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Exploring Neighborhood-Level Environmental Justice to Tackle County-Level Disparities in Breast Cancer Outcomes

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Abstract

Breast cancer is a disease in which cells, originating from the breast epithelium, grow out of control and form tumors. The progression of breast cancer can vary, and its severity is often categorized by stages ranging from early, localized forms to more advanced stages involving widespread dissemination. Breast cancer cases can be hereditary or non-hereditary; Hereditary cases are caused by a penetrant gene mutation: one that is pathogenic and has the potential to promote the development of cancer whereas non-hereditary cases can be caused by a variety of day-to-day exposures affected by socioeconomic disparities and health literacy rates. Despite scientific and technological advancements, researchers and health officials still do not know enough about the disease and breast cancer incidence rates in the United States have steadily increased. This literature review aims to synthesize the relationship between breast cancer health outcomes and environmental justice, health literacy, and socioeconomic disparities. This relationship was first examined from a county - level in the state of Florida. We first examined three Florida counties with varying socioeconomic profiles (Broward, Miami-Dade, and Palm Beach) and then examined neighborhoods within the county of Miami-Dade (selected because it has the highest breast cancer rates out of all Florida counties). This examination revealed higher incidences of breast cancer in Latinx and African American communities with high environmental exposures and lower socioeconomic statuses. The identification of specific neighborhoods primarily affected by environmental exposures and low socioeconomic statuses emphasizes the need for neighborhood level modeling to inform future breast cancer research and intervention strategies.

Keywords: Breast Cancer Incidence, Health disparities, Neighborhood-level modeling, Environmental justice, Wealth Stratifications, Community Vulnerability

Introduction

As of 2023, in the United States, an estimated 297,790 people are diagnosed with breast cancer and approximately 43,170 people are predicted to die from the disease (National Cancer Institute, 2023). This makes Breast Cancer the second leading cause of cancer death among women. At the gene level, breast cancer occurs as a result of genetic alterations in one's DNA, involving genes such as BRCA1, that disrupt the regulation of normal cells (National Library of Medicine, 2023). These genetic alterations are mostly hereditary- meaning they are passed down from family members causing mutations in BRCA genes that can cause the onset of Breast Cancer (Feng, 2018). Genetic alterations can also occur de novo in individuals without familial genetic history.

However, only 5-10% of breast cancer cases stem from known genetic defects while the remaining 90-95% originate from factors relating to environment and lifestyle (Feng, 2018) (Figure 1A). Many cases of breast cancer are caused by a combination of both genetic variants and environmental factors as environmental stressors can stimulate genetic predispositions. Specifically, nutrients such as folate and B-vitamins in combination with mutations of polymorphism genes (involved in one carbon metabolism) can affect DNA replication and repair, causing modifications in gene expression patterns and increasing susceptibility to breast cancer (Mbemi, 2020). In many cases, awareness of pathogenic mutations and family history of the disease allow for early detection and prevention (Olopade, 2015). Methods of detection include mammograms, self-examinations, and self-monitoring of symptoms. However, those that do not have family history with the BRCA1 gene mutation can be blindsided by the sudden onset of breast cancer.

Since environment and lifestyle play such a significant role in non - hereditary breast cancer onset and outcomes, a closer look at specific risk factors is warranted (Ajmi, 2020). Specifically, factors such as socioeconomic conditions, healthcare accessibility, urban infrastructure, racial segregation, environmental influences, and policy frameworks have all been linked to the occurrence of cancer. In addition, increased outdoor air pollution (including toxic waste and pesticides) directly affects breast cancer incidence rates (White et al., 2023). The care cascade reveals wealth-based disparities in cancer outcomes across screening, diagnosis, staging, treatment, survival, and mortality (Zahnd & McLafferty, 2017).

Communities affected by these disparities are especially vulnerable to the potentially cancer-causing effects of environmental injustice (Zahnd, 2021). In order to analyze these disparities, the State of Florida was selected, and counties Broward, Palm Beach, and Miami-Dade were analyzed. Florida was chosen because of its diverse demographic and environmental characteristics and its high cancer rates, ranking second in the nation in newly diagnosed cancer cases and mirroring national trends for the top cancer sites. Florida, Broward, Palm Beach, and Miami-Dade counties have a combined average annual count of 4,460 breast cancer cases, accounting for 25% of all Florida breast cancer cases (Florida EPA, 2023). In this paper, we explore county level stratifications in socioeconomic factors, environmental exposures, and health literacy rates relating to breast cancer using quantitative analysis, correlation analysis, and neighborhood-level modelling to ultimately identify the disparities in breast cancer factors.

