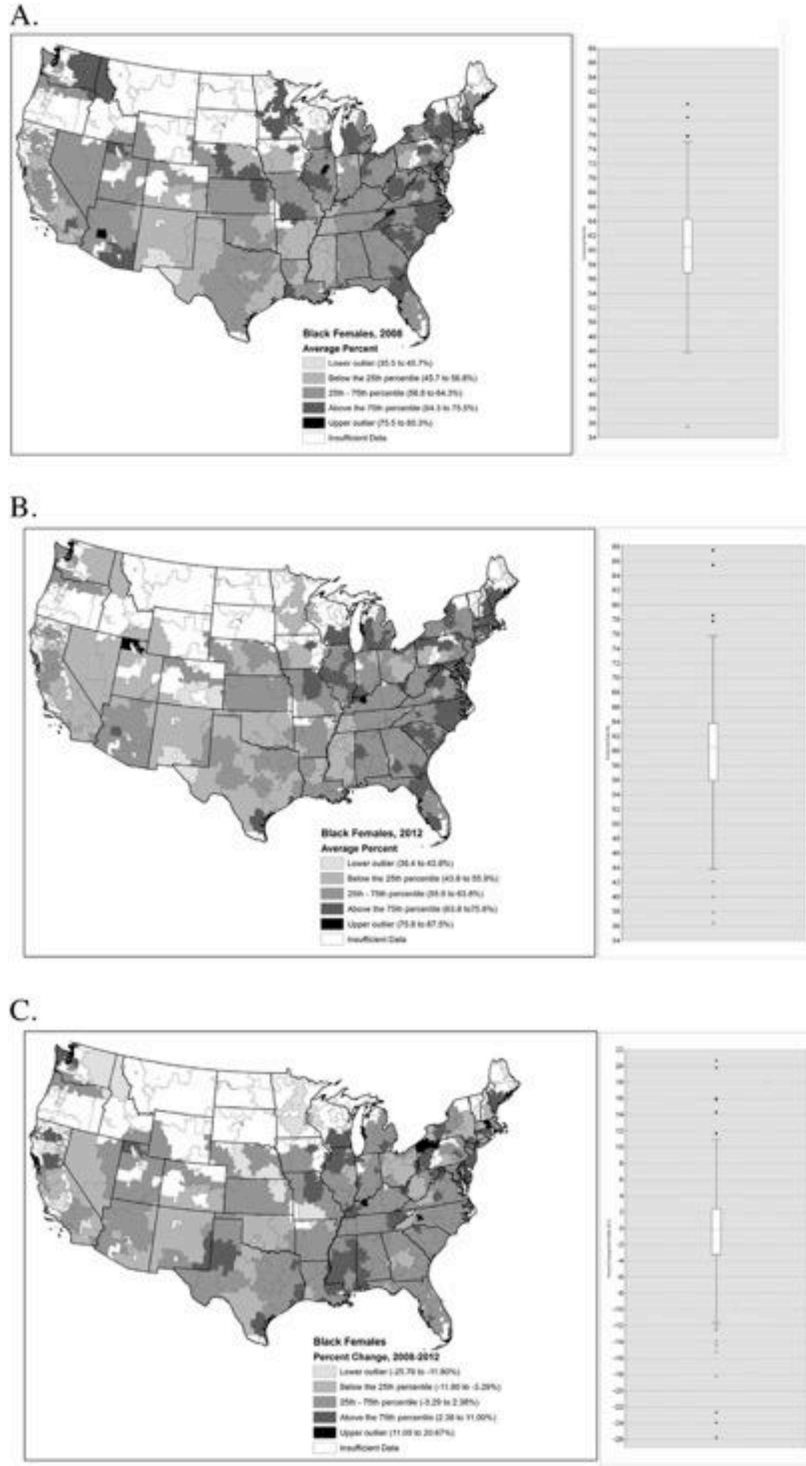

Figure 2. Box Maps and Matching Box Plots for Black Female Medicare Beneficiaries Ages 67–69 by Hospital Referral Region (HRR): Average Percent Reporting Having Had a Mammogram in the Last Two Years, 2008 (A), 2012 (B); and Change in the Proportion (%) of Those Reporting Having Had a Mammogram in the Last Two Years, 2008 and 2012 (C). State lines provided for reference only. All changes measuring above the 75th percentile in map C were positive.

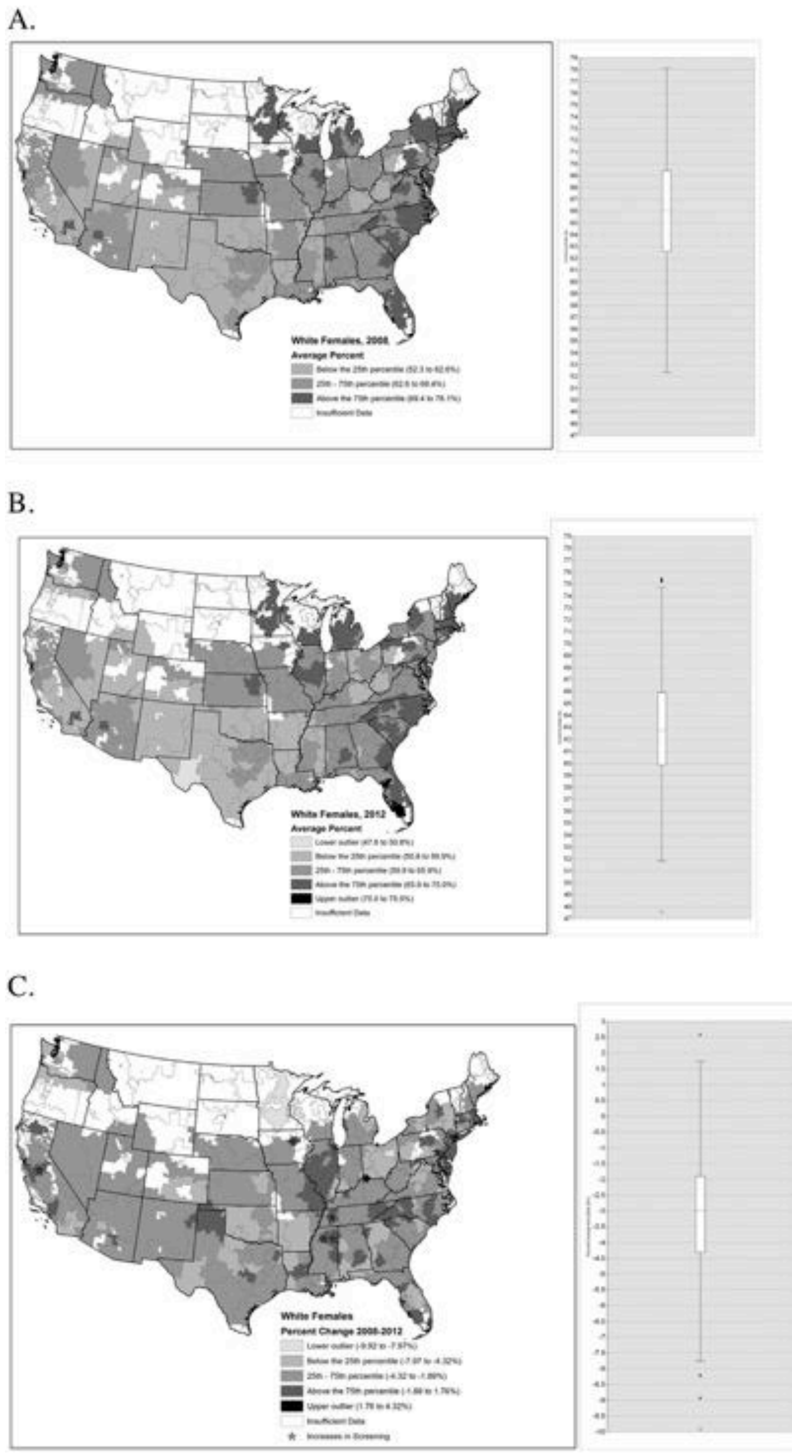

Figure 3. Box Maps and Matching Box Plots for White Female Medicare Beneficiaries Ages 67–69 by Hospital Referral Region (HRR): Average Percent Reporting Having Had a Mammogram in the Last Two Years, 2008 (A), 2012 (B); and Change in the Proportion (%) of Those Reporting Having Had a Mammogram in the Last Two Years, 2008 and 2012 (C). State lines provided for reference only. Regions in map C with an increase in screening are denoted with a star, as not all changes measuring above the 75th percentile were positive.

Trends for Black Women

For Black women across the U.S., the mean percentage change was -0.8% (SD = +5.95) when comparing mammography screening data from 2012 with respect to 2008, indicating an overall small decrease in utilization. The box map and box plot in Fig. 2 (C) display the variation in the distribution of screening utilization changes for Black women across HRRs. Most changes were small, from slightly negative to slightly positive, falling within the interquartile range (IQR: 25th percentile = -3.3%; 75th percentile = +2.5%). The 125 HRRs reflecting these changes were spread across the U.S. HRRs with values falling below the 25th percentile to the bottom whisker (n = 51), represent moderate decreases in screening that range from -3.3% to -11.6%, located across the U.S. from New England, to Texas and the West. Regions with values beyond the 75th percentile to the top whisker (n = 55) experienced increases in utilization, ranging from 2.5% to 10.9%, and were concentrated in the eastern half of the U.S., but were also found in Washington state, California, and other locations. The box plot suggests a symmetric distribution with a wide range due to the presence of 16 outliers. Ten of them, mainly in the mid-West and West, pointed to large decreases in screening (ranging from -11.9% to -25.8%) compared to the national trend, while 6 outliers suggested big increases (ranging from +11.6% to +20.7%) in a few areas in the Northeast and California. The largest increase occurred in Worcester, MA, with a change of 20.7%, while the largest decrease occurred in Johnson City, TN, with a change of 25.8%. Global Moran's I analysis of changes in screening utilization did not yield statistical significance (I = 0.022; p-value = 0.38).

Fig. 4(A) displays the nine statistical clusters for Black women identified through the LISA test. Five clusters- Palm Springs/ Rancho Mirage, CA; Topeka, KS; Tulsa, OK; Elgin, IL; and Minneapolis, MN- represented significant decreases (ranging from -7.0% to -18.2%) in utilization of screening, while four clusters- Santa Rosa, CA; Lubbock, TX; Erie, PA; and Worcester, MA- represented significant increases (ranging from +10.9% to +20.7%). Regions representing opposite trends in the change of screening utilization surrounded some of the clusters. Thus, the clusters in Santa Rosa, Lubbock, Erie, and Worcester were located near other HRRs that experienced decreases or little increases in utilization. In contrast, the clusters in Elgin and Minneapolis occurred in the vicinity of other HRRs characterized by either increases, or small decreases, in screening utilization.

Trends for White Women

With a mean change of -3.1% (SD = 1.90), White women across the U.S. also presented with an overall decrease in screening from 2008 to 2012; it was larger than that of Black women. The box map and box plot in Fig. 3(C) display the variation in the distribution of screening utilization changes for Whites across the HRRs. Large areas across the U.S. experienced small negative changes in utilization that fell within the IQR (25th percentile = -4.3%; 75th percentile = -1.9%). The 125 HRRs reflecting these changes are located throughout the contiguous U.S. HRRs with values falling below the 25th percentile to the bottom whisker (n = 58), represented moderate decreases in screening utilization that range from -4.3% to -7.8%, and are found in the eastern and southern parts of the U.S., as well as Washington, Oregon, California, and Arizona. Regions with values beyond the 75th percentile to the top whisker (n = 60) experienced either small increases or small decreases in utilization, ranging from -1.9% to +1.7%, and were located mostly in the eastern half of the U.S., but also Texas, Arizona, and California. The box plot in Fig. 3(C) suggests a symmetric distribution with a relatively narrow range and the presence of a few outliers (n = 4). Three outliers, located in Minnesota and Ohio, point to relatively large decreases in screening utilization (ranging from -8.2% to -9.9%) compared to the national trend, while one outlier suggests a relatively big increase (+2.6%) in Covington, KY. This represented the largest screening increase among White women, while the largest decrease occurred in Canton, OH, with a change of -9.9%. Global Moran's I indicated statistically significant positive spatial autocorrelation ($I = 0.193$; p-value < 0.001) of the changes in screening utilization.

Fig. 4(B) displays the 22 statistical clusters identified for White women through the LISA test. Seven clusters- Pittsburgh, PA; and Akron, Canton, Cleveland, Columbus, Elyria, and Youngstown, OH- represented significant decreases (ranging from -4.6% to -9.9%) in utilization of screening. Fifteen clusters- Montgomery, AL; Covington, KY; Amarillo, TX; Chicago, Hinsdale, Joliet, and Melrose Park, IL; Oxford, MS; Camden, New Brunswick, and Paterson, NJ; Bronx, Manhattan, and White Plains, NY; and Jackson, TN- identified regions of significant increases in utilization relative to all values for this population, but actual values ranged from -1.1% to +2.6%, indicating slight decreases to small increases in utilization. Regions representing contrasting trends in screening utilization surrounded some clusters. Thus, the clusters in Alabama, Kentucky, and Texas were located near other HRRs that experienced moderate decreases in utilization.

