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Historical Redlining, Treatment Storage and Disposal Facilities, and Breast Cancer Mortality

By

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Master of Public Health

Global Epidemiology

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Lauren E. McCullough, PHD, MSPH
Committee Chair

Historical Redlining, Treatment Storage and Disposal Facilities, and Breast Cancer Mortality

By

Madison Gardner

B.S. Interdisciplinary Health Sciences
University of Illinois at Urbana-Champaign
2021

Thesis Committee Chair: Lauren E. McCullough, PHD, MSPH

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Global Epidemiology
2023

Abstract

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Previous epidemiologic studies have explored the association between exposure to hazardous waste and breast cancer incidence. In this study, we aim to identify if there is an existing relationship with use of treatment, storage, and disposal facilities (TSDF's) as a proxy for hazardous waste exposure, and a relationship with breast cancer mortality outcomes. Spatial analysis was used to determine if TSDF's are more likely to be concentrated in Historically Redlined areas in Metro Atlanta. Using the Kernel Density Estimation (KDE) analysis and Global Moran's I for Poisson distributed data, we determined that individuals living in HOLC Grade D, (most hazardous areas) are more likely to have a higher spatial concentration of TSDF's in their census block group (CBG) compared to those living in HOLC Grade A (least hazardous areas). Among our analytic cohort we looked at 5,832 women diagnosed with breast cancer from the Georgia Cancer Registry. (Figure 5) A stratified Cox procedure estimated multivariable adjusted Hazard Ratios (HR) of breast cancer subtypes in relation to prevalence of TSDF's and breast cancer mortality. In examining the associations between TSDF prevalence by exposure level and breast cancer mortality we observed large effect sizes, insignificant p-values, and wide CI's that included the null. Though precision was low, the largest effect size was observed among those living in a CBG with a high TSDF prevalence. Among the high TSDF exposure level, Luminal B (HR=1.23, 95% CI, 0.47-3.21, p=0.67) and TNBC (HR=1.11, 95% CI, 0.65-1.91, p=0.69) were associated with a small increased level of risk, with a high level of risk for BC mortality for those diagnosed with the HER2 subtype (HR=2.06, 95% CI, 0.68-6.16, p=0.20). (Table 4) Despite having over 5,000 women in our study larger studies are needed to understand the spatial distribution of TSDF's and breast cancer mortality and investigate the biologic pathway that may contribute to the association.

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Introduction

In 2022 it is estimated that there will be 287,850 total new cases of primary breast cancer. (Susan G. Komen, 2022) Information from the Centers for Disease Control and Prevention (CDC,2022) notes that breast cancer (BC) is the 2^{nd} most common cancer among women in the US. It is estimated that about 1 in every 8 U.S. females are likely to develop invasive breast cancer over the lifespan. (CDC, 2022)

Incidence rates of breast cancer are relatively equally distributed between non-Hispanic White (NH-W) and non-Hispanic Black women (NH-B). However, when we compare the breast cancer mortality rate by both groups, we see that NH-W women and NH-B women, are dying at 19.9 and 28.0 deaths per case by 100,000 persons, respectively. Not only is this difference stark, but a large mortality disparity is still observed when we compare US NH-B women's breast cancer mortality rates to any other racial/ethnic group as well. (NIH, 2022)

According to a study on racial disparities in breast cancer by Williams et al, Black women are overall 'more likely to have lower stage-for-stage survival rates.' (Williams et al, 2016) There are various well researched reasons for this disparity, including being diagnosed at a later stage, with more aggressive disease (ER-/TNBC) limited access to care, and being less likely to receive and adhere to guideline treatments. However, these factors do not entirely account for the disparity. Emerging research suggests that certain social determinates of health (SDoH) and structural racism may impact the development of aggressive tumor types and breast cancer prognosis. Black women's lived experiences with racism as well as the structural consequences of racism that have disproportionally increased their everyday exposure to risk factors breast cancer and tumor progression.

Social Determinants of Health (SDoH) is a framework that describes the impacts of policies that shape the built environment, and how it impacts population and community health outcomes. (Gehlert et al, 2021) SDoH explains the barriers related to poverty, stress, lack of access to appropriate grocery stores, outdoor green space, or transportation. These barriers contribute to poor nutrition and physical inactivity, exposure to environmental toxicants, barrier to health care access, and economic barriers which may increase a woman's risk of breast cancer. (Gerend, 2008) For example, in a study by Qin et al, Neighborhood Social Economic Status (nSES) was associated with a higher risk of TNBC (the most aggressive subtype of BC) compared to Luminal A (the most prognostically favorable subtype of BC). Compared to census tracts with high nSES, the relative risk (RR) of TNBC was 1.95 (95% CI: 1.27–2.99) times the risk for study participants living in low nSES areas (2021). As subtype is an important driver of BC prognosis SDoH such as nSES may be important for understanding mortality disparities. Additionally, there may be other characteristics related to SDoH are likely to impact prognosis independent of BC subtype.