Methods

Literature search:

These questions informed the search:

1. What is the effect of environmental factors on breast cancer incidence and mortality rates over 1-5 years?

2. What socioeconomic factors/wealth stratifications affect breast cancer incidence and mortality rates?

3. What is the effect and importance of neighborhood level modeling on public health studies and research?

The search engines PubMed, SEER, and Google Scholar were used in this review. To optimize our search, we filtered the data to only include these search terms: breast cancer, Non-hereditary, neighborhood, county, environment, income.

Data Validation:

We first performed quantitative research on demographic data relating to the topic of environmental justice factors and breast cancer in the following Florida counties: Broward, Palm Beach, and Miami-Dade. Information on living conditions, socioeconomic factors, and toxic exposures were extracted from Florida health charts. After excluding various factors, includingeducation level and access to water, we reviewed the remaining studies and examined the correlation between the percentage values of various environmental and socioeconomic variables in each county.

Next, we performed more detailed quantitative research on Miami-Dade County specifically, analyzing the granular details of environmental justice and breast cancer correlations within the county. We did this by comparing various neighborhoods and communities to each other. We then performed correlation analyses on data extracted from this localized using excel scatter plot and creating linear regression lines. Using linear regression lines, we observed the correlation coefficient values to determine the correlation between leading breast cancer exposures and location, We ran multiple regression lines and narrowed the analysis to the neighborhoods with the highest amount of carcinogen exposure in the air because that yielded the most robust data.

Results

Although many contextual factors affect other health outcomes as well, distinctive characteristics of cancer such as the long latency period, diversity of disease sites, interactions among individual demographic and genetic factors and environmental exposures, and the important role of diagnostic and treatment services in disease outcomes present unique challenges for multilevel investigations (Gee & Payne-Sturges, 2018). In our specific investigation we focused on Florida counties Miami Dade, Broward, and Palm Beach. As of 2021, Palm Beach had a median income of $68,874, Broward had a median income of $64,522, and Miami-Dade had a median income of $57,815. Income levels are closely tied with breast cancer incidence rates as late-stage diagnoses are associated with lower socioeconomic statuses (Clegg et al., 2008).

Furthermore, many studies show that in areas with lower socioeconomic status, such as areas along major roads or near industrial zones, the value of land has decreased. This heightens exposure and increases the commonality of diseases within these communities (Hajat et al., 2021).

However, when socioeconomic variables (i.e., percent of people without healthcare and percent of high school graduates) and environmental exposures (i.e., people 500 feet of a busy roadway and air quality index) were examined on a county level in the context of Florida, figure 2A and

2B, the variables that were expected to have varying outcomes based on county income levels only fluctuated a few percentage points among the different counties.

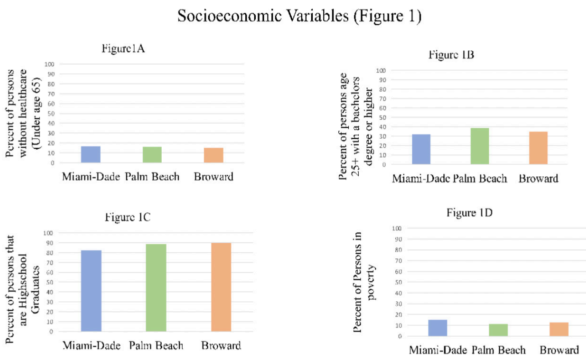

Figure 1: Socioeconomic variables. This combined bar chart graph displays Florida counties on the X-axis. The Y axis of the chart represents percent of persons without healthcare percent of persons aged 25 + with Bachelor's degree or higher, percent of Persons that are Highschool graduates, and percent of persons in poverty. [The Florida Department of Health, 2023]

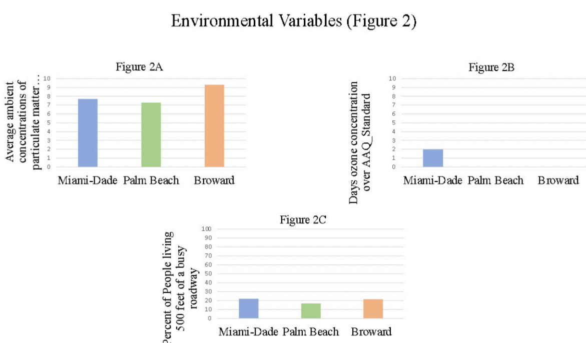

Figure 2: Environmental variables.