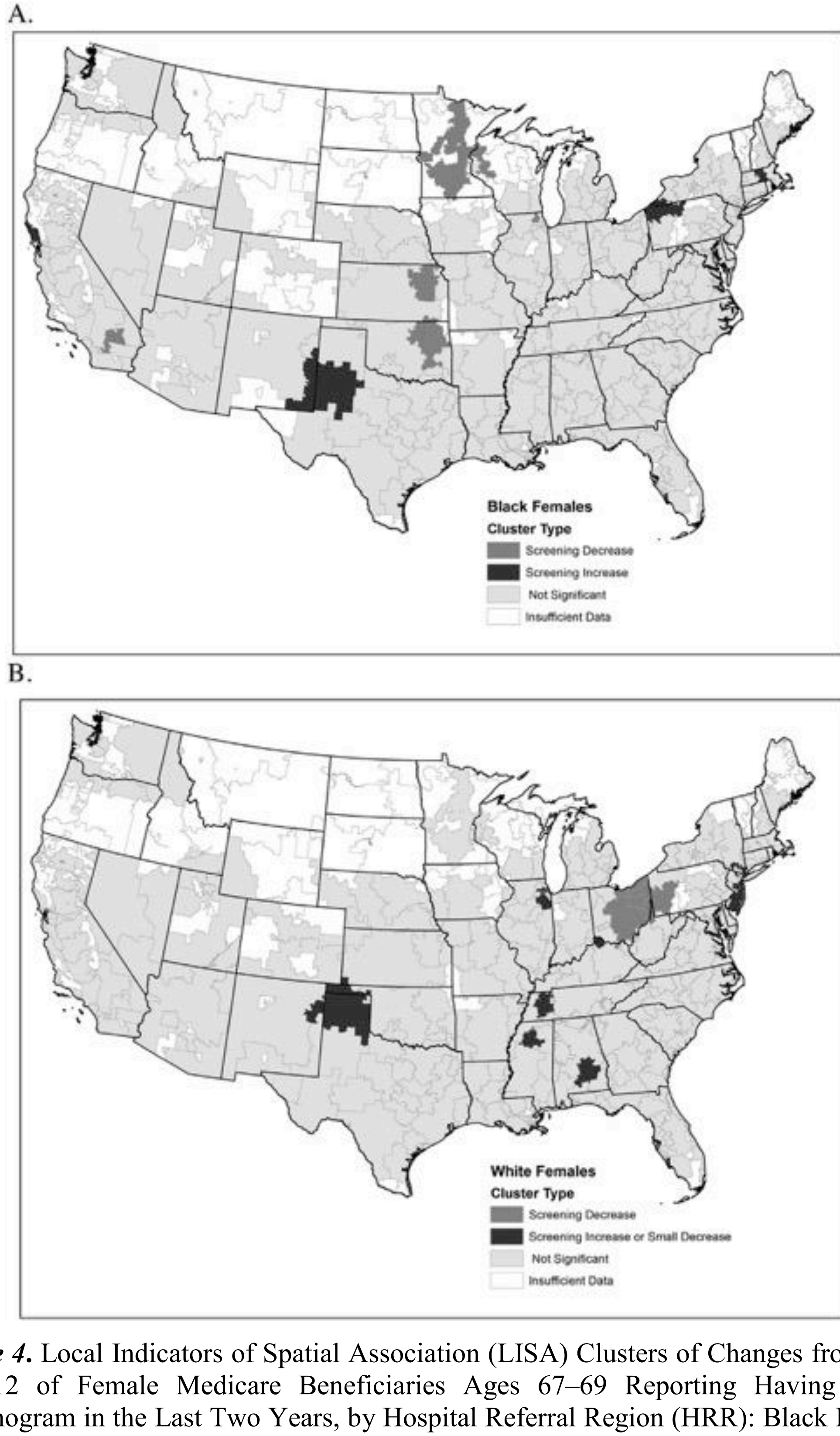

***Figure 4*.** Local Indicators of Spatial Association (LISA) Clusters of Changes from 2008 to 2012 of Female Medicare Beneficiaries Ages 67–69 Reporting Having Had a Mammogram in the Last Two Years, by Hospital Referral Region (HRR): Black Females (A), White Females (B). State lines provided for reference only. Clusters in map A based on data analysis after removing outliers from 2008 and 2012 input years.

Disparity Statistics

Results of the Disparity Statistics are shown in Fig. 5, including maps identifying statistically significant differences between Black and White women's rate of screening in both 2008 and 2012, when White women are taken as the reference. In 2008, statistically significant variations in absolute screening rates were most pronounced in the Southern U.S., and also occurred in patches through New England, Texas, the Midwest, and the West Coast. These disparities all indicate Black women received less screening than White women. Significant differences between Black and White women's absolute screening rates in 2012 persisted in New England, Texas, the Midwest, and the West Coast, but appear to have lessened in the South. Black women had lower screening than White women in all regions except Chicago and Blue Island, IL, where Black women had higher screening than White women.

The significance of the *relative disparity statistic*, or rate ratio, tells a similar story. In 2008, Black women were screened less than White women in areas across the South, New England, Midwest, and West Coast. Likewise, in 2012, the relative differences between Black and White women indicate lower screening for Black women in the West, Midwest, South, and East. However, there were also four regions where Black women had higher relative screening rates than White women: Chicago and Blue Island, IL; Muskegon, MI; and Owensboro, KY.

When comparing the maps in Fig. 5, the absolute and relative differences in screening between Black and White women in each of these years followed one another for the most part. In 2008, there was a correlation between the absolute rate difference and rate ratio between Black and White women through the West Coast and middle of the

U.S. However, there were HRRs in Texas, Florida, the Midwest, and parts of the Northeast where absolute and relative differences were not correlated. In 2012, regions in Washington, California, Michigan, Rhode Island, Kentucky, Virginia, and Mississippi had HRRs where absolute and relative differences were not correlated. We found that in 2008, 66% (n = 117,049) of Black women were affected by racial disparities in screening, as identified by regions where both absolute and relative differences correlated. In 2012, this number decreased to 41% (n = 80,627).

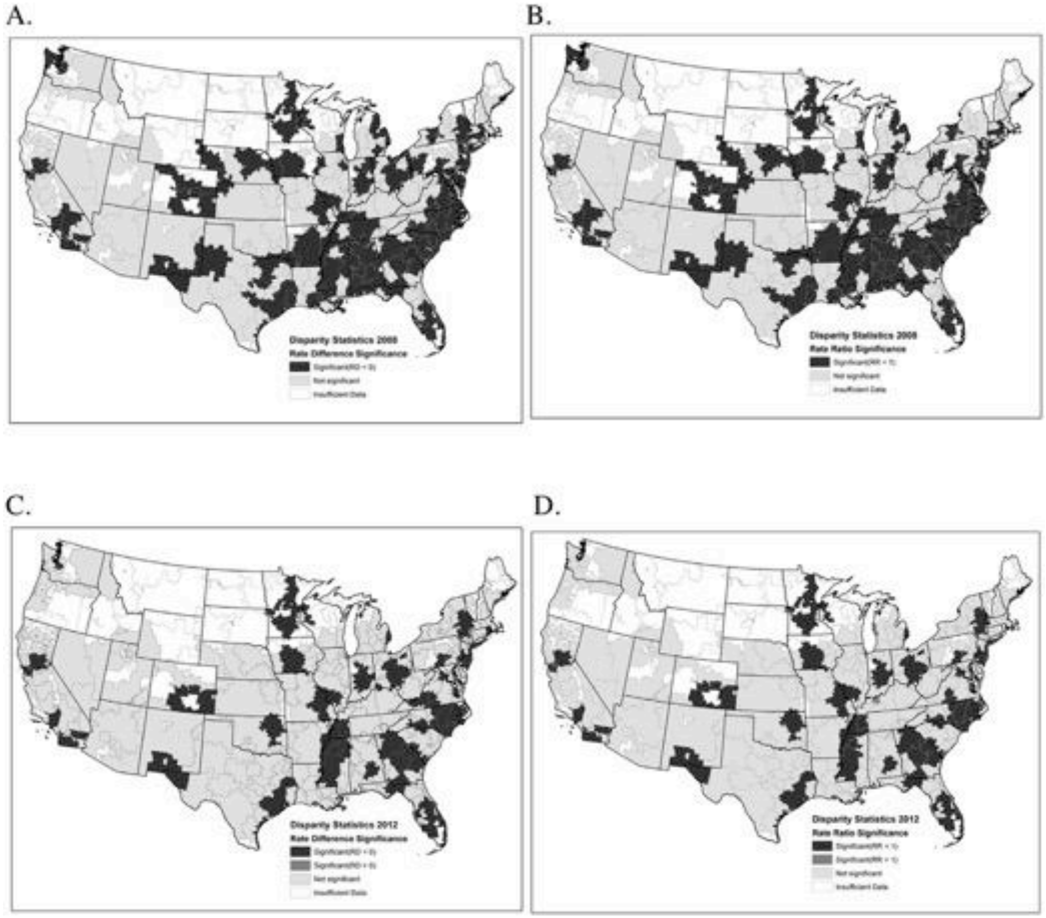

Figure 5. Disparity Statistics Between Black and White Female Medicare Beneficiaries Ages 67–69 by Hospital Referral Region (HRR): Significance of Rate Differences, 2008 (A); Significance of Rate Ratio Differences, 2008 (B); Significance of Rate Differences, 2012 (C); Significance of Rate Ratio Differences, 2012 (D). State lines provided for reference only.

Discussion

This study assessed geographic variations in screening mammography, accounting for both race and geographic context. This paper highlights the importance of exploring this health-seeking behavior from a spatial perspective: indeed, nation-wide averages of changes in mammography do not uncover the more complete story of stark differences between Black and White women when assessing data using a method that incorporates geography. This study also adds to existing disparities research by assessing the change in screening for women across an important period of time (2008–2012), during which the national rates for breast cancer incidence and mammography for Black and White women converged, as well as the differences between Black and White women in each of these years. While Medicare beneficiaries are only one segment of U.S. women, the changes in screening we observed may point to larger trends as their Medicare status equalizes lack of insurance as a potential confounder. Indeed, we found that changes were not consistent across the U.S. for either Black or White women, which is likely to hold true for other age groups. Additionally, this paper lays the foundation for further study that investigates factors influencing these changes.

Screening utilization decreased in both groups of female Medicare beneficiaries ages 67-69 from 2008-2012, though Whites had a larger decrease. While there was little overall change in screening among Black women for the U.S. as a whole, the change within individual HRRs varied greatly. More importantly, summary statistics do not reveal the large geographic differences in changes that exist for Black women. While the mean percentage of screening among White women across the U.S. decreased overall, they presented with less variation in the change. That is, there is less spread in the distribution of screening utilization change among White compared to Black women, and fewer outliers. Black women thus experienced both higher magnitudes of increases and decreases in screening, indicating greater within-group variability.

Global Moran's I analyses indicated stronger positive spatial autocorrelation for White compared to Black women, suggesting the changes in screening among Whites demonstrate a more clustered pattern across the U.S. Further, there were more LISA clusters for Whites, with significant decreases in screening concentrated in Ohio and Pittsburgh. There were also clusters of relative increases in the eastern U.S. for Whites, but the absolute magnitude of their associated values ranged from slight decreases to small increases in utilization. Thus, similar values of percent change in mammography were geographically located near one another for Whites.

Overall, there does not appear to be a distinct clustered pattern in the distribution of regions with more noticeable changes (in either the positive or negative direction) for Black women. Such changes tend to be dispersed and not concentrated in a major region in the U.S., as evidenced by the weak Global Moran's I result and few LISA clusters. This fragmentation (lack of clustering) in screening changes among Black women indicates the absence of an obvious, large-scale factor underlying changes in mammography utilization (e.g., Black population density). Thus, deviations from the national trend are likely to be rooted in local health practice signatures rather than broad regional trends. Such local influences may range from personal beliefs about screening to the effects of women entering retirement age and thus able to access health insurance. Further, local educational efforts may have spurred women who are gaining access to Medicare to seek mammograms, especially as with the advent of the Affordable Care Act

(2011), covered women could receive a screening mammogram once every 12 months without out-of-pocket costs [24].

Exploring differences between Black and White women's screening in 2008 and 2012 respectively revealed that there are regions where there are disparities in screening rates in absolute and relative terms, between Black and White women. For the most part, Black women's screening was lower than that of White women. Indeed this gap, while we found that it decreased, affected two-thirds of Black female Medicare enrollees ages 67–69 in 2008, and two-fifths of this population in 2012.

Our study is relevant because recommendations on how often women of different ages and races should receive screening mammograms are fraught with debate, having significantly changed over time and by agency. For example, in 2002, The United States Preventive Services Task Force (USPSTF) recommended screening mammograms every one or two years for women ages 40 and above [25]. In 2009 and 2016, however, the agency changed its guidelines so that its screening recommendations differed by age range [26,27], essentially recommending fewer screenings for women of certain ages. This change was criticized by some as ignoring existing science and overemphasizing potential harms of the procedure [28], and contrasted with guidelines put forth by other organizations, such as the American Cancer Society (ACS), which, in 2014, suggested women receive mammograms every year beginning at age 40 [29]. In 2015, however, the ACS amended its recommendation to also vary screening by age, including recommending fewer screenings [30]. By contrast, the American College of Obstetricians and Gynecologists (ACOG) maintained its 2015 recommendation in 2016, advising annual mammograms beginning at age 40 [31]. Such a plethora of changes in screening guidelines can result in confusion among women (and their caregivers) about the best preventive care measures. Researchers who favor less regular screening mammography cite the problem of over-diagnosis [8], though others argue over-diagnosis is often overestimated [32]. Although the effects on individual women are under debate, proponents argue that screening also poses the potential for increased psychological distress [33,34], unnecessary biopsies [33,34], and additional radiation exposure [34] due to false positive results. Others, and more specifically advocates for Black women, argue that this population presents with breast cancer earlier and more often with treatment resistant cancer [35,36], and that this should be taken into account when suggesting less use of mammography. Clearly these issues affect both individual decision-making regarding mammography, as well as screening recommendations and policy.

For women ages 67–69, the USPSTF currently suggests screening every two years, the ACS recommends screening every two years or have the option to continue yearly screening, and the ACOG advises yearly screening [27,30,31]. In assessing this age group, in which all women have the option to access healthcare through Medicare, we identified geographic areas in which beneficiaries are in adherence to guidelines recommending mammograms at least every two years. We found that even when women gained access to screening through Medicare, utilization did not uniformly increase. Thus, community-based educational outreach to Black women and others at high risk is a critical element in addressing breast cancer disparities.

Future research should assess geospatial differences in screening changes, and their relationship to breast cancer incidence, across the U.S. among women of all ages. We also suggest exploring factors that may be associated with these variations, allowing for the systematic identification of environments, policies, and individual-level variables that may impact preventive health behavior. Such discoveries may then be used to further contextualize and inform policy changes, as well as assist healthcare professionals in understanding who is most and least likely to screen, and thus how to effectively tailor communications with different patients, which have the potential to assist in efforts to decrease health disparities.

Conflicts of Interest

None.

Authorship Contributions

Stiel, Soret, and Montgomery each contributed to the manuscript in accordance with the four criteria of the International Committee of Medical Journal Editors, contributing substantially to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafting or critically revising the work for content; and providing approval of the final version and agreeing to be accountable for the work, ensuring questions are appropriately investigated and resolved.

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CHAPTER 5

CONTEXTUAL FACTORS AFFECTING INCREASED COUNTY SCREENING MAMMOGRAPHY BY U.S. BLACK AND WHITE MEDICARE BENEFICIARIES

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Abstract

Objective. To assess whether certain ecological-level variables are associated with the geospatial pattern of change in screening mammography among Black and White Medicare enrollees.

Data Sources/Study Setting. Secondary data representing the contiguous U.S., drawn from the Dartmouth Atlas of Health Care on female Medicare recipients ages 67-69, and from the American Community Survey on county characteristics.

Study Design. We conducted aspatial and geographically-weighted logistic regression to determine whether county median age, 2008 screening rate, racial and income concentration, and the percentage of high school graduates, married population, and females with health insurance, were predictors of a county having an increase in screening among Black and White women, from 2008 to 2012.

Data Collection. Datasets were integrated using geographic information systems (GIS). Analyses included 837 counties for Black women and 1,600 counties for White women.

Principal Findings. For Black and White women, the odds of increased screening declined when the 2008 screening rate rose. The impacts of other variables on screening vary by race and location.