An important consideration in understanding social risks for BC include exposure to environmental toxicants. Although the literature on environment and BC mortality is limited, there are data that suggest association with BC outcomes. For example, a study by Fuerst, showed that women living in census tracts with the highest concentrations of cadmium and antimony were association with a 10-20% increased risk of ER- breast cancer among both pre-menopausal and post-menopausal women. (Fuerst, 2019)

While the relationship between breast cancer mortality and environmental exposures is not fully explored, there are various studies that have looked at how environmental exposure contributes to increased BC incidence. Examples include air pollution, proximity to traffic, proximity to industrial and chemical facilities, proximity to waste incinerators, and exposure to heavy metals. (Lewis-Michl, 1996; Gatti, 2021; Dai & Oyana, 2008; Gasca-Sanchez et al, 2021)

We understand that these chemical exposures contribute to both the incidence and potentially poorer prognosis for BC among Black women. However, we have yet to explore how discriminatory policies have contributed to Social Determinants of Health (SDoH) that in turn spatially increased proximity to these environmental toxins among NHB women. Some of those policies include segregation, Jim Crow laws, and Redlining. For example, Krieger et al. determined that Black women who were born in Jim Crow states had poorer breast cancer outcomes, including more aggressive forms of cancer, compared to White women, regardless of their state of birth (Gehlert , 2021) This association between Black women's outcomes and exposure to Jim Crow laws demonstrates the type of "toxic environment" that has been created due to discriminatory policies across the country.

Redlining emerged in the 1930's as a housing initiative led by the federal government's Homeowner's Loan Corporation (HOLC). The HOLC wanted to identify the potential real estate values in various cities throughout the US, so they developed reports and "security" maps that categorized various residential areas from best ("A" groups) marked in blue lines, to worst ("D" groups). These categorizations, however, were largely influenced by neighborhood demographics and areas with predominantly Black residents were often marked as "D" groups and considered hazardous areas. The intent of these categorizations were to keep Black and White communities separate, as well as limit home ownership among of African American communities (Hillier 2003, Huang and Sehgal 2022). As a result of these discriminatory housing policies, disinvestment resulted in redlined areas impacted everything from the types of zoning policies, land use decisions, to the institutions and infrastructures that were brought into the neighborhood, including industrial sites and highways. (Cooperman, 2021)

It is particularly important to consider the ways in which structural policies, such as redlining, influenced the spatial distribution of hazardous sites and how they subsequently impact breast cancer outcomes. This thesis will examine the relationship between living in proximity to Treatment, Storage and Disposal Facilities (TSDFs) and Breast Cancer Mortality using data from the EPA RCRA Database and the BRIDGE 2010-2017 Cohort Database.

Thesis Aims

Aim 1: Is there spatial heterogeneity in the relationship between the placement of Historic Redlining Graded Areas and the concentrations Active and Inactive TSDF's in those areas?

Hypothesis: There is evidence of more spatial clustering of hazardous sites (TSDFs) in HOLC Grade D areas compared to HOLC Grade A areas.

Aim 2: Is there an association between prevalence of Active and Inactive TSDF's at study enrollment & time until breast cancer death?

Hypothesis: Increased prevalence of TSDFs by census block group will increased the risk of breast cancer mortality.

Methods

Study Population

The Georgia Cancer Registry is a statewide registry that has collected the majority of all cancer cases among Georgia residents since a January 1st, 1995 diagnosis date. Using this information, we identified 6,164 metro-Atlanta female non-Hispanic Black and non-Hispanic White residents with a first primary stage I-IIIA BC diagnosis occurring from January 1st 2010 to December 31st, 2017. Participants in the metro-Atlanta region for this study includes women living in Dekalb & Fulton County. All other diagnosis were excluded, including those among other race/ethnic groups, patients <18 years old, male patients, and patients with a previous history of cancer or secondary tumor diagnosis. In addition, patients were excluded if we did not have available information on their census block group. (Figure 5)

Exposure Assessment

TSDF's; Treatment, Storage and Disposal Facilities (TSDFs)

The Environmental Protection Agency (EPA) has a Resource Conservation and Recovery Act Information Database (RCRAInfo). For the calculation of the Density of TSDF's we used "All Handler Universes" which includes Transport, Storage, Disposal Facilities, Large Quantity Generators, Small Quantity Generators, Conditionally Exempt Small Quantity Generator, Transporters, and Used Oil Universes. A TSDF is defined as any facility that handles through treatment, storage, or disposal of hazardous waste. Owners and operators of TSDF's are required to submit a waste analysis with detailed information on their handling procedures. For this analysis, we utilized the RCRAInfo database to select All Process, All Handler Universe, Active and Inactive Facilities within Atlanta, Georgia with data extracted from the site in November, 2022. (EPA, 2023) Individuals with no TSDF's in their CBG were considered unexposed (N=4,354). Quartiles were used to determine intervals between low, medium, and high exposure groups. Individuals with 1 TSDF located in their CBG were considered low exposure (N=530).