This combined bar chart graph displays Florida counties on the X-axis. The Y-axis of the chart represents Average Ambient concentrations of particulate matter in PM2.5 per ug/m3, percent of people living 500 feet from a busy roadway, and the days ozone concentration is over AAQ standard yearly. [The Florida Department of Health, 2023]

As shown in figures 2B and 2A; environmental and socioeconomic variables that are expected to vary based on wealth fluctuations did not vary noticeably on a county level. Figure 3A takes neighborhood level (as defined by zip code) environment exposures into account; specifically, air carcinogens released into the air as a result of toxic waste and pesticides in various neighborhoods (as defined by zip code) within Miami-Dade.

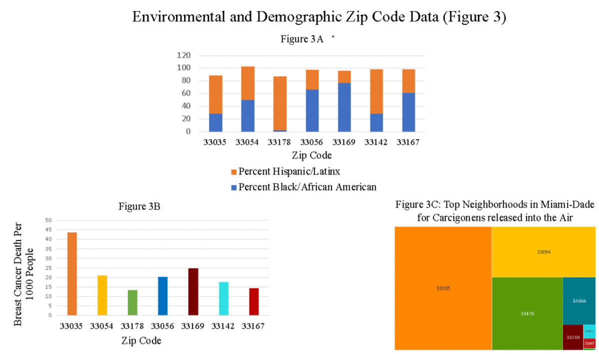

Figure 3A: Demographic data. This stacked bar chart reveals the demographic breakdown of seven Miami-Dade counties; specifically, the bar accounts for the percent of Hispanic/Latinx individuals and African American/Black individuals. [Miami-Dade Matters Demographics, 2023]

Figure 3B: Breast cancer death per 1000 people. This bar chart illustrates the breast cancer death rate in seven Miami-Dade Counties [Miami-Dade Matters Demographics, 2023]

Figure 3C: Top neighborhoods in Miami-Dade for carcinogens released into the air. This bar chart displays the pounds of recognized air carcinogens, as per the U.S. Occupational Safety and Health Administration (OSHA), in various Miami-Dade neighborhoods (as defined by zip-code).

**Demographic Percent composition exceeds 100% because some people identify as both African American and Hispanic/Latinx*

Figure 3 demonstrates that the neighborhoods with the largest amount of carcinogen exposure in the environment (Florida EPA, 2023), such as zip codes 33035 and 33178, were predominantly Latinx and African American communities respectively. Zip Code 33035 is composed of 59% Latinx individuals and 28% African American individuals and zip code 33178 is composed of 85% Latinx individuals and 2% African American individuals (Figure 3C). These neighborhoods also have the highest incidence of breast cancer in the county (Figure 3B). Furthermore, a study on the association of air pollution and increased incidence of breast cancer revealed that the release of air pollutants, including nitrogen oxides, carbon monoxide, sulfur dioxide, and volatile organic compounds, demonstrated a significant positive correlation with the incidence of breast cancer. The strong associations, indicated by correlation coefficients (R^2) of 0.89, 0.82, 0.71, and 0.68, respectively ($p < 0.001$), suggest a noteworthy link between air pollution and the occurrence of female breast cancer in the United States (Wei, Davis, Bina, 2011). Therefore, these communities, which are predominantly minority-based, are especially vulnerable to the effects of environmental injustice and could benefit the most from preventive measures. Furthermore, after performing our own correlation analysis on three Miami-Dade neighborhoods with the most pounds of recognized air carcinogens, examining the relationship between breast cancer deaths per 1000 people and pounds of recognized air carcinogens we found a strong positive correlation between released air pollutants and breast cancer rates within Miami-Dade neighborhoods (R^2=0.98, p=...).