Conclusions. While some national patterns of mammography utilization exist, screening practice also varies locally and is impacted by the contextual climate.

Key Words. Mammography, health disparities, health services utilization, contextual factors, geographic information systems

Introduction

Nationally, and in most U.S. states, Black women are more likely to be diagnosed with late-stage breast cancer than White women (Deshpande et al. 2009; Elmore et al. 2005; Mobley and Kuo 2015; Warner and Gomez 2010), though the reverse is true in Utah, Wyoming, and North Dakota (Mobley and Kuo 2016). Late-stage breast cancer diagnosis is associated with worse survival (Howlader 2016; Li, Malone, and Daling 2003). By contrast, improved breast cancer survival outcome is associated with early detection by mammography in combination with improved treatment (Kaplan et al. 2015).

Recently, the overall number of U.S. women reporting having had a mammogram within the past two years has risen, and the rate of Black women receiving screening has recently met, and by some accounts surpassed, that of White women (DeSantis et al. 2015; National Center for Health Statistics 2014). Among older women, however, there is some debate as to whether screening has increased or decreased. While some studies of self-reported mammography have found no statistically significant decreases in screening among older women since 2009 (Howard and Adams 2012; Pace, He, and Keating 2013; Yao, Bradley, and Miranda 2014), another study found that screening declined from 2008 to 2010 and 2008 to 2012, among women ages 50- 74 and 75 years and above (Gray and Picone 2016), and studies assessing Medicare claims also discovered declines (Jiang et al. 2015; Jiang, Hughes, and Duszak 2015). Studies of Medicare recipients by Health Referral Region (HRR) indicate an overall decline in screening nationally, but increases in some individual HRRs, with larger magnitude increases and decreases among Black compared to White women from 2008 to 2012

(Anonymous 2017) and an increase in screening nationally among Black recipients when separated by race from 2007 to 2012 (Chang et al. 2016).

In order to determine the variables that contribute to screening, especially among Black women, many studies have explored characteristics of individuals, such as age (Reiter and Linnan 2011), education (Williams et al. 2008), socioeconomic status (Conway-Phillips and Millon-Underwood 2009), access to health care (Conway-Phillips and Millon-Underwood; Reiter and Linnan 2011; Young, Schwartz, and Booza 2011), and cultural attitudes and beliefs (Conway-Phillips and Millon-Underwood; Peek, Sayad, and Markwardt 2008). However, these analyses are incomplete, because institutional, community, and public policy factors also influence health care (McLeroy et al. 1988).

Since structural forces in society affect local neighborhood conditions, including poverty, racial isolation, and land use, which in turn affect other neighborhoods (Massey 2001), place matters. As Krieger (2016) points out, "people literally embody, biologically, the multilevel dynamic and co-constituted societal and ecologic context within which we live, work, love, play, fight, ail, and die, thereby creating population patterns of health, disease, and well-being within and across historical generations" (p. 832). Particularly for Blacks compared to Whites, residential segregation based on race affects both disparities in health (Williams and Collins 2001), and inequalities in health care (White, Haas, and Williams 2012). Place of residence may also be an independent factor in use of screening mammography (Legler et al. 2002).

Indeed, some studies have assessed ecological factors associated with screening mammography, finding increased likelihood of screening among Kansas Medicare beneficiaries who lived in counties with higher median incomes and a larger proportion of high school graduates (Engelman et al. 2002), and increased adherence to screening guidelines among U.S. women ages 50-74 who lived in areas without a shortage of primary care providers, more screening facilities with tracking and reminder systems, higher HMO market share, and higher screening charges (Phillips et al. 1998). Never having had a mammogram has been inversely associated with median area education level, positively associated with a high proportion (70-100%) of area residents being Hispanic, and more likely in areas with the following: median income between $10,000-$29,999; median age between 18-29 compared to 45-59; and 10-39% of residents in poverty Wells and Horm (1998). An increase in the proportion of women ages 65-74 screened was associated with total price-adjusted per capita Medicare spending, but only for White and Hispanic women, and with the composite quality score of Medicare effective care use, but only for Whites (Chang et al. 2016). For Black women, the proportion screened was positively associated with poverty rate and negatively associated with percent rural (Chang et al.). Among women ages 75 and older, the proportion screened was positively associated with Medicare spending for all races except Black women, who did not have any significant associations (Chang et al.).

In order to gain a better understanding of the role of structure in affecting breast cancer health disparities, the present study was designed to assess not only how screening mammography is influenced by contextual characteristics of place, but also how this may vary by geographic location and race. Our objective was thus to explore whether certain ecological-level variables are associated with the geospatial pattern of change in screening mammography among female Medicare recipients ages 67-69 across the contiguous U.S. from 2008 to 2012. In particular, we assessed whether an increase in the percentage of a county's female Medicare enrollees ages 67-69 having had a mammogram over the last two years was impacted by county characteristics during this time.

Method

Data and Variables

The dichotomous dependent variable in these analyses was whether a county had an increase (no=0/yes=1), from 2008 to 2012, in the percentage of female Medicare enrollees ages 67-69 having had a mammogram in the last two years. We analyzed rates for Black and White women separately. This data was obtained from The Dartmouth Atlas of Health Care (DAHC), which integrates multiple databases to provide data on services used by Medicare recipients who are not enrolled in a risk-bearing health maintenance organization (HMO) (The Dartmouth Atlas of Health Care 2015); mammography data is only available for women ages 67-69.

To account for baseline screening, we included the DAHC measure of percentage of Medicare recipients, for each racial group, in 2008 reporting having had a mammogram in the last two years as an independent variable. The remaining independent variables were drawn from the 2008-2012 Five-Year American Community Survey (ACS), which is provided by the U.S. Census Bureau (U.S. Census Bureau 2014). These include county-level data for the following: median age; percentage of the population age 25 and over with a high school diploma, GED, or alternative only (not including those with any higher education); percentage of the population age 15 and over who are married (except separated); and percentage of the female civilian non-institutionalized population with health insurance coverage.

Data on race and income from the ACS were also used to calculate two Index for Concentration at the Extremes (ICE) variables. ICE was developed by Massey (2001) to estimate the proportional (im)balance between two groups within a local area, instead of separate effects, which can also lead to problems with multicollinearity. The variable provides a quantification of the concentration of privilege in an area on a continuum from -1 (most deprived) to 1 (most privileged). While Massey proposed the measure for use with income disparity, Krieger et al. (2015) introduced it for use with the polarization that exists due to race/ethnicity. Understanding race as a social construct, $ICE_{race/ethnicity}$ is important since racial residential segregation affects health care (White, Haas, and Williams 2012). Based on previous studies (Feldman et al. 2015; Krieger, Singh, and Waterman 2016; Krieger et al. 2016) and defining the cutoffs for low income at the 20th income percentile and high income at the 80th percentile, we calculated these measures, for each county, as follows:

$$ICE_{income} = \frac{(Number\ of\ households\ earning \geq \$100{,}000) - (Number\ of\ households\ earning < \$25{,}000)}{Total\ number\ of\ households\ in\ county\ with\ income\ data}$$

$$ICE_{race/ethnicity} = \frac{(White\ non{-}Hispanic\ population) - (Black\ non{-}Hispanic\ population)}{Total\ population\ in\ county\ with\ race/\ ethnicity\ data}$$

Statistical Analysis

We screened the data for missing values and multicollinearity, and assessed outliers using Mahalanobis testing. Forward stepwise (Likelihood Ratio) logistic regression was conducted to determine which independent variables were predictors of an increase in screening for Black and White women, respectively. SPSS Version 24 (IBM Corp. 2016) was used for data screening and the aspatial regression analyses.

We then applied a geographically weighted regression (GWR) for each group with the same variables used in the aspatial models, using SpaceStat Version 4 (BioMedware 2014). Especially valuable for use with large geographic areas, GWR provides local estimates of the impact of variables on the model, rather than assuming they are constant across the area as with traditional, aspatial regression (Goovaerts et al. 2015). Because the sample points were not regularly spaced in the study area (Charlton and Fotheringham 2009), we used an adaptive bandwidth with a fixed number of neighbors: 67 neighbors for Black women, and 149 for White women. These kernel sizes were determined by assessing correlograms created with GeoDa (Anselin, Syabri, and Kho 2006) using the residuals from each of the aspatial regression analyses. While we used two different weighting approaches, the Bisquare-Adaptive and Equal Weights methods, only results from the Equal Weights method are presented here. Mapping of results was conducted using ArcGIS version 10.3 (Esri 2014).

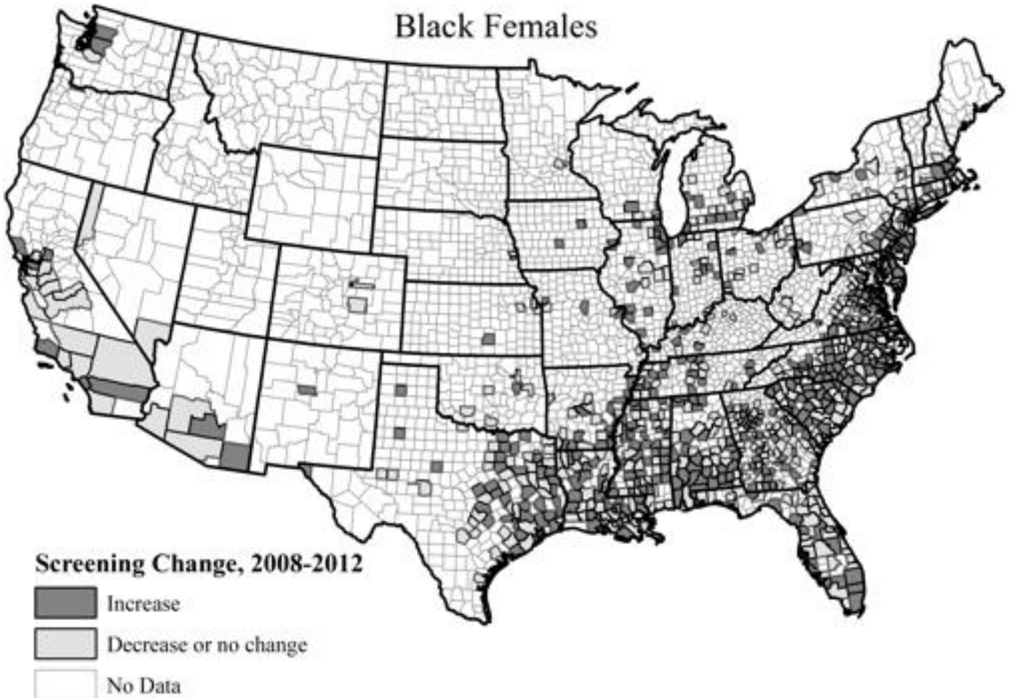
Results

Descriptive characteristics are shown in Table 1. Counties with rates based on fewer than 11 individuals were not included in the analyses because they are suppressed by the DAHC to protect patient confidentiality (The Dartmouth Atlas of Health Care 2015). In order to be included, counties must have had screening rates available for both 2008 and 2012. We excluded an additional seven counties from the analyses of Black women and 28 counties from those of White women based on Mahalanobis testing for outliers. Figure 1 displays the counties that had screening increases, and those that did not.

Table 1. Descriptive characteristics.

	Black Females	White Females
Counties with increased screening, *n*(%)	410 (49.0)	381 (23.8)
Counties with no change or decreased screening, *n*(%)	427 (51.0)	1219 (76.2)
Total *n* of counties in analyses	837	1,600
Characteristics of counties analyzed		
2008 Screening rate, Mean (*SD*)	60.00 (8.98)	65.19 (8.29)
Median age, Mean (SD)	38.31 (4.05)	40.56 (5.02)
Percentage of population with high school diploma or equivalent, Mean (SD)	32.16 (6.54)	34.61 (6.76)
Percentage of population now married, Mean (SD)	48.38 (6.59)	52.73 (7.47)
Percentage of females with health insurance, Mean (SD)	85.72 (4.61)	86.39 (5.17)
$ICE_{income,}$ Mean (SD)	0.11 (0.18)	0.13 (0.15)
$ICE_{race,}$ Mean (SD)	0.40 (0.31)	0.64 (0.34)
Female Medicare enrollees ages 67-69, 2008		
Total *n* in counties analyzed	163,455	1,281,253
Mean (SD) by county	195.29 (452.61)	800.78 (1815.51)
Minimum by county	14	16
Maximum by county	8,245	36,358
Female Medicare enrollees ages 67-69, 2012		
Total *n* in counties analyzed	181,026	1,382,582
Mean (SD) by county	216.28 (485.01)	864.11 (1982.28)
Minimum by county	16	18
Maximum by county	8,917	38,083

A.



B.

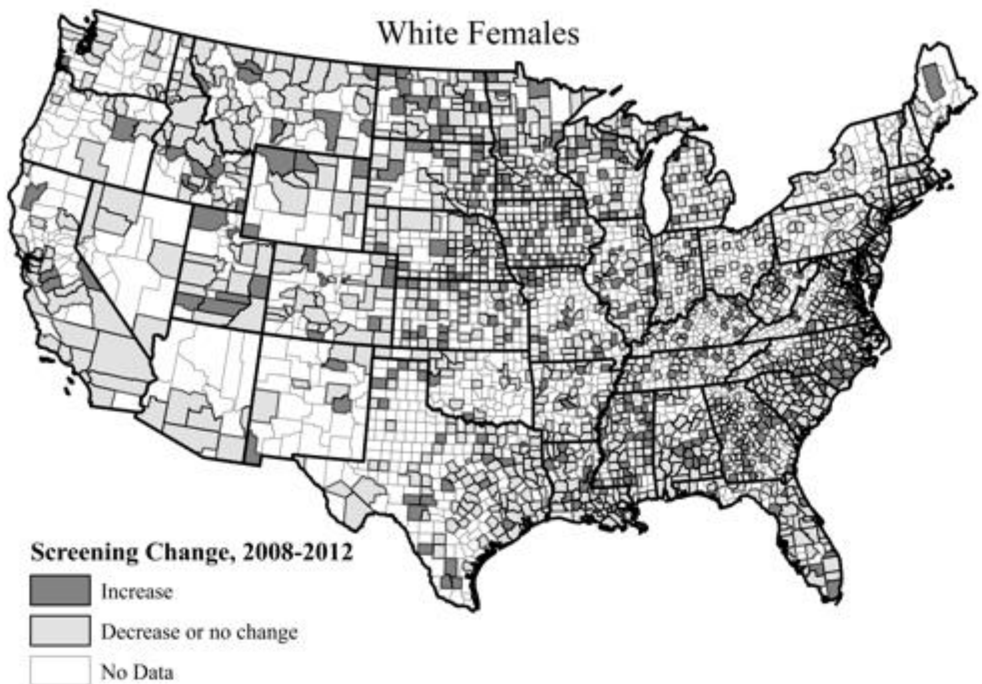


Figure 1. Counties with Increase or Decrease/No Change in the Average Percent of Medicare Beneficiaries Reporting Having Had a Mammogram in the Last Two Years, 2008-2012: Black Females (A), and White Females (B). State lines provided for reference only.