Individuals with 2-4 TSDF's located in their CBG were considered medium exposure (N=663). The remainder of individuals had somewhere from 4-88 TSDF's in their CBG and were considered a high exposure group (N=617). (Table 1A, 1B)

Outcome Assessment

Breast Cancer Mortality

To determine breast cancer mortality status of women in the BRIDGE Cohort we ascertained underlying cause of death, which was abstracted by GCR staff using death certificates. We only recorded breast cancer related deaths recorded through the censor date January 1st, 2020.

Covariates of Interest

Living in a HOLC Graded Area

In 1935 a U.S. Federal Agency, the Homeowners' Loan Corporation (HOLC) was tasked to assign neighborhoods a grade based on their determined mortgage investment risk across US metropolitan areas. Using historic redlining scores for 2010 US Block Group Level Data in metropolitan Atlanta, Georgia that were subset from the publicly available Meier et al dataset. (Meier, 2021) Redlining scores were calculated from the summed proportion of HOLC grades multiplied by a weighting factor based on the area within each census block group. HOLC grades were assigned a numerical value as follows: 1 for "A" grade, 2 for "B" grade, 3 for "C" grade, and 4 for "D" grade. For this analysis, the scores were grouped into four categories: 1 to 2 "A" grade, 2 to 3 "B" grade, 3 to 3.5 "C" grade, and 3.5 to 4 for "D" grade.

Other covariates

Among the subset of women in the BRIDGE Cohort, we looked at race, and subset our population to include Non-Hispanic Black (NHB) and Non-Hispanic White (NHW) populations. Age is an important confounder to consider in breast cancer studies, so we also made sure to control for this variable. Cancer stage at diagnosis was also considered, this variable was created based on the AJCC 7th edition staging manual. (AJCC, 2010) For this analysis we subset to Stage I-IIIA only. Additionally, we considered molecular subtype as well. Individuals with positive ER+ and /or PR+ and HER2- status were designated as Luminal A. For individuals with positive ER+ and /or PR+ and HER2+ status were designated as Luminal B. Those with negative ER- and /or PR- and HER2+ status were designated HER2-enriched. And finally, those with both negative ER- and /or PR- and HER2- status were designated as triple negative breast cancer (TNBC) subtype. (Gradishar et al, 2016)

American Community Survey (ACS) survey data was also collected at the census block group (CBG) level to determine potential confounding variables. Covariates included percent less than HS education, and percent Black population by block group.

Statistical Analysis

Spatial Analysis (Clustering of High Proximity Scores within HOLC Graded Areas)

Kernel Density Estimation

We calculated a Spatial Density of TSDF's using Kernel Density Estimation (KDE). KDE is a non-parametric modeling strategy that characterizes local neighbors in a way similar to inverse distance weighting. We used Adaptive Smoothing allowed the smoothing to be utilized more in sparse data areas and less in areas with more point density. We calculated and mapped the spatial intensity of TSDF point data using an to produce a spatially continuous surface (raster) to represent disease risk across HOLC Graded Areas. (Kramer, 2022)

Global Moran's I Test

We conducted a spatial cluster analysis to test where significant clusters of TSDF's are located across HOLC Graded Areas. To detect spatial autocorrelation (a deviation from the null assumption that TSDF's are equally distributed) we used a Global Moran's I for Poisson-Distributed data using K-nearest neighbor definitions.[1] (Kramer, 2022)

The Moran's I statistic evaluates the degree to which pairs of random variables correlate with one another. Moran's I evaluates a single random variable for each areal unit and compares it to the same variable observed for the neighboring areal unit. Similarities in values of the measure between neighbors will indicate spatial autocorrelation. For spatial mapping, we used the Local Moran's I with constant Risk Assumption, which allows Poisson distributed case event counts over population at risk. (Kramer, 2022)

Aspatial - Survival Analysis (Prevalence of TSDF's value impact on BC Mortality)

The Stratified Cox Procedure was used to calculate age-adjusted and multivariable adjusted hazard ratios (HR's) for the approximation of relative risks and 95% confidence intervals to estimate the association between TSDF prevalence and the risk of breast cancer mortality stratified by molecular subtype. The multivariable adjusted model included age and stage.