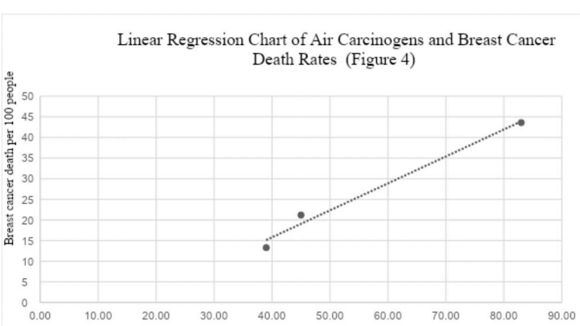

Figure 4: Linear Regression chart of Air Carcinogens and Breast Cancer Death Rates.

This linear regression analysis displays the correlation between pounds of carcinogens released into the air and breast cancer deaths per 100 people in three Miami-Dade zip codes with leading amounts of carcinogens released in the air.

Additionally, a correlation analysis on median income and breast cancer incidence rates per 1000 people in the three Miami-Dade Zip Codes with the leading number of pounds of air pollutants yielded a correlation coefficient of .78, (p=...), indicating a strong positive correlation between median income per household and breast cancer Incidence. This relationship suggests that wealthier neighborhoods may have more access to healthcare and therefore are more likely to be diagnosed with breast cancer, whereas in poorer neighborhoods, the true association with cancer may be confounded by an inability to seek care.

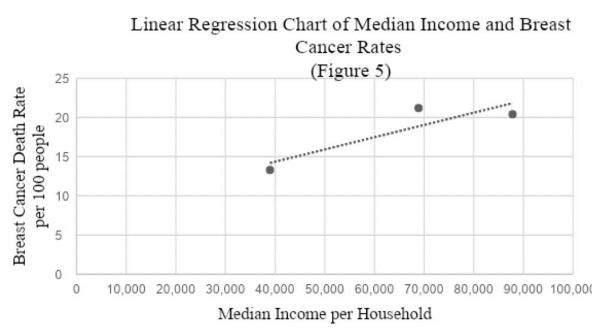

Figure 5: Linear Regression chart of Median Income and breast cancer Rates

This linear regression analysis displays the correlation between median income per household and breast cancer death rate per 100 people in three Miami-Dade zip codes with leading amounts of air carcinogens.

In addition, we found that these communities (as defined by zip code) also face disparities in terms of health literacy. Between 13%-30% of the adult population (ages 25+) within these neighborhoods have less than a high school education and between 26.9%-34.4% of adults (aged 18-64) do not have health insurance (Figure 3A)

Figure 6: Zip Code Health Literacy Data

This bar chart illustrates key health literacy factors as y values including high school graduation rates, percentage of people with bachelor's degree or higher, percentage of adults who have routine checkups, and percentage of adults without Health Insurance in the three Miami-Dade Zip Codes with the highest amount of recognized air carcinogens.

Data has revealed that having private insurance significantly improves the odds of breast cancer survival amongst women (Gilbertson et al., 2021). Furthermore, education levels play a crucial role in the staging, clinical and pathological characteristics, examination implementation, and the choice of treatment patterns in the context of cancer. (Liu, 2017). This is evident in the high breast cancer rates in these neighborhoods. Specifically, in zip code 33035, which has the highest breast cancer incidence in all of Miami-Dade, we found 29.3% of its population does not have health insurance and 19.5% of its adult population has less than high school education. After performing our own correlation analysis on the percentage of adults aged 25+ with a bachelor's degree or higher and breast cancer death rates per 1000 people in seven Miami-Dade neighborhoods with the most pounds of recognized air carcinogens, we found an R value of .00001. This indicates no correlation between zip codes with a higher percentage of population with a bachelor's degree and higher breast cancer rates; suggesting that attaining a higher level of education through a bachelor's degree does not impact breast cancer incidence rates.

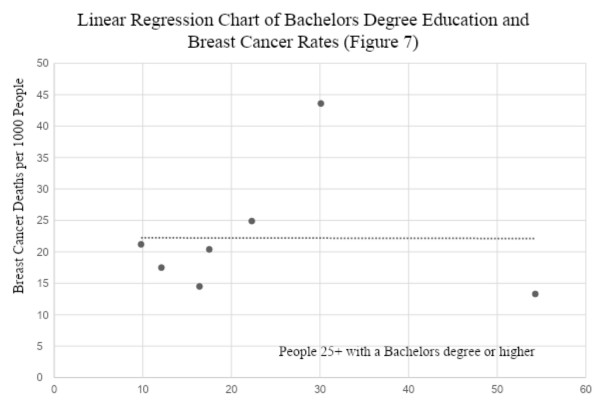

Figure 7: Linear Regression chart of bachelor's degree education and breast cancer rates

This linear regression chart displays the correlation between percentage of population ages 25+ with a bachelor's degree and cancer death rates per 100 in seven Miami-Dade zip codes with leading amounts of carcinogens released in the air.