Aspatial Regression Analyses

Results of the aspatial regression analyses are presented in Table 2. For Black women, results indicated an overall model fit of three predictors (screening rate for Black women in 2008, median age in county, and percent of females with health insurance) with Cox and Snell R^2= .210 (-2 Log Likelihood= 962.853) and statistically significant in distinguishing screening increase ($\chi^2(3)$= 197.130, p< .001). The model correctly classified 69.9% of cases. There is a small increase in the likelihood of a county's Black female Medicare population ages 67-69 having had an increase in screening mammography from 2008-2012 when median county age rises and the percentage of females with health insurance rises, and a decrease in the likelihood of having had an increase in screening when the 2008 screening rate for this group rises.

For White women, aspatial regression results indicated an overall model fit of six predictors (screening rate for White women in 2008, median age in county, percent of population married, percent of females with health insurance, ICE_{income}, and ICE_{race}) with Cox and Snell R^2= .131 (-2 Log Likelihood= 1532.363) and statistically significant in distinguishing screening increase ($\chi^2(6)$= 224.146, p< .001). The model correctly classified 78.6% of cases. There is an increase in the likelihood of a county's White female Medicare population ages 67-69 having had an increase in screening mammography from 2008-2012 when there is a rise in median age, the percentage of females with health insurance, and the percentage of the population who are married. There is a decrease in the likelihood of having had an increase in screening when the values for ICE_{income}, $ICE_{race/ethnicity}$, and the 2008 screening rate for this group rise.

Table 2. Results of aspatial logistic regression.

Black Females				
Variable	Parameter est.	Std. error	*p* value	Odds ratio (95% C.I.)
Screening rate, 2008	-0.138	0.012	<.001	0.871 (0.852-0.892)
Median age	0.057	0.020	0.004	1.058 (1.018-1.100)
Percentage of females with health insurance	0.047	0.018	0.009	1.048 (1.012-1.086)

White Females				
Variable	Parameter est.	Std. error	*p* value	Odds ratio (95% C.I.)
Intercept	-5.320	1.486	<.001	-
Screening rate, 2008	-0.119	0.010	<.001	0.888 (0.872-0.905)
Median age	0.030	0.017	0.077	1.031 (0.997-1.066)
Percentage of population now married	0.046	0.015	0.002	1.048 (1.017-1.079)
Percentage of females with health insurance	0.099	0.017	<.001	1.104 (1.068-1.140)
ICE_{income}	-1.542	0.561	0.006	0.214 (0.071-0.643)
$ICE_{race/ethnicity}$	-1.092	0.315	0.001	0.336 (0.181-0.623)

GWR Analyses

Table 3 provides a summary of the GWR results, indicating the number of counties with significant values for Black and White women respectively, as well as counts for the number of counties with odds ratios greater and less than one. Unlike the aspatial regression results, in which only some variables significantly contributed to the models, the GWR analyses resulted in all variables having at least some counties with significant values.

The only variable to have significant values across all counties was 2008 screening rate. As with the aspatial models for both Black and White women, the GWR showed that the odds of a county having had an increase in screening in 2012 decreased as the 2008 screening rate for each group went up (Figure 2A).

For Black women, the odds of increased screening rose as county median age went up for those counties with significant values in the GWR (Figure 2B). This was also true for most counties with significant values for White women, except in the Midwest, where the odds of increased screening declined as median county age rose.

Although education was not a significant factor in the aspatial models, it was significant in some counties in the GWR for both Black and White women (Figure 2C). For most counties with significant values, the odds of screening decreased as the percentage of the population with just a high school diploma or equivalent rose. However, odds increased as the percentage of high school graduates increased in counties in Louisiana and Arkansas for Black women, and in Tennessee, North Carolina, Alabama, Georgia, and Florida for White women. Interestingly, for Garland County, Arkansas, odds increased for Black women but decreased for White women, as the percentage of graduates rose. In Alabama, Georgia, and Florida, the reverse was true: a number of the same counties had screening odds that decreased for Black women but increased for White women as the percentage of graduates went up.

For both Black and White women, the odds of screening increased as the percentage of the population now married rose, in most counties with significant values in the GWR (Figure 2D). This was especially true in the Southeast, with significant values in North Carolina counties for both groups of women.

As the county percentage of females with health insurance went up, odds of increased screening also rose for most counties with significant values in the GWR (Figure 2E). For White women, counties in which the odds of increased screening declined were located in West Virginia and nearby states. For Black women, most counties with odds that decreased were located in the South, especially in Florida.

$ICE_{race/ethnicity}$ was not significant in the aspatial model for Black women, but 134 counties in the GWR did have significant values (Figure 2F). Of these, 120 had odds ratios less than one, indicating that the odds of increased screening declined as the $ICE_{race/ethnicity}$ value moved from a concentration of Black non-Hispanic residents toward a concentration of White non-Hispanic residents (less diverse). $ICE_{race/ethnicity}$ was significant in the aspatial model for White women with an odds ratios of less than one, meaning that the odds of increased screening fell as a county's population moved from a concentration of Black non-Hispanic residents toward a concentration of White non-Hispanic residents. In the GWR, 164 counties had significant odds ratios less than one, and 42 counties had odds ratios greater than one. There is some overlap in the states in which Black and White women experienced decreased odds of screening.

Although ICE_{income} was not a significant factor in the aspatial model for Black women, it was significant in 98 counties in the GWR (Figure 2G), 94 of which had ICE_{income} values that concentrate more to low income (Table 3). In 68 counties across Louisiana, Mississippi, and Arkansas, odds ratios were greater than one, indicating that the odds of increased screening rose as this variable moved from a concentration of low income toward a concentration of higher income. The reverse was true for 30 counties in Alabama, Georgia, Florida, North Carolina, and South Carolina, where odds ratios were less than one, suggesting that the odds of increased screening declined as a county's income concentration moved from lower to higher.

While most counties in the GWR for Black women with significant ICE_{income} values had odds ratios greater than one, the opposite was true for White women. The aspatial model for this group indicates that the odds of a county having had an increase in screening among White women fell when county household income moved from a concentration of lower income toward a concentration of higher income. GWR results were similar: 109 counties, located in South Dakota, Nebraska, Kansas, Minnesota, Iowa, New Jersey, Pennsylvania, Maryland, Delaware, Virginia, North Carolina, and South Carolina, also had odds ratios less than one (meaning the odds of increased screening declined as county income concentration shifted from low to high), while only 37 had odds ratios greater than one (signifying increased odds of screening rose as county income concentration shifted from low to high), located in Montana, Wyoming, Missouri, Illinois, Ohio, Pennsylvania, Virginia, West Virginia, Kentucky, and Louisiana. The majority of counties with significant values for this variable in the GWR had ICE_{income} values that concentrate more to low income.

Table 3. Result summary of GWR analyses.

Black Females	OR>1	OR<1	Not Significant	White Females	OR>1	OR<1	Not Significant
Screening rate, 2008							
< 60.00%	0	410		< 65.19	0	756	
≥ 60.00%	0	427		≥ 65.19	0	844	
Total	0	837	0	Total	0	1600	0
Median age							
< 38.31 years	36	0		< 40.56	89	12	
≥ 38.31 years	33	0		≥ 40.56	81	25	
Total	69	0	768	Total	170	36	1394
Percentage of population with just a high school diploma or equivalent							
< 32.16%	2	30		< 34.61	20	120	
≥ 32.16%	5	34		≥ 34.61	21	41	
Total	7	64	766	Total	41	161	1398
Percentage of population now married							
< 48.38%	19	1		< 52.73	90	0	
≥ 48.38%	15	0		≥ 52.73	79	2	
Total	34	1	802	Total	169	2	1429
Percentage of females with health insurance							
< 85.72%	7	51		< 86.39	98	18	
≥ 85.72%	83	11		≥ 86.39	169	10	
Total	90	62	685	Total	267	28	1305
$ICE_{race/ethnicity}$							
-1.00 to 0	0	9		-1.00 to 0	0	21	
0.01 to 1.00	14	111		0.01 to 1.00	42	143	
Total	14	120	703	Total	42	164	1394
ICE_{income}							
-1.00 to 0	64	30		-1.00 to 0	30	90	
0.01 to 1.00	4	0		0.01 to 1.00	7	19	
Total	68	30	739	Total	37	109	1454

Note: Significance tested at *p* <.05. OR= Odds ratio.

A.

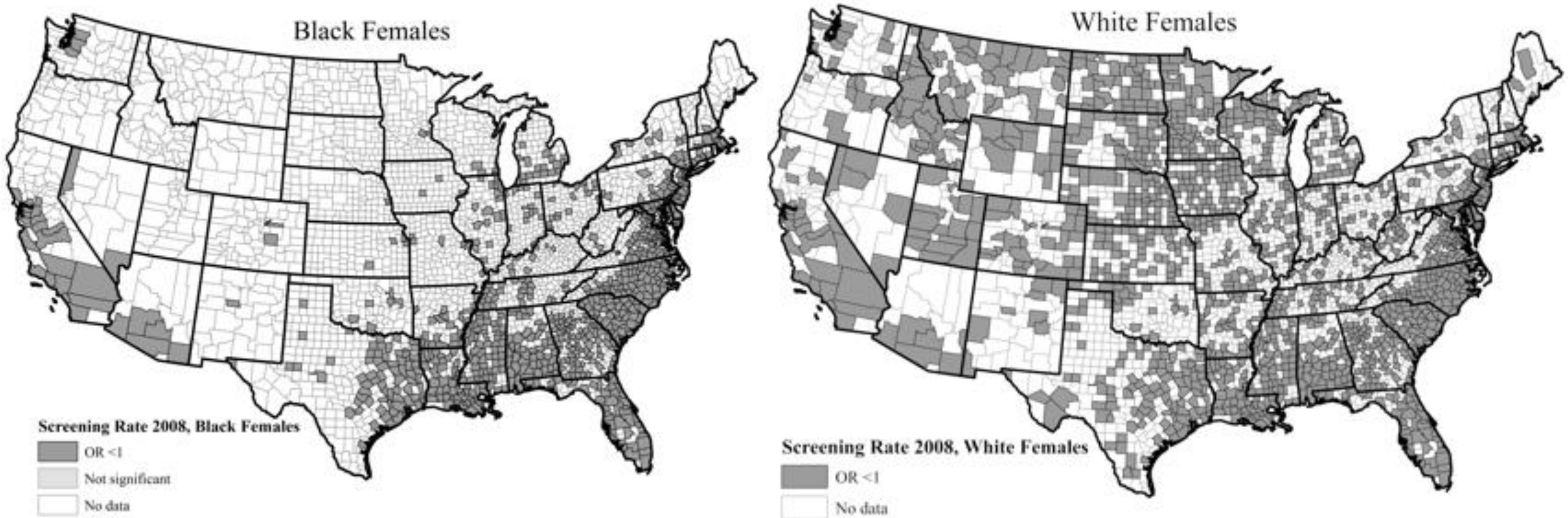


Figure 2. Maps of Odds Ratios from the GWR for the 2008 Average Percent of Female Medicare Beneficiaries Reporting Having Had a Mammogram in the Last Two Years (A), County Median Age (B), Percentage of the Population with Just a High School Diploma or Equivalent (C), the Percentage of Population Now Married (D), Percentage of Females in County with Health Insurance (E), ICE$_{race/ethnicity}$ (F), and ICE$_{income}$ (G), in Analyses of Black and White Females. State lines provided for reference only.
Note: OR= odds ratio; Pct= percent; HS= high school

B.

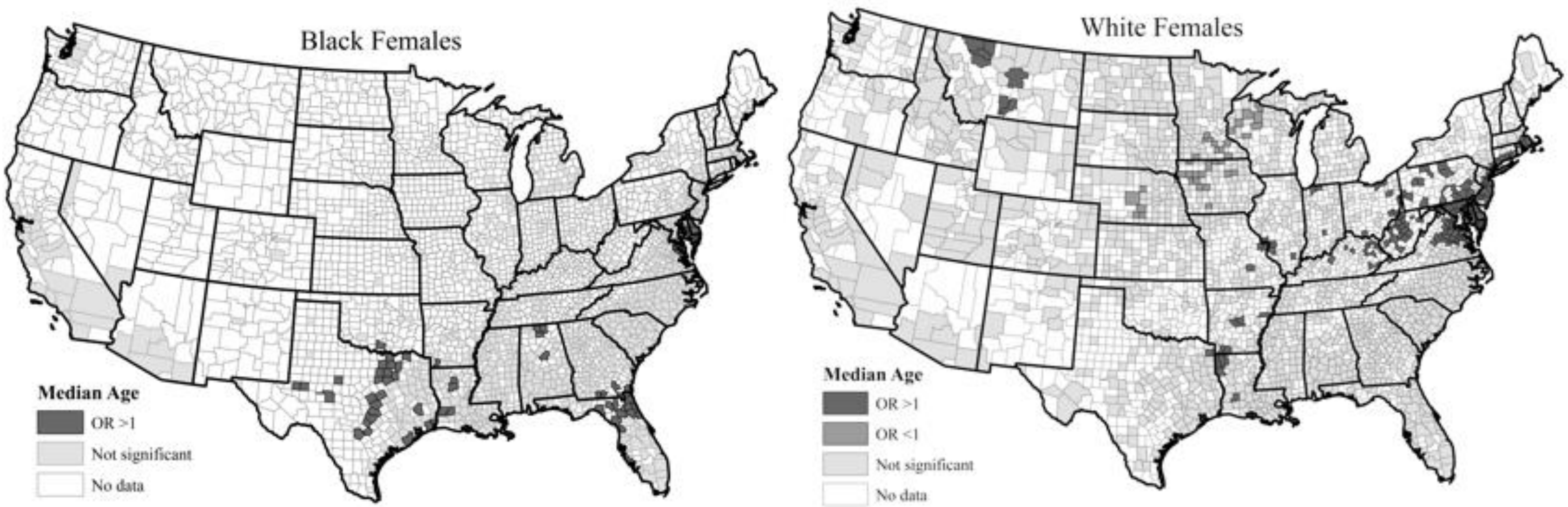


Figure 2. *Continued.* (B) County Median Age

C.