All analyses were conducted with RStudio version 4.2.1. (R Foundation for Statistical Computing, Vienna Austria), and SAS version 9.4 (SAS institute, Cary, USA). All statistical tests were two sided, and p-values < 0.95 were considered statistically significant.

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[1] To create a k-nearest neighbor object, we first must identify the relative proximity of potential neighbors. To define who is nearest to whom, we measure the Euclidean distance between the centroids of polygons (the geometric center), under the assumption that this is an average location to describe the polygon.

Descriptive Results

A total of 6,164 women in the cohort were followed for our descriptive results. Table 1A shows relatively even rates of race (cohort) and percent Black residents (by CBG) by TSDF categorical exposure level. We observed a slight disparity in decreased educational attainment by CBG as the TSDF exposure level increases. We found that individuals with higher TSDF prevalence CBG's also have lower Median Household Income by CBG (Table 1B).

Spatial Analysis Results

The study area contains 213 census block groups that include all HOLC Graded Areas inside Fulton & Dekalb County, Georgia. Figure 1 includes the distribution of the Assigned Grades by Census Block Group. Red (3.5-4) represents redlined (most hazardous) areas on the map, whereas green areas (1-<1.5) represent the least hazardous areas on the map.

We found that areas with High-high risk are block groups that have a high exposure to TSDF's are also neighboring other block groups with a high exposure to TSDF's (Figure 2). Low-low groups represent that block groups with low exposure to TSDF's are neighboring block groups with low exposure as well. When we compare Figure 1 to Figure 2, we can see that the High-high areas are also located in HOLC Grade B (1.5-<2.5), C (2.5-<3.5), and primarily D (3.5-4) areas. Whereas the Low-low groups are primarily located in Grade A (1-<1.5), Grade B (1.5-<2.5) and surprisingly Grade C (2.5-<3.5) areas. This constant risk map supports our hypothesis that there is spatial clustering of high TSDF exposure risk in HOLC Grade D areas compared to HOLC Grade A areas. Additionally, when testing the TSDF distribution using the Global Moran's I for Poisson Distribution Data, the statistic was 0.13 iwith a p-value of 0.026. (Table 3)

Figure 3 summarizes the evidence in relation to the null hypothesis that the geographically weighted mean value of TSDF site density is stationary, against the null hypothesis that at least some locations have significantly more extreme local values than expected under the null. According to the pseudo-p values created here, we can see that when referencing Figure 1, most of the significantly high extreme site density is located in HOLC C & D graded areas. Surprisingly, the significantly low extreme site density is primarily located in HOLC C & D graded areas as well. When we look at the density of the values overall, without considering those that are statistically signification under the 90% and 95% significance range, (Figure 4) we find that the high- and low-density patterns to visually follow the HOLC Grade A &, B and D distribution.

Aspatial Results

The study area contains 934 census block groups (CBG) that include all CBG's in Dekalb & Fulton County, Georgia. The stratified Cox model was performed on N=5,832 individuals in the cohort (excluding those missing information on identified molecular subtype). Among the crude & multivariable models, a small affect size between the association of TSDF prevalence by exposure level and breast cancer mortality was observed. Precision was also low, with no statistical significance. When we assessed for Proportional Hazards (PH), we found that Subtype did not meet the PH assumption, therefore we decided to stratify our results by subtype. Using the stratified Cox model, we had moderate effect sizes, however we saw wide 95% CI's, with no statically significant associations between TSDF prevalence by exposure level and breast cancer mortality. Among the low TSDF exposure level, Luminal A (HR=1.21, 95% CI, 0.77-1.89, p=0.40) and HER2 (HR=1.49, 95% CI, 0.34-6.49, p=0.60) had the highest risk of BC mortality.

Among medium TSDF exposure level only HER2 was associated with a small increased risk of BC mortality (HR=1.12, 95% CI, 0.33-3.86, p=0.85) Surprisingly, though there seemed to be a trend for increasing risk from Low to High exposure, this same trend was not seen among any of the medium exposure levels. Among the high TSDF exposure level, Luminal B (HR=1.23, 95% CI, 0.47-3.21, p=0.67) and TNBC (HR=1.11, 95% CI, 0.65-1.91, p=0.69) were associated with a small increased level of risk, with a high level of risk for BC mortality for those diagnosed with the HER2 subtype (HR=2.06, 95% CI, 0.68-6.16, p=0.20). (Table 4)

Discussion

In this study, we investigated the association historic redlining and presence of TSDFs with breast cancer mortality. The data showed us that TSDF's are more likely to be located in HOLC Grade D block groups compared to HOLC Grade A. This supports previous research that states African American women are more likely to living in census tracts with higher exposure to toxic chemicals and heavy metals (Fuerst 2019, Lewis-Michl 1996). The mechanisms behind this are clear. Due to historic policies minority and foreign-born families experienced systematic sorting into communities that were either already environmentally hazardous or targeted for toxic waste sites due to their lack of political agency. While there are ongoing debates about the use of HOLC-grades in examining contemporary health outcomes it is evident that these historic polices had a lasting effect on the distribution of environmental contaminants, many of which persist in communities of color today (Huang and Sehgal, 2022).