Discussion

The neighborhood level modeling performed identified the specific communities predominantly affected by negative environmental factors such as pollution and carcinogens in the air. Over the years, racism has confined racial and ethnic minority groups to residential areas characterized by increased risks of environmental pollutants, such as those in proximity to industrial facilities. (Wong et al., 2022). Therefore, our analysis of the demographic composition and health literacy levels in relation to breast cancer incidence on a neighborhood level allowed us to pinpoint the minority groups most affected by environmental disparities.

Furthermore, our analysis of factors such as insurance rates and levels of education allowed us to examine inconsistencies in health literacy in these communities, unveiling the direct effect of socio-economic factors on breast cancer outcomes.

Our examination revealed a correlation between lower median incomes and heightened breast cancer incidence rates on a neighborhood level, aligning with existing literature associating higher breast cancer incidence and diagnoses with higher socioeconomic statuses indicating better access to healthcare resources that allow for detection in more affluent neighborhoods. Solutions to this include: establishing financial assistance programs that provide cancer screenings and diagnostic tests to lower income neighborhoods that allow for creating a community outreach program that increases awareness about available healthcare, and promoting and distributing current data that underscores the risk and exposure of certain geographical areas.

Another factor we found to be correlated to cancer on a neighborhood level was carcinogen exposure in the environment. Solutions to this include advocating for stricter environmental regulations and policies to reduce the release of carcinogens, engaging in community activism to address specific environmental concerns, and promoting research initiatives to further investigate the impact of environmental factors on cancer outcomes. Lastly, we found health literacy to be a contributing factor to increased breast cancer rates. Specifically, lack of education and insurance coverage can result in delayed screenings and diminished awareness of preventive measures, aggravating the challenges associated with breast cancer diagnosis and treatment. Ways to combat disparities in health literacy rates include implementing policies that facilitate access to affordable healthcare services, promoting the importance of regular screenings, and providing education opportunities for communities with especially low education rates.

Although many contextual factors affect other health outcomes as well, distinctive characteristics of cancer such as the long latency period; diversity of disease sites; interactions among individual demographic and genetic factors and environmental exposures; and the important role of diagnostic and treatment services in disease outcomes present unique challenges for multilevel investigations. The unique challenges presented by cancer's characteristics required a specialized approach in research. Our correlation analysis was also limited by the availability of few data sources, which may not have been completely representative of other counties/zip codes worldwide. Future research could consider additional data sources.

Conclusion

By examining and extracting data on county-level health exposures and their correlation with environmental justice and breast cancer incidence, our study provides insights on environmental equity and public health. Our research extends beyond county boundaries to focus on neighborhoods and communities within Miami-Dade, revealing hidden nuances and trends and pinpointing relationships that broader geographical analysis would have missed. In doing so, we found that micro-level analysis on a neighborhood level is necessary to formulate targeted solutions for environmental justice and health concerns. This approach takes a closer look into neighborhoods, ensuring underserved populations are reached and represented (Figure 3A). Future research opportunities include extending this neighborhood level analysis to a broader range of cancer types and outcomes, examining the effects of changing environmental conditions on breast cancer incidence and mortality, and studying the effect of improved understanding of neighborhood level data on breast cancer outcomes. Extending this neighborhood level analysis to a broader range of cancer types and outcomes can uncover shared risk factors and socio-economic disparities among different cancer types, providing health officials with a new understanding of neighborhood-level inequalities that can aid them in providing marginalized neighborhoods with specialized help and attention. Examining the effects of changing environmental conditions on breast cancer incidence and mortality can allow for a more granular distinction between cancer related environmental exposures and non-cancer related environmental exposures. This nuanced understanding can inform future public health measures and interventions to mitigate these risks, ultimately reducing the effect of environmental exposures. Lastly, understanding the effect of increased awareness of neighborhood-level data on breast cancer outcomes can highlight the need for improved breast cancer education. This study encourages researchers to evaluate how likely informed communities are to take preventive measures regarding breast cancer.

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