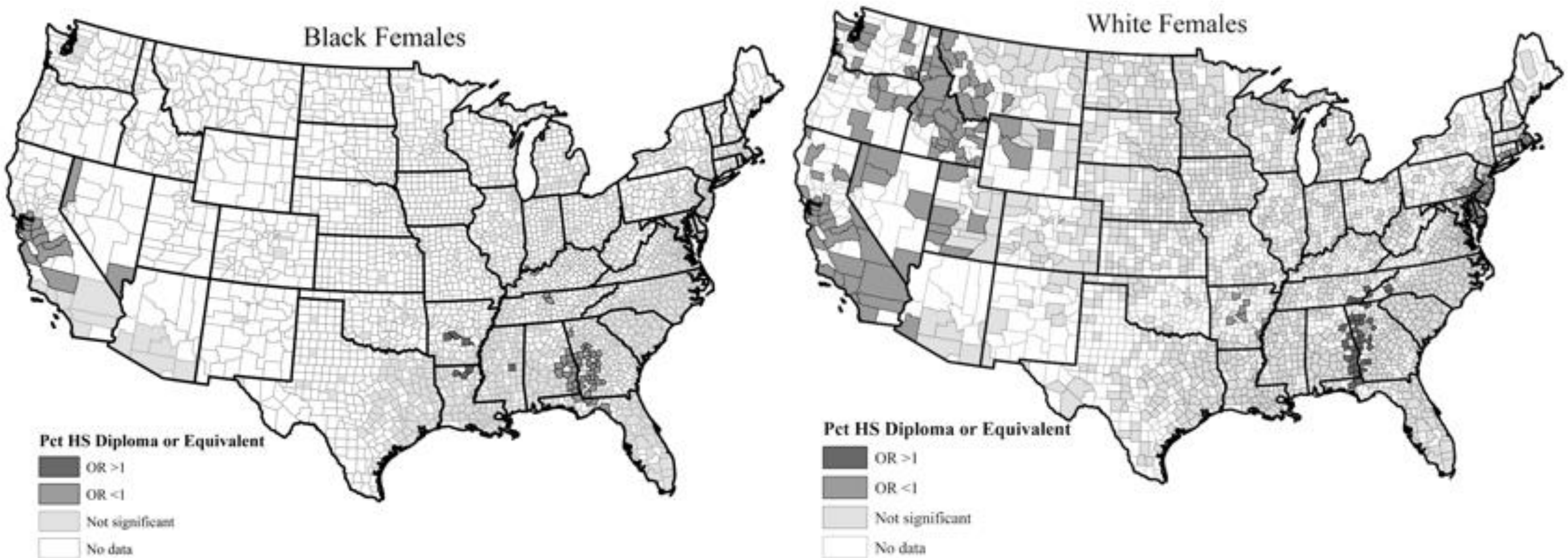


Figure 2. *Continued.* (C) Percentage of the Population with Just a High School Diploma or Equivalent

D.

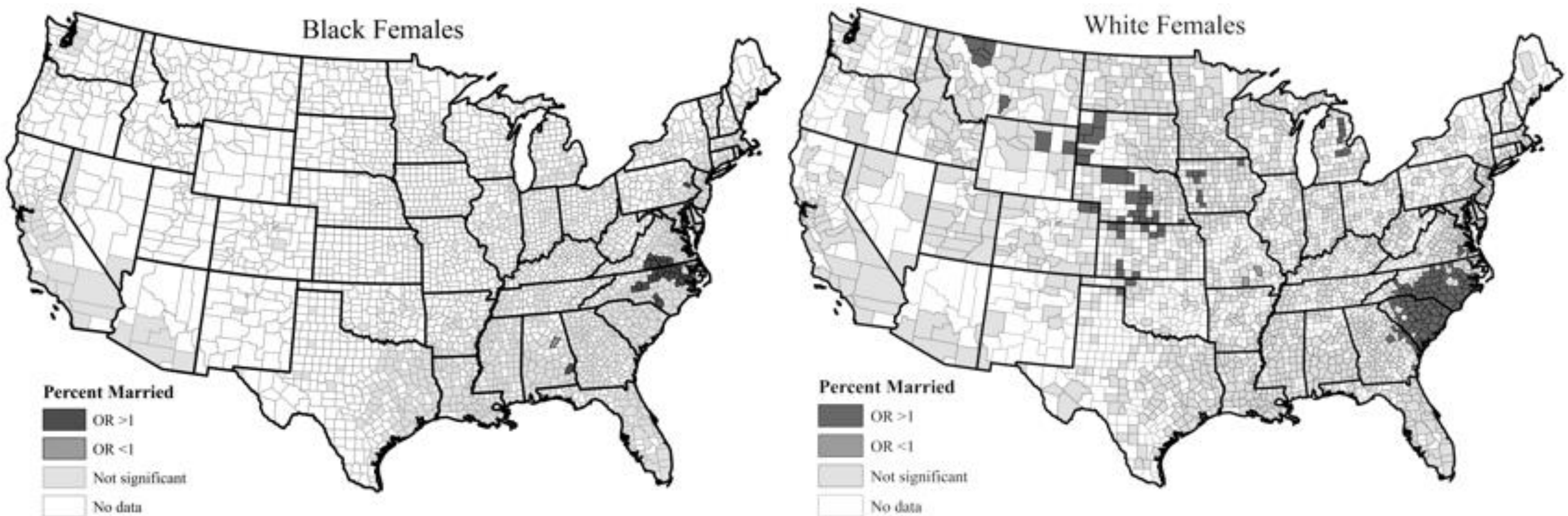


Figure 2. *Continued.* (D) Percentage of Population Now Married

E.

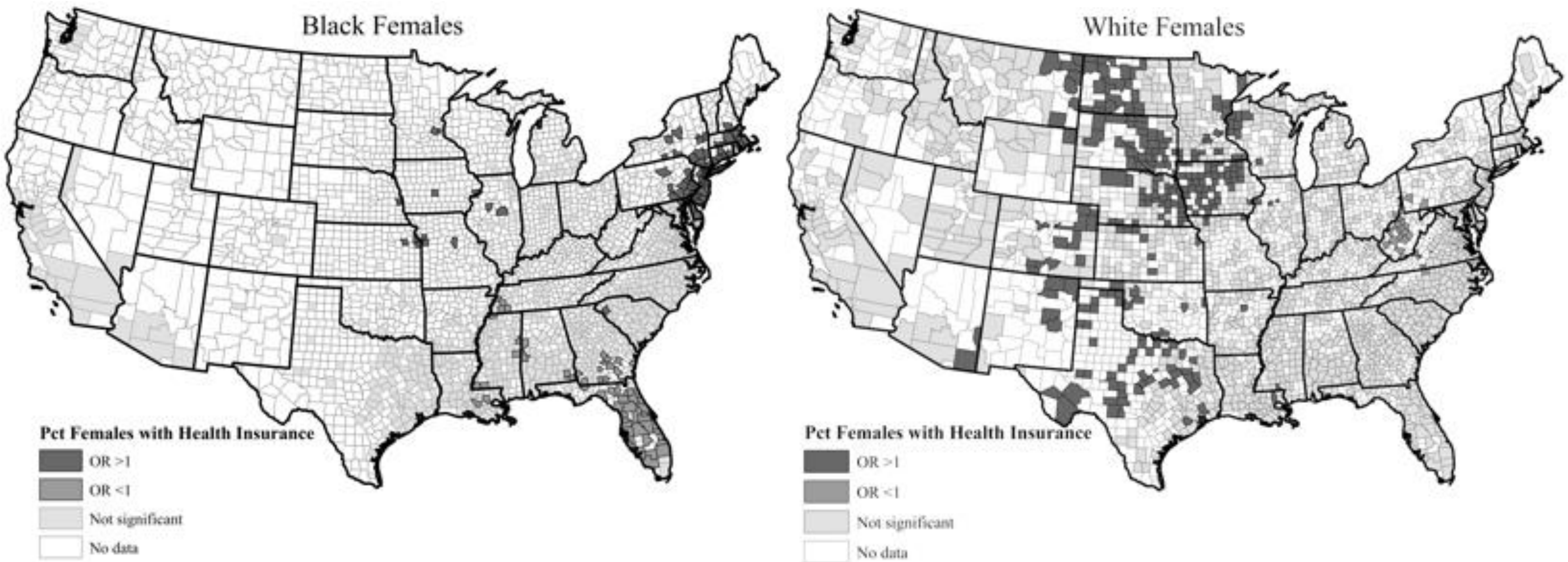


Figure 2. *Continued.* (E) Percentage of Females in County with Health Insurance

F.

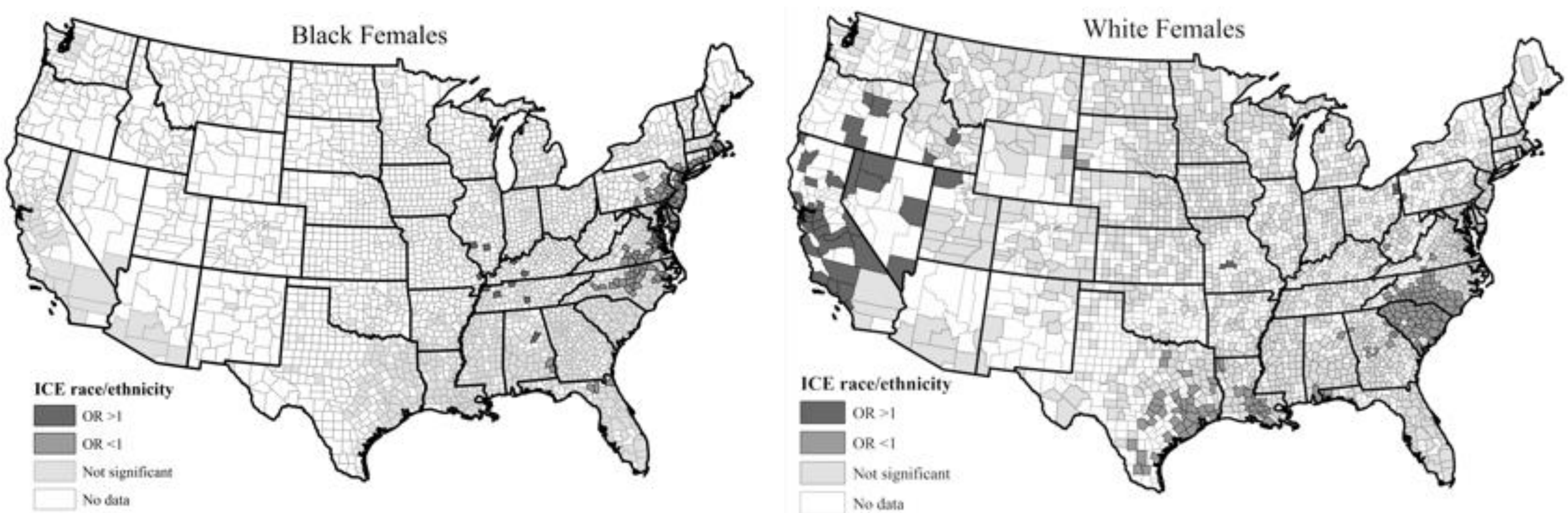


Figure 2. *Continued.* (F) ICE race/ethnicity

G.

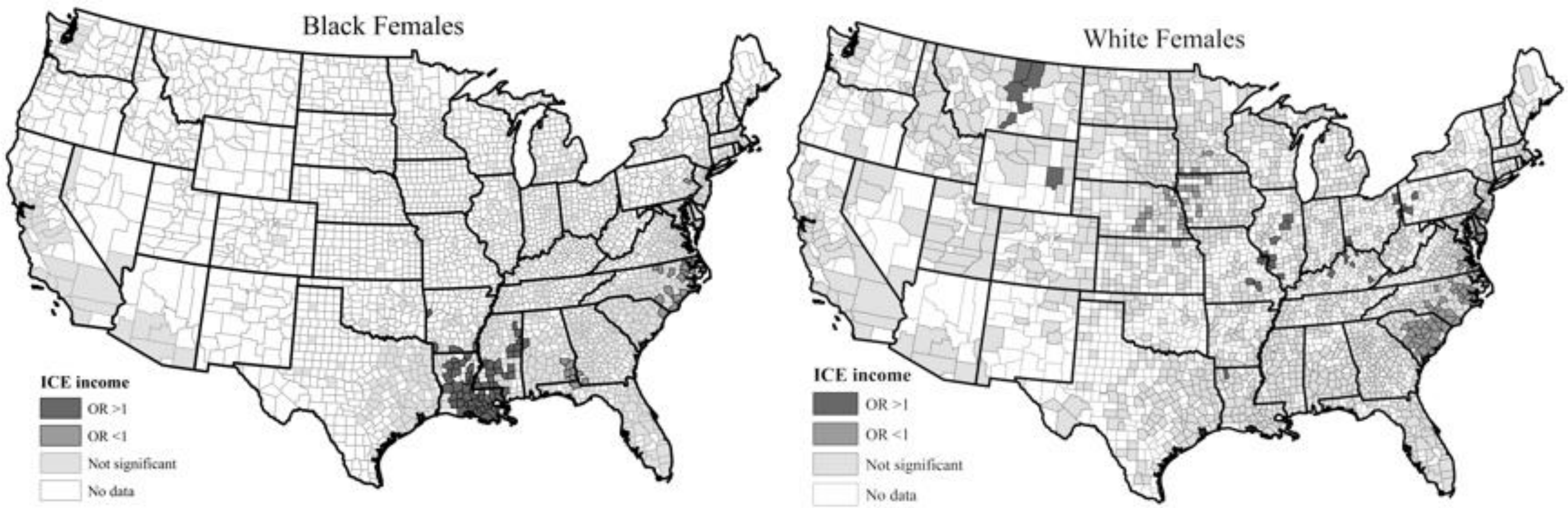


Figure 2. *Continued.* (G) ICE income

Discussion

This study explored whether contextual factors impacted the odds of a county having increased screening mammography by Black and White female Medicare enrollees ages 67-69, using both aspatial regression and GWR. While aspatial regression results provided models for both Black and White women that describe trends across the U.S. as a whole, GWR provided local estimates, revealing that the impact of the variables assessed varies by geographic location.

For example, the aspatial regression models for both Black and White women indicate that odds of increased screening rose as the percentage of females with health insurance in a county rose. Although this was also true for most counties with significant values in the GWR, there were also some counties in which the opposite trend occurred: the odds of increased screening declined as the percentage of females with health insurance rose. While more research is needed to understand why counties with more insured women would have lower odds of having had an increase in screening, mammography *capacity*, which affects access to screening, may play a role. For instance, screening availability in the South decreased from 2002 to 2008, lacking the capacity to screen 100 percent of women ages 40 and above, plus 15 percent for second views or diagnostics (Eberth et al. 2014). Decreased odds may also be affected by differences in the health insurance benefits offered in different states and counties. For example, in a study of women ages 65-74 with Medicare Advantage insurance from 2007-2012, Jena et al. (2017) found that those who had access to more affordable screening (in which a $20 copayment was eliminated), had an increase in screening compared to those who did not have access to free screening, especially for women who were not receiving screening previously, regardless of neighborhood SES or race.