The results from our analytic study do not support an association between TSDF prevalence and breast cancer mortality across molecular subtypes luminal A, luminal B, HER2-enriched and TNBC. However, there was evidence of modest risk increase from groups with no-exposure to TSDF's compared to the high exposure category. Research on previous studies also have a limited association between exposure to hazardous waste and breast cancer progression. Only a study by Fuerst, showed an increased risk of ER- breast cancer for women living in census tracts with higher levels of cadmium and antimony metals. Many studies (including our own) are limited by small numbers—an artifact of using the HOLC graded areas. There is robust evidence on the association between environmental exposure, particularly exposure to hazardous waste, and breast cancer risk. Whether there is an association with breast cancer mortality, independent of the association with risk, remains unclear. However, we'd expect many of the same biologic pathways implicated in the etiology of breast cancer to be related to tumor progression, including: alterations to hormonal and inflammatory parameters. It may be of interest to characterize these associations in strata of treatment characteristics (particularly endocrine therapy) to better understand the mechanisms by which environmental exposure impact breast cancer outcomes.

There are several limitations to this study. This is the first study to investigate the association between proximity of TSDF and breast cancer mortality using EPA data. Previous studies have looked at the spatial distribution of industrial activities as a proxy for exposure to environmental risk. (Gasca -Sanchez, 2021) However in this case, I think the use of TSDF Prevalence as a proxy for exposure could have led to exposure mismeasurement. The exposure variable itself, is quite remedial as it does not take into consideration the biologic pathways for exposure. Further, census block groups do not account for the ways in which pollution through air, water, or soil from TSDF's in the neighborhood may be passed from the structure to the individual. Additionally, this measure does not consider the spatial clustering that we determined is present in Aim 1. To get a better understanding of how exposure differs, we would need to incorporate spatial neighbors in the exposure measure for a spatial modeling analysis.

We were also limited by the lack of information from the RCRA database regarding the ways in which sites were categorized as active or inactive. More information on when the sites were considered hazardous would also help to establish temporality. The RCRA did provide information on each site, and TSDF's range from large industrial site activities (waste disposal facilities) to places where exposure to hazardous waste could be extremely low (for example, local CVS). Future studies should refine the exposure measure to give each site a different level of toxicity.

We hypothesized that proximity to TSDF's would increase breast cancer mortality risk. However, our results suggested that there is no significant relationship between TSDF prevalence by block group and breast cancer mortality. However, there is an indication of potential association between high exposure to TSDF's and BC mortality, particularly among cases with the HER2 subtype. The results of this study indicate the need for additional research in the relationship between environmental toxicant exposure and BC progression. Given the limitations of the exposure measurement, future research should consider more robust measurements of environmental exposures and proximity to hazardous waste.

Tables

Table 1A: Characteristics of all-cause mortality cases and controls, stratified by prevalence of TSDF's

Variables		Overall (N=6,164)	No Exposure (N=4,354)	Low Exposure (N=530)	Medium Exposure (N=663)	High Exposure (N=617)
N (%)						
Age	<55	2306 (38%)	1666 (38%)	184 (35%)	225 (34%)	231 (37%)
	≥ 55	3858 (63%)	2688 (62%)	346 (65%)	438 (66%)	386 (63%)
Race	NHW	3042 (49.35)	2171 (50%)	266 (50%)	309 (47%)	296 (48%)
	NHB	3122 (50.62)	2183 (50%)	264 (50%)	354 (53%)	321 (52%)
% Black (N=6,163)	< 20%	2393 (39%)	1708 (39%)	211 (40%)	245 (37%)	229 (37%)
	≥ 20%	3770 (61%)	2645(61%)	319 (60%)	418 (63%)	388 (63%)
% Less than HS (Among women) (N=6,161)	< 20%	5408 (88%)	3904 (90%)	448 (85%)	571(86%)	485(79%)
	≥ 20%	753 (12%)	449 (10%)	80 (15%)	92(14%)	132(21%)

Table 1B: Characteristics of all-cause mortality cases and controls, stratified by prevalence of TSDF's