The role of the racial makeup of a county, as measuered by $ICE_{race/ethnicity}$, in impacting screening also varied by geographic location. For most counties with significant values in the GWR for both Black and White women, odds ratios were less than one, indicating that the odds of increased screening declined as the $ICE_{race/ethnicity}$ value moved from a concentration of Black non-Hispanic residents toward a concentration of White non-Hispanic residents. Decreased odds of a county having a rise in screening when race is more concentrated toward White non-Hispanic residents may be due to the implementation of programs targeting Black women for early detection through increased screening mammography. This is the proposal offered by Haas et al. (2008), who found that while Black women were less likely than White women to be diagnosed with early-stage breast cancer, this disparity was smallest in the most segregated areas, suggesting that living in an area with more Black women may have helped diagnose breast cancer in Black women earlier due to screening programs targeting this group. Similarly, in a 1993-1994 study of low-income women ages 50-64, Black women were more likely to have had a recent mammogram than Whites, despite adjustments for insurance coverage, place of care, residence in city, education, geographic region, and age; further, screening increases were more rapid among Black compared to White women from 1991-1994 (Makuc, Breen, and Freid 1999). As was true for a study by Warner and Gomez (2010) on the impact of racial residential segregation on breast cancer stage at diagnosis and survival, our analyses did not take into account the history of residential segregation experienced by women in the study, and the possibility that the counties assigned to women may not reflect where they spend the most time, as women may live in different counties than those in which they work or receive health care. Instead, $ICE_{race/ethnicity}$ provides a snapshot of county composition based on population data taken from 2008-2012.

Not only did GWR demonstrate the ways in which the impact of contextual factors varies by location, it also revealed how this impact varies by race. While ICE_{income} was not significant in the aspatial model for Black women, it was significant in 98 counties in the GWR, 68 of which had odds ratios greater than one, indicating that the odds of increased screening among Black women rose as a county's household income concentration moved from low to high. By contrast, the opposite was true for White women. In both the aspatial model, and in 109 of the 146 counties with significant values in the GWR, odds ratios were less than one, signifying that the odds of a county having had an increase in screening among White women fell when ICE_{income} moved from a concentration of lower income toward a concentration of higher income. Additional research is needed to understand why, for the majority of counties with significant values, household income concentration affects the odds of increased screening differently for Black and White women. Only in North Carolina and South Carolina were there counties in which the odds ratios were in the same direction for both Black and White women (less than one). It is possible that White women in counties with a concentration of lower income households are benefitting from programs targeting low-income women, while Black women benefit from living in counties with assets found in higher income counties, such as more screening facilities.

Implications for Policy and Practice

Regardless of the phenomena that may contribute to differences in screening odds for each of the variables assessed in this study, the results of our aspatial and GWR analyses taken together suggest that selected counties can drive the role of a particular variable in the development of aspatial models. That is, our analyses demonstrate that models that do not account for place can miss the local differences that exist between counties and vary by race. Since the contextual variables associated with screening changes vary by location, effective policy and practice must integrate knowledge of local health practice signatures, and how larger structural forces affect them.

Despite statistics indicating that Black women are screening at similar rates to White women, and in some locations at higher rates, inequities in breast cancer incidence and mortality remain. An analysis by Anderson et al. (2014) using GWR to study screening in 138 Appalachian counties from 2006-2008 highlights these persistent disparities: they found that breast cancer screening was associated with early cancer detection, independent of area deprivation, county economic status, and health care service availability. They also discovered that later stage tumors were associated with not only low screening rates, but also area deprivation; however, this relationship was place-specific, with a stronger impact in Pennsylvania than Ohio or Kentucky. Furthermore, Anderson et al. assert that for every ten percent increase in Black female residents in the population under study, there was more than a 15 percent increase in the number of later stage breast cancer tumors.

Such findings suggest that national breast cancer screening policies and recommendations, which are based on research conducted with mainly White women, do not reflect the reality that Black women present with more advanced stage tumors, and at younger ages. Institutional policy that does not account for these disparities lacks attention to the impact of social and political determinants of health, including the persistent effects of racism and lack of diverse voices in science and other forms of knowledge production that inform practice. As Krieger (2017) points out, racism, not "race", causes inequities in breast cancer survival, and cancer prevention efforts must focus on health equity, because health inequities are avoidable.

Thus, one approach to working toward health equity is to better understand how national policies affect breast cancer outcomes differently in Black and White women. Our study adds to this effort by demonstrating the variations that exist across the country in how screening is utilized at the county level, by race, and by sociopolitical climate. While these differences are likely due to the interplay of both how services are delivered locally and how women use them, this paper sets the stage for future research exploring how national policies and practices affecting screening are being implemented in different ways in specific locations, whether they are effective in improving the health of individuals and communities, and if they can be translated effectively for use in other regions. Such work would benefit from including the voices of Black women, from both academic and lay perspectives.

This understanding can then be used to inform future policy aimed at reducing breast cancer disparities, including practices focused on eliminating the mortality divide between Black and White women, and diagnosing tumors in Black women at earlier stages. This may include, for instance, recommendations for Black women in certain geographic locations to begin screening at younger ages.

Strengths and Limitations

The analyses presented here are novel in their use of ICE for income and race/ethnicity as factors for studying increased screening mammography. One limitation, however, is that the variables assessed do not include differences in cultural factors.

Another strength of this study is that it examines the contextual environment by assessing how the characteristics of the counties in which women reside affect screening. At the same time, though, use of a lower level of aggregation, such as cities within counties, could be more valuable, because larger levels of aggregation diminish the diversity that can be observed in smaller areas (Krieger, Singh, and Waterman 2016). Such an analysis of screening across the continental U.S., however, may be difficult to interpret because of the country's size, and may diminish the number of regions available for analysis due to lack of cities with a large enough Black population to protect privacy. Also, while the analyses presented here did assess the role of county-level factors, they did not control for individual-level variables, and future studies should take both of these into account. Similarly, while describing aggregate change over time, our results are not longitudinal by individual, which would provide insight into the odds of increased screening for women over time. Instead, our analyses provide data on changes in county screening rates.

Another limitation of this study is that it evaluated only one segment of the population, though Medicare beneficiaries are an important group to study because of their omnibus access to health insurance, including coverage for mammograms, a great equalizer for access to health care issues. However, future studies should assess a broader sample using GWR.

The approach used in this paper, including analyses that compare and contrast national and geographically weighted data, is also beneficial in the way it provides a model for future work on other health services. For example, similar research could be conducted to evaluate how contextual factors affect screening for other cancers, and how they vary, or do not vary, by place. Further, this approach can also be applied to other vulnerable populations that experience health concerns, such as those who are disabled or low-income, to explore how access to health services differ from majority populations.

Conclusion

Our manuscript makes an important contribution to the literature on breast cancer health disparities, as "the continued study of how segregation and other characteristics of place may contribute to diminishing disparities in health care access, utilization, and quality by identifying avenues for intervention and policy-based solutions" (White, Haas, and Williams 2012, p. 1292). Taken together, the results of our analyses reveal that the aspatial models do not fully demonstrate how the impacts of different variables vary across the country. Rather, such variations, which are more discernable through the use of GWR, can be indicative of differences in not only regional demographic characteristics, but also local health care practice signatures. As such, policies designed to increase screening mammography may have varying results in each county. Thus, in order to better trace impact on health disparities, there is a clear need to take into account the *role of place* in assessing how broader structural forces affect local contextual factors that impact health care.

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CHAPTER 6

MULTILEVEL ANALYSIS OF INDIVIDUAL AND COUNTY VARIABLES AFFECTING SCREENING MAMMOGRAPHY IN U.S. WOMEN

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Abstract

Recommendations for how often U.S. women, and of which ages, should receive screening mammograms have been fraught with debate in recent years, and there are mixed results as to how these policies have affected screening rates. This is especially true for sub-groups at risk with higher breast cancer incidence and mortality patterns. There is a lack of research on screening mammography during this time period that includes contextual variables with individual factors. The aim of this study was to assess the impact of individual and ecological variables on whether a woman age 40 and above had a mammogram in the last two years. Self-reported screening mammography and demographic and health care characteristics were drawn from Behavioral Risk Factor Surveillance System surveys in 2008 and 2012 from U.S. women ages 40 and above. County characteristics were drawn from the 2008-2012 American Community Survey. Nesting individuals (n= 307,672) within counties (n= 2,256), we performed multilevel logistic regression. Both individual and county-level characteristics, as well as the complex, intersecting roles of race and income, affect the odds of having had a mammogram in the last two years, revealing how place affects preventive health care. Improved access to health care, measured through four dimensions, increased screening odds. Programs designed to reach out to both low-income and Black women for early detection via increased screening appear to have been successful, and assisting women in finding personal doctors, accessing routine checkups, and with medical costs, could improve screening rates.

Introduction

Recommendations for how often U.S. women, and of which ages and racial/ethnic backgrounds, should receive screening mammograms have been fraught with debate in recent years, particularly after the release of the 2009 U.S. Preventive Services Task Force (USPSTF) statement (U.S. Preventive Services Task Force, 2009). There are mixed results in the literature as to how this recommendation change affected screening rates (Fedewa et al., 2016; Howard & Adams, 2012; Lee, Malak, Klimberg, Henry-Tillman, & Kadlubar, 2016; Qin, Tangka, Guy Jr., & Howard, 2016) and there are concerns that sub-groups such as Black women who are at higher risk for younger incidence (DeSantis et al., 2016), later stage diagnosis (Mobley & Kuo, 2015), and higher mortality (Howlader et al., 2016) may suffer negative results. While studies have explored individual variables affecting screening since this guideline change, women are also located in communities, and place matters in health and health care (White, Haas, & Williams, 2012). Far less research has been conducted on the effects of both individual characteristics and ecological-level variables on screening during this time, though some have been conducted using earlier time periods (Benjamins, Kirby, & Huie, 2004; Mobley et al., 2016). One study of women ages 66-75 from 2005-2010, however, found screening adherence to be affected by education, primary care use, Medicare enrollment, co-morbidities, and living in communities with higher newspaper readership, greater public transport expenditures, a higher diversity index, and higher median household income (Hubbard et al., 2016). Furthering this line of inquiry, the objective of our study was to assess whether certain individual and ecological factors can predict whether a woman age 40 or older had a mammogram in the last two years, using data from 2008-

2012.

Methods

Data, Sample, and Measures

Individual-level data on women ages 40 and above were drawn from the Behavioral Risk Factor Surveillance System (BRFSS), from 2008 and 2012. The U.S. Centers for Disease Control and Prevention (CDC) established BRFSS surveys to gather information about health behaviors, using a sample that is representative of each U.S. state (Division of Health Informatics and Surveillance, 2016). County-level variables were drawn from the American Community Survey (ACS) 5-year estimate of data collected from 2008-2012, which is administered by the U.S. Census Bureau through a random sample (U.S. Census Bureau, 2016). Data from the ACS were also used to calculate two additional county-level variables designed to quantify the concentration of privilege in an area on a continuum from -1 (most deprived) to 1 (most privileged). Originally developed by Massey (2001) to measure income disparity, the Index for Concentration at the Extremes (ICE) has also been established to describe polarization due to race/ethnicity (Krieger, Waterman, Gryparis, & Coull, 2015), which is important since residential segregation affects health care (White, Haas, & Williams, 2012). Guided by previous studies (Feldman, Waterman, Coull & Krieger; 2015; Krieger, Singh, & Waterman, 2016), we calculated these variables as follows:

$$ICE_{income} = \frac{(Number\ of\ households\ earning \geq \$100{,}000) - (Number\ of\ households\ earning < \$25{,}000)}{Total\ number\ of\ households\ in\ county\ with\ income\ data}$$

$$ICE_{race/ethnicity} = \frac{(White\ non-Hispanic\ population) - (Black\ non-Hispanic\ population)}{Total\ population\ in\ county\ with\ race/\ ethnicity\ data}$$

Statistical Analysis

SPSS Version 24 (IBM Corp., 2016) was used to compile datasets and calculate descriptive statistics. Nesting individuals within counties across the U.S., multilevel logistic regression was conducted using HLM 7 (Raudenbush, Bryk, & Congdon, 2013) creating a unit-specific model with logit link function. The dichotomous dependent variable was whether a participant received a screening mammogram in the last two years (no=0/yes=1). In order to be included in the analysis, participants must have had data available for the outcome variable and each of the individual-level independent variables listed in Table 1. Year surveyed, health care coverage, personal doctor, unable to see a doctor because of cost (medical cost), marital status, and employment status were coded as dichotomous. Time since last checkup, income, education, and age were considered scale variables. Race/ethnicity was dummy coded into three variables, with White non-Hispanic as the reference group, as it was the largest. County-level independent variables (shown in Table 1) were all continuous; there were no missing values. Since this analysis was exploratory, all individual and county independent variables were entered into the model at once. Due to the large size of the dataset, we ran the intercept function with random effects, but the remaining functions with fixed effects.

Table 1. Participant and county characteristics.

Individual characteristics	Did not receive mammogram (n= 72,624) n (%) or Mean (SD)	Received mammogram (n= 235,048) n (%) or Mean (SD)	Total (n= 307,672) n (%) or Mean (SD)
Year surveyed			
2008	34,161 (47.0%)	115,048 (48.9%)	149,209 (48.5%)
2012	38,463 (53.0%)	120,000 (51.1%)	158,463 (51.5%)
Has any kind of health care coverage			
No/ don't know	12,941 (17.8%)	12,176 (5.2%)	25,117 (8.2%)
Yes	59,683 (82.2%)	222,872 (94.8%)	282,555 (91.8%)
Has a personal doctor or health care provider			
No/ don't know	13,348 (18.4%)	10,549 (4.5%)	23,897 (7.8%)
Yes	59,276 (81.6%)	224,499 (95.5%)	283,775 (92.2%)
Had a time in the past 12 months when needed to see a doctor, but could not because of cost (Medical cost)			
No/ don't know	57,383 (79.0%)	214,256 (91.2%)	271,639 (88.3%)
Yes	15,241 (21.0%)	20,792 (8.8%)	36,033 (11.7%)
Time since last routine checkup			
Less than 1 year ago	40,406 (55.6%)	200,448 (85.3%)	240,854 (78.3%)
1- less than 2 years ago	9,956 (13.7%)	22,858 (9.7%)	32,814 (10.7%)
2 - less than 5 years ago	9,932 (13.7%)	6,321 (2.7%)	16,253 (5.3%)
5+ years	11,194 (15.4%)	4,370 (1.9%)	15,564 (5.1%)
Never	1,136 (1.6%)	1,051 (0.4%)	2,187 (0.7%)
Marital status			
Married or part of unmarried couple	32,442 (44.7%)	126,249 (53.7%)	158,691 (51.6%)
Divorced, widowed, separated, never married	40,182 (55.3%)	108,799(46.3%)	148,981 (48.4%)
Employment status			
Not working, retired, student	32,626 (44.9%)	103,902 (44.2%)	136,528 (44.4%)
Employed, homemaker	39,998 (55.1%)	131,146 (55.8%)	171,144 (55.6%)
Household income			
Less than $10,000	6,453 (8.9%)	11,632 (4.9%)	18,085 (5.9%)
$10,000 - less than $15,000	7,589 (10.4%)	14,421 (6.1%)	22,010 (7.2%)
$15,000 - less than $20,000	8,606 (11.9%)	18,268 (7.8%)	26,874 (8.7%)
$20,000 - less than $25,000	9,265 (12.8%)	22,959 (9.8%)	32,224 (10.5%)

$25,000 - less than $35,000	9,548 (13.1%)	28,799 (12.3%)	38,347 (12.5%)
$35,000 - less than $50,000	9,749 (13.4%)	36,067 (15.3%)	45,816 (14.9%)
$50,000 - less than $75,000	9,071 (12.5%)	39,127 (16.6%)	48,198 (15.7%)
$75,000+	12,343 (17%)	63,775 (27.1%)	76,118 (24.7%)
Highest level of education completed			
Did not graduate high school	8,227 (11.3%)	16,585 (7.1%)	24,812 (8.1%)
Graduated high school	24,293 (33.5%)	68,867 (29.3%)	93,160 (30.3%)
Attended college or technical school	20,937 (28.8%)	65,601 (27.9%)	86,538 (28.1%)
Graduated from college or technical school	19,167 (26.4%)	83,995 (35.7%)	103,162 (33.5%)
Race/ethnicity			
White non-Hispanic	59,541 (82.0%)	192,697 (82.0%)	252238 (82.0%)
Black non-Hispanic	5,431 (7.5%)	22,100 (9.4%)	27,531 (8.9%)
Other race or multi-racial, non-Hispanic	3,939 (5.4%)	9,728 (4.1%)	13,667 (4.4%)
Hispanic	3,713 (5.1%)	10,523 (4.5%)	14,236 (4.6%)
Age	60.06 (14.1)	60.96 (11.9)	60.75 (12.5)

County characteristics (n=2,256)	Mean (SD)
Median age	39.36 (4.6)
Percent of population with just a high school diploma or equivalent	34.44 (7.2)
Percent of population now married	52.07 (6.3)
Percent of females with health insurance	86.44 (5.2)
$ICE_{race/ethnicity}$	0.68 (0.3)
ICE_{income}	-0.12 (0.2)

Results

There were 369,816 women ages 40 and above with mammography and state/county location data in the 2008 and 2012 BRFSS datasets (excluding Guam, Puerto Rico, and the Virgin Islands). A total of 307,672 women located in 2,256 U.S. counties were included in the analysis; most excluded cases were due to lack of income information (n= 55,635). Table 1 displays descriptive characteristics for the sample. Results of the multilevel logistic regression are shown in Table 2. The only individual-level variable that was not significant in the model was age.

Three individual-level variables were not affected by county-level characteristics: medical cost, employment status, and non-Hispanic Black race/ethnicity. To this end, the odds of a woman having had a mammogram in the last two years declined when she reported having needed to see a doctor in the past 12 months but could not, because of cost (medical cost). Similarly, screening odds declined when a woman was employed or a homemaker, compared to not working or being a student or retired. The odds of having been screened were higher for non-Hispanic Black women compared to all other groups.

The remaining individual-level variables were impacted by county characteristics. First, the odds of screening overall decreased between 2008 and 2012. However, this decrease was lessened in counties where the percentage of high school graduates was higher. Conversely, as county household income concentration (i.e. ICE_{income}) increased, the odds of screening actually increased between 2008 and 2012.

Also, overall the odds of screening increased when a woman had health care coverage. This increase was even greater for women who lived in counties with higher percentages of married couples.

Not surprisingly, the odds of screening increased when a woman had one or more people she considers her personal doctor or health care provider. These odds further increased in counties with higher concentrations of non-Hispanic White individuals (in comparison to non-Hispanic Black individuals). However, this benefit was reduced for women who lived in counties where the percentage of married couples was higher.

For all individuals, screening odds decreased the longer it had been since a woman last visited a doctor for a routine checkup. This notable decrease is impacted further when the woman lives in a county with a higher median age, larger ICE_{race} value, and higher percentage of females with health insurance. However, these odds were more positive for women who lived in counties with higher percentages of high school graduates, and higher ICE_{income} values.

Odds of screening decreased when a woman was divorced, widowed, separated, or never married. These decreases were more pronounced in counties where the median age was higher.

The odds of having had a mammogram in the last two years were higher for women with higher household incomes. For these women, their positive odds increased when they lived in counties that had higher percentages of married couples and higher percentages of females with health insurance. However, these odds decreased as county income concentration (i.e. ICE_{income}) became wealthier.

Screening odds increased as a woman's level of education rose. This positive association was even stronger in counties where racial makeup had a higher concentration of non-Hispanic White (in comparison to non-Hispanic Black) individuals.

Odds of screening were increased for both non-Hispanic Black and Hispanic women. Women of other minority racial/ethnic groups had lower odds of screening. While Hispanic women had greater odds of being screened overall, these odds were decreased as median county age increased. The decreased odds for women of other minority racial/ethnic groups were even greater in counties with higher concentrations of non-Hispanic White individuals (in comparison to non-Hispanic Black individuals), and in counties with higher income concentration (i.e. wealthier counties).

Table 2. Results of multilevel logistic regression.

	Coef-ficient	Standard Error	*p*-value	Odds Ratio	Confidence Interval
Intercept, β0	-0.288	0.034	<0.001	0.750	(0.701,0.802)
Median Age, γ01	0.027	0.008	<0.001	1.028	(1.011,1.044)
Year surveyed, β1	-0.125	0.012	<0.001	0.882	(0.862,0.903)
Pct. of people with just a HS education, γ14	0.007	0.002	<0.001	1.007	(1.003,1.011)
ICE_{income}, γ16	0.290	0.102	0.005	1.337	(1.094,1.634)
Health care coverage, β2	0.512	0.020	<0.001	1.668	(1.604,1.735)
Pct. of population now married, γ22	0.011	0.004	0.012	1.011	(1.002,1.020)
Personal doctor, β3	0.674	0.021	<0.001	1.963	(1.885,2.044)
Pct. of population now married, γ32	-0.017	0.004	<0.001	0.983	(0.976,0.991)
ICE_{race}, γ33	0.292	0.087	<0.001	1.339	(1.129,1.587)
Medical cost, β4	-0.276	0.017	<0.001	0.759	(0.733,0.785)
Time since last routine checkup, β5	-0.696	0.006	<0.001	0.498	(0.492,0.505)
Median Age, γ51	-0.003	0.001	0.035	0.997	(0.994,1.000)
ICE_{race}, γ63	-0.107	0.028	<0.001	0.898	(0.850,0.949)
Pct. of people with just a HS education, γ64	0.004	0.001	0.002	1.004	(1.001,1.006)
Pct. of females with HI, γ65	-0.007	0.001	<0.001	0.993	(0.990,0.995)
ICE_{income}, γ66	0.149	0.057	0.009	1.161	(1.038,1.298)
Divorced/ widowed/ separated/ never married, β7	-0.194	0.014	<0.001	0.824	(0.803,0.846)
Median Age, γ71	-0.013	0.003	<0.001	0.824	(0.803,0.846)
Employed/ homemaker, β8	-0.058	0.014	<0.001	0.944	(0.919,0.969)
Household income, β9	0.113	0.004	<0.001	1.120	(1.112,1.128)
Pct. of population now married, γ92	0.002	0.001	0.012	1.002	(1.000,1.003)
Pct. of females with HI, γ94	0.002	0.001	0.042	1.002	(1.000,1.003)
ICE_{income}, γ96	-0.082	0.032	0.011	0.921	(0.865,0.981)
Education, β10	0.098	0.007	<0.001	1.103	(1.088,1.117)
ICE_{race}, γ103	0.070	0.030	0.018	1.073	(1.012,1.137)
Non-Hispanic Black, β11	0.428	0.032	<0.001	1.534	(1.441,1.632)
Other race/ethnicity, β12	-0.103	0.031	<0.001	0.902	(0.849,0.959)
ICE_{race}, γ123	-0.415	0.115	<0.001	0.660	(0.527,0.827)
ICE_{income}, γ126	-0.569	0.260	0.029	0.566	(0.340,0.943)
Hispanic, β13	0.281	0.039	<0.001	1.324	(1.226,1.430)
Median Age, γ131	-0.019	0.007	0.005	0.981	(0.968,0.994)

Note: variables with *p*-values ≥ .05 not shown. Pct= percentage; HS= high school; HI= health insurance.

Discussion

Both individual- and county-level characteristics, as well as the complex, intersecting roles of race and income, affect the odds of having had a mammogram in the last two years. Individual-level factors with a positive effect include having health care coverage, a personal doctor, higher household income, higher education, and being non-Hispanic Black or Hispanic. Negative individual factors include lack of resources to cover medical costs, increased length of time since last routine checkup, being divorced/widowed/single, being employed/a homemaker, and identifying as another minority racial/ethnic group besides Black or Hispanic.

Although these individual-level factors are important, a woman's community can exacerbate negative factors and enhance or diminish positive factors, and the effects of these environmental influences on individual characteristics vary. Thus, the structure of society, and not simply individual decision-making alone, clearly has a role in affecting health and preventive health care. This was particularly evident with the roles of ICE_{race} and ICE_{income}, both of which are influenced by historical patterns. For instance, as the concentration of wealthy households in a county increased, odds of screening associated with a longer time since last checkup were improved, but odds associated with higher individual-level household income and belonging to a minority racial/ethnic group besides Black or Hispanic were decreased. Similarly, as the concentration of non-Hispanic White individuals in a county increased, odds of screening associated with having a personal doctor and higher education were improved, whereas odds associated with a longer time since last checkup and belonging to a minority racial/ethnic group besides Black or Hispanic were decreased.

This further decline in screening odds for women who identified with other minority racial/ethnic groups besides Black or Hispanic, living in counties that had a larger concentration of non-Hispanic White residents, is similar to other findings of increased screening among Hispanic women living in counties with a high percentage of Black residents (Benjamins, Kirby, & Huie, 2004) and in women ages 71-75 living in more diverse communities (Hubbard et al., 2016). However, our result differs from another report that Medicaid recipients had decreased screening odds when they lived in areas of Black residential segregation, but increased odds in areas of Hispanic residential segregation (Mobley et al., 2016). Since the $ICE_{race/ethnicity}$ variable we used did not account for county Hispanic population, we cannot distinguish whether this was also true for our sample.

Regardless of county characteristics, and after adjusting for the other individual variables, odds of screening increased when a woman was non-Hispanic Black; this effect was fairly strong. To a lesser degree, screening odds also increased when a woman was Hispanic. In a review of studies on screening mammography, Purc-Stephenson & Gorey (2008) found that Black, Hispanic, and Asian/Pacific Islander women appeared to have screened less than White women, until socioeconomic status (SES) was also assessed, and there was no longer a significant difference. This highlights the intersecting roles of race and income that are not always distinguished in the literature, and the ways in which structurally-influenced factors like SES can mistakenly be associated with, and lead to false conclusions about, race and screening.

Our results related to individual and county racial variables suggest that screening programs designed to reach out to underserved women, such as the CDC's National

Breast and Cervical Cancer Early Detection Program (NBCCEDP), have been successful. In this way, programs focusing on Black and Hispanic women may be benefiting all women who live in counties with lower $ICE_{race/ethnicity}$ values. Early detection is particularly key for Black women, who have the highest breast cancer mortality rate of all groups and are more likely to be diagnosed with later stages of the disease.

Our findings related to income also suggest the effectiveness of programs like the NBCCEDP. In our study, though the odds of screening increased as a woman's household income rose, this effect was reduced as her county's income concentration grew wealthier. While other research has found higher screening adherence with increased income (Narayan et al., 2017), it may be unexpected that living in a county with a higher concentration of wealth would have a negative impact on screening odds. However, higher screening odds have been found among women who lived in counties with persistent poverty status over the last 25 years (Mobley et al., 2016). Thus, programs targeting low-income women for screening may be benefiting not only individually less wealthy women, but also other women who live in less wealthy counties, due to increased information about and activity around screening in their communities, even if their incomes are too high to qualify for free or low-cost screening.

If such programs were eliminated, screening could fall for low-income and minority women. Results of our analysis indicating that, consistent with previous research (Narayan et al., 2017), improved access to health care (i.e. health care coverage, personal doctor, medical cost, and less time since last checkup) increased screening odds, also suggest that policies and practices assisting women in finding a personal doctor and accessing routine checkups may help improve odds of receiving recommended screening, whether or not women live in areas that have a higher concentration of non-Hispanic White residents or wealthier households. Since medical cost had a consistent effect regardless of county characteristics, it should also be considered in nation-wide efforts to increase screening mammography.

Unaffected by county characteristics, screening odds were decreased when women were employed/homemakers, which may be due to having little time available for accessing preventive care. If so, then mammography- across the U.S.- may also be facilitated by practices that lengthen the hours available for screening to evenings and weekends, or offering mobile clinics, which can help increase screening participation (Guillaume et al., 2016).

Age was the only individual-level variable that did not have a significant effect on the odds of screening, which could be due to mammography recommendations that changed, and varied by organization, over the study period.

We also discovered that although screening odds declined if a woman was surveyed in 2012 compared to 2008, this effect was reversed as her county's income concentration grew wealthier. This finding reflects the mixed results of other reports on whether or not screening increased or decreased after the 2009 USPSTF recommendation changes, which depend on the data sources, time periods, and age groups assessed, as well as other variables considered in analysis. However, the vast majority of such studies explore individual characteristics only, and to our knowledge, ours is the only study examining county-level income concentration as a factor influencing screening alongside two time periods encompassing the USPSTF changes. For example, while Fedewa et al. (2016) found screening declined among high SES younger women in 2013 compared to

2008, they did not consider how living in wealthier counties might have affected these rates. By contrast, Hubbard et al. (2016) found that among women ages 66-70, those living in the highest income communities had a decreased hazard of screening non-adherence. Clearly the ways in which structure and environment affect individuals are complex, and additional research is needed to better understand how the effects of a woman's individual income and the wealth of her county affect her screening at different time points. However, our results indicate affordable screening programs should be continued not only for low-income women, but also within lower-income communities.

Strengths and Limitations

Limitations of our study are that it is cross-sectional, though two different time points are used, and that it relies on self-reported screening data. However, the dataset used is nationally representative, and our method may be useful to researchers exploring other preventive care measures and populations. The difference between the number of survey respondents and those analyzed, though, represent a limitation to the generalizability of these findings to the broader U.S. population, as the sample differs from the data collected in the original surveys. However, missing data was not concentrated in certain counties compared to others. Another strength of this study is the way in which it integrates individual- with county-level factors, highlighting the importance of understanding health and preventive care as being affected by both people and the places in which they live. Similarly, this paper demonstrates that nation-wide statistics do not distinguish between variables that may have constant effects across the country, and those that differ locally.