Variables		Overall (N=6,164)	No Exposure (N=4,354)	Low Exposure (N=530)	Medium Exposure (N=663)	High Exposure (N=617)
N (%)						
Stage	1	3239 (53%)	2265 (52%)	288 (54%)	357 (54%)	329 (53%)
	2	2481 (40%)	1769 (41%)	205 (40%)	262 (39%)	245 (40%)
	3	444 (7%)	320 (7%)	37 (7%)	44 (7%)	43 (7%)
Subtype	Luminal A	4140 (67%)	2897 (66%)	364 (68%)	474 (71%)	405 (66%)
	Luminal B	711 (12%)	504 (12%)	61 (11%)	74 (11%)	72 (12%)
	HER-2	250 (4%)	187 (4%)	16 (3%)	25 (4%)	22 (4%)
	TNBC	731 (12%)	524 (12%)	61 (11%)	56 (8%)	90 (15%)
	Unknown / Other	332 (5%)	242(6%)	28 (5%)	34 (5%)	28 (4%)
Mean (SE)						

Median HH Income ($)	$71, 421 ($43,030)	$74, 615 (44,004)	$66, 366 ($42,267)	$65,230 ($40,374)	$59,858 ($35,872)

Table 3: Results for Global Moran's I Spatial Cluster Analysis of TSDFs across HOLC Graded Areas
Global Moran's I Statistic is: 0.13. P-value: 0.026

Table 4: * Hazard ratio, 95% CI, and p-value for breast cancer–specific death according to TSDF exposure level among NHW and NHB women diagnosed with breast cancer in the metropolitan Atlanta area, 2010 to 2017, and registered with the Georgia Cancer Registry by subtype.

		Hazard Ratio (HR)	**95% CI:**	**P-value:**
Crude *age adjusted	TSDF Exposure Level:			
	Low	1.1	(0.77-1.55)	0.61
	Medium	0.65	(0.44-0.96)	0.03
	High	1.1	(0.79-1.51)	0.58
	TSDF Exposure Level:			

Multivariable *age, stage & subtype adjusted	**Low**	1.1	(0.77-1.55)	0.61
	Medium	0.65	(0.44-0.96)	0.03
	High	1.1	(0.79-1.51)	0.58
Stratified Cox Procedure:				
Luminal A	TSDF Exposure Level:			
	Low	1.21	(0.77-1.89)	0.40
	Medium	0.78	(0.48-1.25)	0.30
	High	0.86	(0.53-1.40)	0.54
Luminal B	TSDF Exposure Level:			
	Low	0.87	(0.26-2.89)	0.82
	Medium	0.23	(0.03-1.71)	0.15
	High	1.23	(0.47-3.21)	0.67
HER2	TSDF Exposure Level:			
	Low	1.49	(0.34-6.49)	0.60
	Medium	1.12	(0.33-3.86)	0.85
	High	2.06	(0.68-6.16)	0.20
TNBC	TSDF Exposure Level:			
	Low	0.96	(0.48-1.9)	0.92
	Medium	0.53	(0.21-1.32)	0.17
	High	1.11	(0.65-1.91)	0.69
***Compared to Unexposed, TSDF Reference was 0 site prevalence in CBG**				

Figures

Figure 1: Assigned HOLC Grade by Census Block Group in Fulton & Dekalb County, Georgia