Conclusion

For most variables assessed, the effect of individual factors on screening odds were influenced by characteristics of the county in which women lived, indicating that place affects health care. Results also suggest that programs designed to reach out to both low-income and Black women for early detection via increased screening have been successful, and assisting women in finding personal doctors, accessing routine checkups, and with medical costs, could improve screening rates.

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CHAPTER 7

DISCUSSION

The goals of this dissertation were to 1) formally characterize the geographic pattern of change over time in mammography for Black women in order to assess whether the spatial distribution of screening utilization is random, 2) explore whether different types of factors are associated with the geographic pattern, and 3) reflect upon how these findings can be used to inform policy that promotes health equity.

First Research Objective

In response to the first objective, we found that there was an overall decrease in screening mammography among Black and White female Medicare beneficiaries ages 67-69 in Health Referral Regions (HRRs) across the contiguous U.S. from 2008-2012. Black women had an overall smaller decrease than White women, but the change observed within individual HRRs varied greatly. In particular, the changes in screening for Black women consisted of higher magnitudes of both increases and decreases. By correlating absolute and relative differences in screening between Black and White women, we found that 66% of Black women were affected by racial disparities in screening in 2008, and 41% in 2012. Unlike the pattern of positive spatial autocorrelation and clustering observed for White women, there was not a distinct clustered pattern in the distribution of screening change for Black Medicare beneficiaries. This suggests that changes in screening during this time were not driven by an obvious, large-scale factor, such as Black population density, but rather rooted in local health practice signatures.

Second Research Objective

In response to the second research objective, we found that there are differences between Black and White women, and by location, in the variables that are associated with screening changes. We also discovered that spatial analysis of screening changes yields more nuanced results than that which does not account for geographic location. When the contiguous U.S. is considered as a whole, the odds of a county having increased screening mammography by Black Medicare enrollees ages 67-69 decreased when the 2008 screening rate increased, and the odds increased when county median age and the percentage of females with health insurance in a county increased. While this was also true for White women, screening was additionally affected by the percentage of the population married, ICE_{income}, and $ICE_{race/ethnicity}$. However, geographically weighted regressions revealed that the impact of the variables assessed on the odds of an increase in screening varies by location, and depending on the geographic weighting function used.

Results of our multilevel analysis also revealed the complex and intersecting influences of race and income on screening mammography. Individual income and race, as well as county concentrations of income and race, affect screening odds in different ways for U.S. women ages 40 and above. Additionally, we found that place does indeed affect preventive health care: both individual and county-level characteristics impact screening mammography odds. Better access to health care, as measured by whether a woman has health insurance and a personal doctor, has recently had a routine checkup, and did not have to avoid seeing a doctor when she needed to because of cost, increased screening odds; at the same time, these variables were also influenced by county characteristics in different ways.

Third Research Objective

Throughout the course of this research, I reflected on how the emerging findings could be used to affect policy and health care. However, my perspective on this has changed since the time I wrote the proposal. I began this project interested in how women made decisions about screening. Although I recognized that the structure of society, including the effects of racism and policy, affected breast cancer health disparities, my focus was still largely on individual decision-making, and "health-seeking behavior." I now understand the structure of society as having a much more important role than I first realized. Further, I recognize that models focusing on individual choice run the risk of becoming theory based on a deficits narrative.

Critical Race Theory (CRT) provides a framework for discussing some of the ways in which structure can influence policy that promotes health equity. For example, Black women continue to be negatively affected by breast cancer health disparities, particularly with regard to having the highest mortality from the disease compared to all other racial/ethnic groups, and for women under age 50, having nearly twice the mortality rate of White women. Addressing these issues reflects the CRT tenet of a commitment to social justice, as the persistence of such disparities indicates a failure in the administration of health equity.

While past studies have asserted that lack of screening mammography by Black women contributed to these disparities, more recent research, and results presented in this dissertation, reveal that this is not the case. In fact, Black women have been screening at rates equal to or higher than those of White women in recent years; further, women of other races/ethnicities living in counties with higher concentrations of Black residents have higher odds of screening. This may be due to national programs targeting Black women for screening, and/or efforts by Black women locally within communities to increase mammography.

Screening practices are affected by policy, and policy is affected by philosophies. One philosophy common to health care is that policy should be founded in evidence-based research. Current screening mammography policies that are based on studies with mainly White participants are problematic because they assume the same experience with breast cancer for all people. If Whiteness is considered normative, then women of other races/ethnicities are systematically excluded, whether this is intentional or not. This exclusion can also be seen more broadly in lack of representation in faculty positions in the basic sciences, as Principal Investigators for National Cancer Institute (NCI) research and training grants, and as participants in NCI-funded clinical trials. However, the CRT principle of anti-essentialism provides a reminder that people do experience different and unique realities, especially given the social construction of race and history of structural racism in the U.S. Ultimately, screening practices reflecting policy based on breast cancer patterns in White women may be related to the continued breast cancer mortality and the more recent higher incidence in Black women, by adding to further late-stage diagnoses in Black women, resulting in higher fiscal costs, and more importantly, lives lost.

Current policies that do not reflect the reality of breast cancer disparities faced by Black women may thus be inappropriate. In this way, screening policy should not only be informed by research that includes Black women, but should also reflect Black women's unique ways of knowing and modes of story-telling that are different than those of current normative science, which is also supported by CRT. At the same time, intersectionality, another principle of CRT, also provides a reminder that race, class, and gender are interwoven in varying ways for different individuals, so the input of multiple voices is necessary.

This dissertation is thus necessarily incomplete, though it does contribute significantly to the larger body of work seeking to better understand screening mammography. However, by incorporating another CRT tenant, transdisciplinary perspectives, policy could better lead to practices promoting health equity. Transdisciplinary perspectives can, for instance, draw from social work, anthropology, sociology, political science, economics, public health, and the basic sciences, to help tell stories about screening from both the lay and academic communities- including patients, practitioners, researchers, policy-makers, and community members- and provide opportunities for all stakeholders to work together on policy.

Findings from this dissertation have demonstrated ways in which GIS can be used to map change in screening mammography. In this way, the "diffusion" of screening can be visualized at successive time periods. Findings have also shown the benefits of using multilevel analyses to account for not only individual variables associated with screening, but also contextual variables, and their relationships to one another. These GIS and multilevel results underscore the way in which nation-wide statistics regarding health care do not reveal the more complete story of local variations. This study thus demonstrates the value in using GIS as a tool to incorporate geography and multiple layers of data in exploring these differences, and their value for use in health care research, policy, and practice, because it can be used to illuminate differences in the distribution of health determinants, which affect individuals, communities, and nations (Krieger, 2017).

By demonstrating local variations in screening and between Black and White women, findings from this dissertation also support the notion that place matters. Structural forces in society affect local neighborhood conditions, including poverty, racial isolation, and land use, which in turn affect other neighborhoods (Massey, 2001), and institutional, community, and public policy factors influence health care (McLeroy, Bibeau, Steckler, & Glanz, 1988). Particularly for Blacks compared to Whites, residential segregation based on race affects both disparities in health (Williams & Collins, 2001), and inequalities in health care (White, Haas, & Williams, 2012). As Krieger (2016) points out, "people literally embody, biologically, the multilevel dynamic and co-constituted societal and ecologic context within which we live, work, love, play, fight, ail, and die, thereby creating population patterns of health, disease, and well-being within and across historical generations" (p. 832).

Since place, and thus the context associated with each place, affects health and health care, the findings from this dissertation are steps toward research that can be used to inform policy that promotes health equity. For example, the use of $ICE_{race/ethnicity}$ furthers the work of others who have demonstrated that one way structural racism is manifested is through residential segregation, which impacts cancer, and thus geospatial research in this area can be used for place-based interventions designed to reduce inequities (Krieger, 2017). Structural racism "refers to the totality of ways in which societies foster racial discrimination through mutually reinforcing systems of housing, education, employment, earnings, benefits, credit, media, health care, and criminal justice" (Bailey et al., 2017, p. 1453), and is related to structural violence, which is represented through social determinants of health, manifested as factors affecting ill health and barriers to health care access (Mukherjee, 2011).

In our analyses, we found that for a number of counties, $ICE_{race/ethnicity}$ significantly affected the odds of an increase in screening in the county rates of both Black and White Medicare beneficiaries. In the majority of these counties, the odds of increased screening decreased as the $ICE_{race/ethnicity}$ value moved from a concentration of Black non-Hispanic residents toward a concentration of White non-Hispanic residents. However, there were also some counties in which the odds of increased screening increased as the $ICE_{race/ethnicity}$ value moved from a concentration of Black non-Hispanic residents toward a concentration of White non-Hispanic residents. Decreased odds of a county having an increase in screening when race is more concentrated toward White non-Hispanic residents may be due to the implementation of programs targeting Black women for early detection through increased screening mammography. This is the suggestion posed by Haas et al. (2008), who found that while Black women were less likely than White women to be diagnosed with early-stage breast cancer, this disparity was smallest in the most segregated areas.

These findings are also interesting when considering that we additionally found that income concentration within a county also affects whether the county had an increase in screening mammography. For Black women, the majority of the counties with significant values for this variable had increased odds of screening as the concentration of households moved from low income toward higher income. By contrast, the odds of increased screening among White women decreased as ICE_{income} increased from a concentration of low income toward a concentration of higher income, for most counties. Income distribution is also affected by structural racism, which has implications for health policy and health equity. There is a long history of economic inequality in the U.S., which has been deepening alongside health care inequalities (Dickman, Himmelstein, Woolhandler, 2017). The millions of Americans who remain uninsured more often forgo care due to cost, which can lead to more health problems, and greater costs, later; while more women have health insurance than men, insured women experience higher out-of-pocket costs (Dickman, Himmelstein, Woolhandler).

By showing that aspatial models do not fully demonstrate how the impacts of different variables vary across the country, our manuscript makes an important contribution to the literature on breast cancer health disparities, as "the continued study of how segregation and other characteristics of place may contribute to diminishing disparities in health care access, utilization, and quality by identifying avenues for intervention and policy-based solutions" (White, Haas, & Williams, 2012, p. 1292). Place differences are more discernable through the use of methods that account for geographic location and can illuminate differences in not only regional demographic characteristics, but also local health care practice signatures. As such, policies designed to increase screening mammography may have varying results in each county. There is thus a need to take into account the role of place in how broader structural forces affect local contextual factors that impact health care. For example, findings from this dissertation reinforce the notion that policies impacting structural racism, one form of which is residential segregation that has been shown to affect income inequality and access to care, must be addressed at both the national and local levels in order to promote health equity.

Strengths and Limitations

One of the limitations of the research presented here is that it is incomplete. Rather than being longitudinal and thus able to better assess causality, Chapters 4, 5, and 6 use serial cross-sectional data. Chapters 4 and 5 also give an incomplete picture of screening among the entire population of U.S. Black women, because they evaluated only Medicare beneficiaries ages 67-69. However, this is an important group to study because of their access to health insurance, including coverage for mammograms.

Chapter 5 is also incomplete in that the analyses presented did not control for individual-level variables. Instead, they focused on the role of county-level factors in affecting county screening rates. This assessment of ecological-level variables can be considered a strength, however, because it draws attention to the role of the contextual environment in screening changes. In this way it also helps to further the field in geospatial research, as the use of GIS for studying the effects of environment and health landscapes on health has been considered to have gaps (Raubal, Jacquez, Wilson, and Kuhn, 2013). At the same time, use of county-level aggregation also may give an incomplete understanding of screening, because compared to lower levels of aggregation, such as cities within counties, higher-level levels of aggregation diminish the diversity that can be observed in smaller areas (Krieger, Singh, & Waterman, 2016).

While Chapter 6 does present both individual and ecological variables, the data used is also incomplete. Although the best available data source was used, it did not include variables measuring cultural issues in order to assess the role of culture on screening mammography. Further, individual data was self-reported. However, a strength of this chapter is that the data source is also nationally representative and includes U.S. women ages 40 and above.

Despite these limitations, strengths of this research are its contribution to existing literature on screening mammography and the groundwork it lays for future work. Recommendations on how often women of different ages and races should receive screening mammograms are fraught with debate, having significantly changed over time and by agency, which affects policy, practice, and possibly outcomes. While other studies have explored factors associated with screening among Black women, there is no research, to my knowledge, using GIS to gain insight into associations with the change in screening for Black women from 2008 to 2012. Through its analyses, this research operationalizes a socioecological perspective that incorporates the concepts of space and place. This dissertation is also novel in its use of ICE variables for income and race/ethnicity as factors for studying increased screening mammography. Additionally, this work is beneficial because research findings can be displayed visually on maps, an opportunity that offers easier access to study findings as compared to traditional reports; often, traditional statistical modeling is not as intuitive for interpretation as maps displaying similar data. At the same time, research that utilizes GIS is valuable for assessing the role of structural context and thus policy affecting potential interventions or program planning.

Future Work

Future research should assess geospatial differences in screening changes, and their relationship to breast cancer incidence and mortality, across the U.S. among women of all ages. Contextual and individual factors associated with these differences should also be explored. As such, spatial thinking, including the use of GIS, would benefit these analyses. Findings can be used to inform policy and practice aimed at reducing breast cancer health disparities, at both the local and national levels.

More research is needed to better understand why residential income concentration affects Black and White women differently. In-depth analyses of the counties in which $ICE_{race/ethnicity}$ and ICE_{income} had significant effects on screening should be conducted, in order to gain a more complete picture of how mammography is affected in those regions. Additional research should also explore the combined effects of income and race/ethnicity on screening, such as through the use of the ICE variable constructed by Kreiger, Singh, and Waterman (2016) to measure racialized economic residential segregation in exploring breast cancer estrogen receptor (ER) status.

The use of analyses incorporating space and place reveal there is future work to be done both nationally, in formulating policy to reduce structural violence and structural racism, as well as locally, where the effects of structure are translated onto counties, neighborhoods, and individuals. Local policy and practice should include community-based organizations, and can benefit from the combined efforts of the public and private sectors, as "multisector, place-based partnerships focusing on equity can be an effective means of placing pressure on the systems of structural racism operating in a specific geographical region" (Bailey et al., 2017, p. 1459). Such work should include initiatives to improve housing and communities, due to their effects on health. Future practice also should involve training students involved in healthcare on structural racism's effects on health, and how geospatial research can be used to better understand them.

Having described national trends in screening mammography, the analyses presented in this dissertation pave the way for future local studies. Of particular interest are regions that had high increases in screening, surrounded by regions with decreases in screening. In these areas, qualitative techniques can be used to better understand variables that may have contributed to screening increases, including those that were not explored in these studies, such as cultural factors and local efforts to promote screening. Working with individuals directly involved in these areas will also provide the opportunity for anti-essentialist storytelling. One potential product of this research is to produce a series of maps that show change over time in the region's structural forces, such as economic fluctuations.

Finally, findings from future studies should be translated for academic, professional, and lay audiences, as achieving health equity in policy and practice will require effort on the part of each of these groups.

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