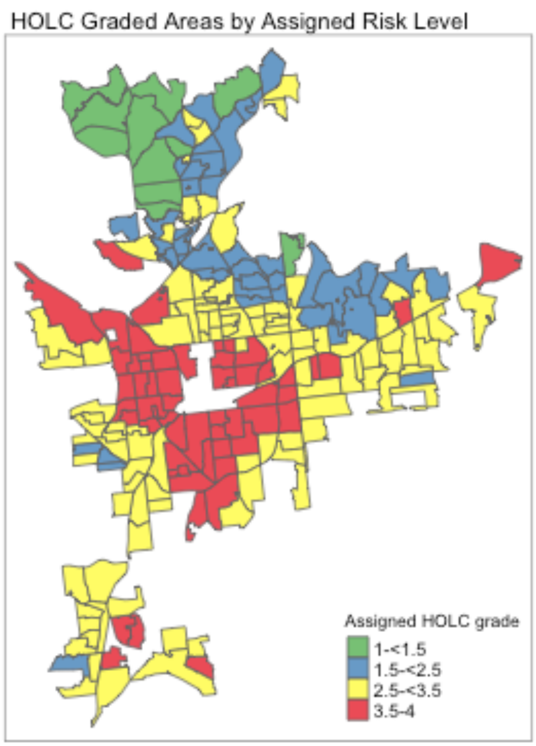


Figure 2: Local Moran's I Mapping with Constant Risk Assumption

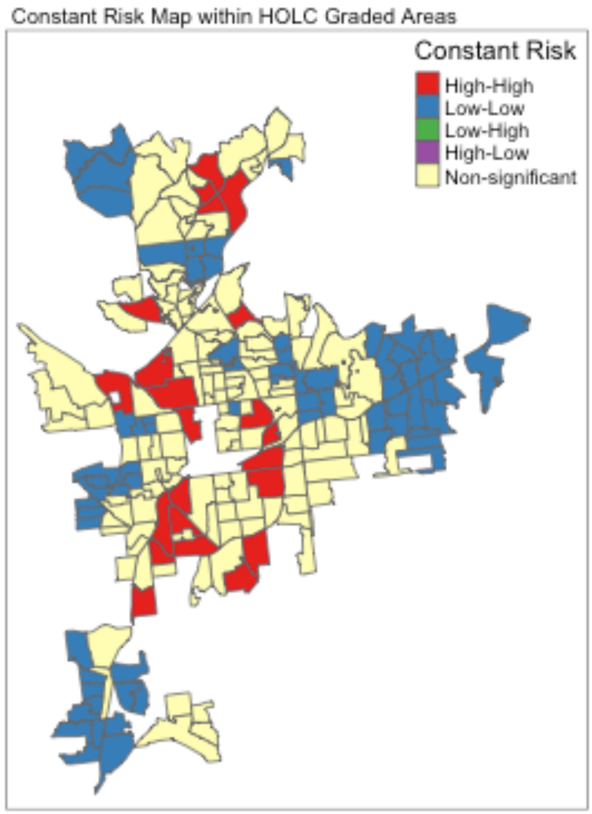


Figure 3: Pseudo P-Value Map looking at Smoothed Estimate of Kernel Density Estimation of TSDFs (density) by Census Block Group in Dekalb & Fulton County, Georgia

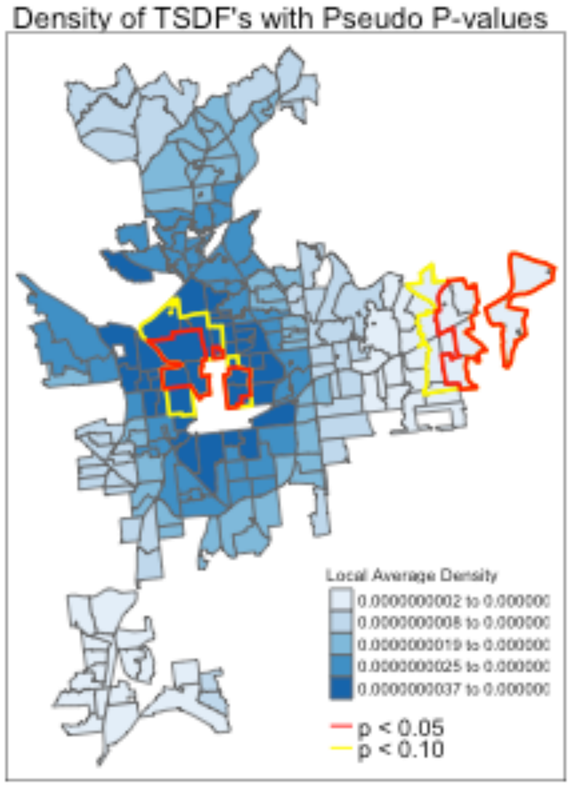


Figure 4: Overall TSDF Site Density from Kernel Density Estimation by Census Block Group in Dekalb & Fulton County, Georgia

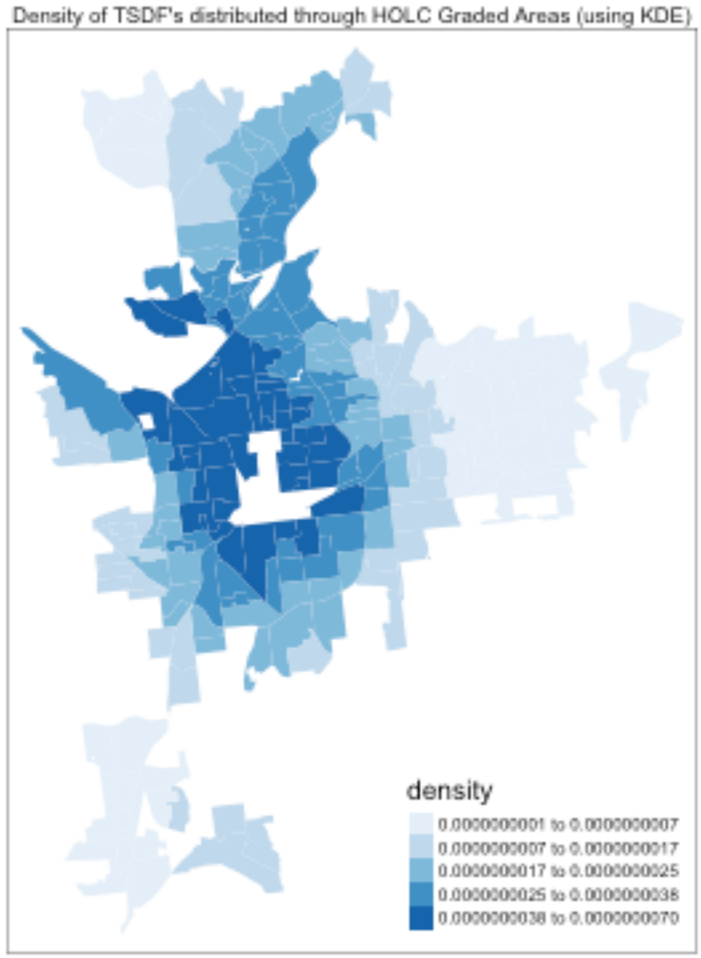


Figure 5: Study Population Exclusion Criteria

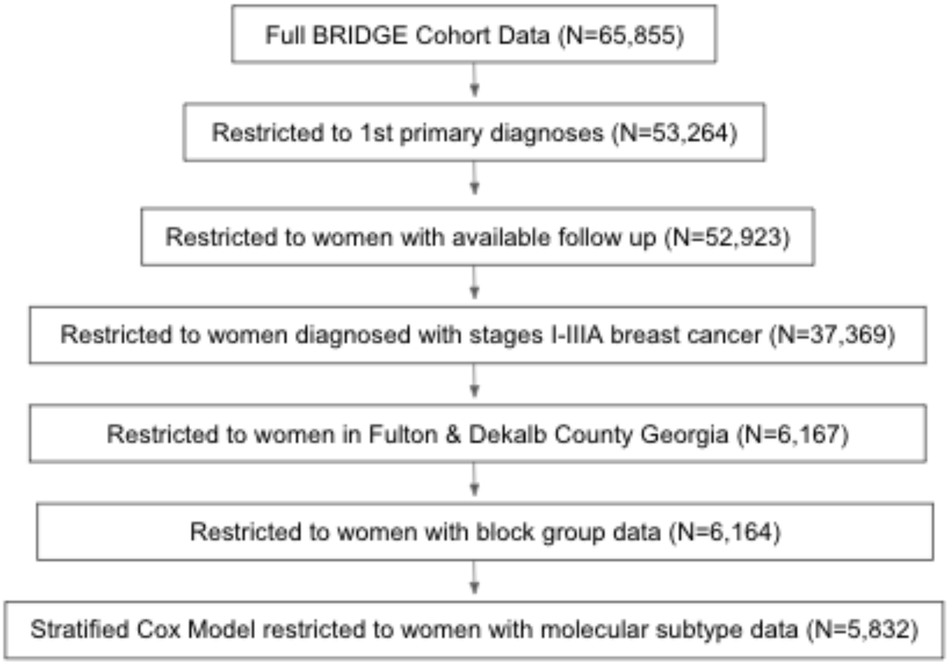
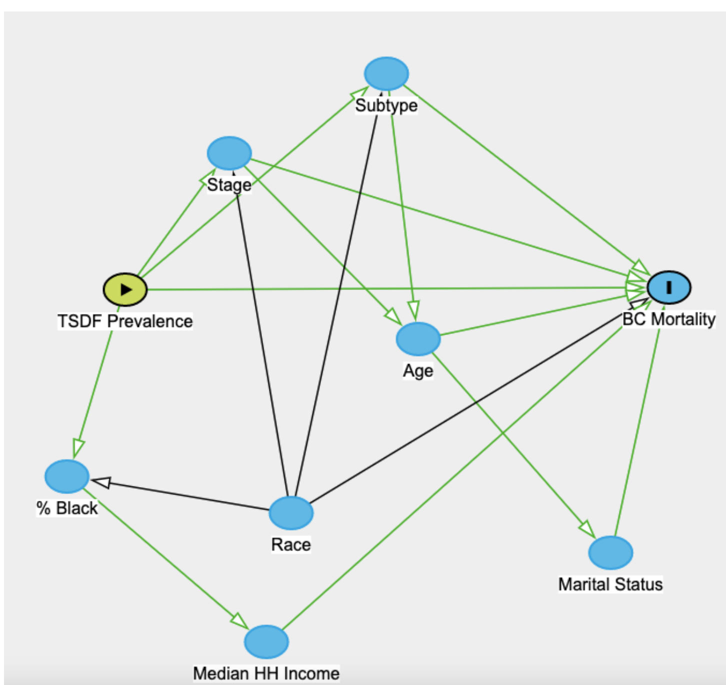


Figure 6: Directed Acyclic Graph (DAG)



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