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Why the visits? A Spatial Analysis of the Socio-ecological Predictors of Asthma Emergency Department Visits in Los Angeles County, California

Abstract

Asthma is one critical health canker that troubles nations across the globe. It has wide array of impacts on the socio-economic growth of places from the local level to the national level. Due to its huge negative impacts, it has gained wide attention and choked numerous academic discourses across the globe. For proper public health policy formulations, there is a rising demand for localized level studies to ascertain the predictors of asthma. The study was conducted in Los Angeles County, California, using PM2.5 concentration, race, house cost burden, and poverty levels, due to its ranking in these socio-ecological factors and asthma levels. The study found that PM2.5 concentration and percentage of Whites are negative predictors of asthma. On the other hand, African-Americans, house cost burden, and poverty levels are positive predictors of asthma. The study suggests that policymakers should pay attention to devising targeted policies for socially vulnerable populations in LA county and similar counties.

1. Introduction

Asthma is one critical health canker that troubles nations across the globe. It has wide array of impacts on the socio-economic growth of places from the local level to the national level. It cuts through increased personal and government spending on health, huge effects on labor force and productivity, and low quality of life (Jansson et al., 2020; Nurmagambetov et al., 2018). Specifically, the USA spends over $50 million on asthma related issues (Wesley et al., 2024). It is argued as one of the deadly chronic disorders. About 180,000 people die from asthma globally each year, with significant differences between continents, regions, age groups, and socioeconomic backgrounds (Nunes et al., 2017). Between 1999 and 2025, about 85, 630 persons have died from asthma (Xu et al., 2025).

Asthma is basically a chronic inflammatory illness that often manifests as a lifelong condition with varying degrees of severity throughout the course of a patient's lifetime. People of all ages are affected by asthma; however, with peaks in childhood (Nunes et al., 2017). According to the National Institute of Health Guidelines on Asthma (NIH Guidelines) asthma is extensively define as “Asthma is a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role: in particular, mast cells, eosinophils, Tlymphocytes, macrophages, neutrophils, and epithelial cells. In susceptible individuals, this inflammation causes recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night or in the early morning. These episodes are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment. The inflammation also causes an associated increase in the existing bronchial hyperresponsiveness to a variety of stimuli. Reversibility of airflow limitation may be incomplete in some patients with asthma." (*NIH*, 2007) Owing to the critical danger it poses to individuals and nations, asthma has gained ample attention in empirical scholarship, with considerable attempts to unravel the causes of it, for better policy formulation.

With the growing body of empirical resources on the predictors of asthma, there has been a widespread association of varied environmental and social factors with asthma prevalence. For instance, fine particulate matter (PM2.5) is one of the key environmental factors that is largely associated with respiratory diseases including asthma (Shu et al., 2024). PM2.5 can develop in the atmosphere from pollution precursors or be directly released. Meteorology influences the amount of PM2.5 released and created in the atmosphere (Nassikas et al., 2022). Fan et al.,(2016) found that, asthma ED visits increased with higher PM2.5 concentrations (RR 1.5% per 10 μg/m3; 95% CI 1.2–1.7%), nevertheless, children were more vulnerable to increasing PM2.5 (3.6% per 10 μg/m3; 95% CI 1.8, 5.3%) than adults (1.7, 95% CI 0.7%, 2.8%). Similarly, Kravitz-Wirtz et al., (2018) revealed that PM2.5 is a predictor of childhood asthma diagnostic OR = 1.25, 95% CI = 1.06–1.46. Moreover, a rise in PM2.5 concentration leads to increase in reported cases of asthma symptoms (Loftus et al., 2015). In the same vain, a study conducted in Kansas City Metro Area unraveled that the higher the PM 2.5 concentration the higher the reports of emergency department visits (Wesley et al., 2024).

As a matter of fact, aside from this environmental factor, there are some identified social factors that are evinced as causal factors of asthma. These are generally the social determinants of health. According to the World Health Organization, social determinants of health (SDoH) is "non-medical factors that influence health outcomes, which can include conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life." (WHO, 2021). With respect to asthma, the key prominent social determinants are poverty and race. It is evident in literature that, social vulnerability index has a positive relationship with asthma risk (Han et al., 2007). After taking other local economic situation into account, Wesley et al., (2024) observe significant differences in the frequency of asthma emergency department visits among census tracts with varying percentages of non-White inhabitants and poverty levels; and further concludes a positive relationship between asthma poverty or race. Moreover, this relationship is longstanding, as researchers have recognized impoverished metropolitan neighborhoods, also known as the "inner city," as hotspots of high asthma incidence and morbidity since the 1960s (Weiss et al., 1992). According to Keet et al.,(2015), prevalence of asthma inner-cities at the census tracts level was 12.9% compared to 10.6% for non-inner cities, nevertheless, the results was not statistically significant after controlling for race and age. On the other hand, individuals or households living g above the national poverty levels reports lower odd of asthma (Assari & Moghani Lankarani, 2018).

Higher racial segregation is also associated with higher asthma reports (Baltrus et al., 2017). Black and Latino Americans face a disproportionate burden of SDoH and have a higher incidence of asthma morbidity and prevalence compared to White Americans (Grant et al., 2022). A study of 1,847 asthma patients revealed that both Black and Hispanic asthma patients had higher odds of hospitalization compared to white patients; (those ever hospitalized patients: 66%; Hispanic, 63%; white, 54%; $p < 0.001$; hospitalized patients in the past year: 31%; Hispanic, 33%; white, 25%; $p < 0.05$) and ED use (median use in the past year: black, three visits; Hispanic, three visits; white, one visit; $p < 0.001$) (Boudreaux et al., 2003). More recently, Wesley et al., (2024) reaffirmed this by revealing that asthma prevalent is higher among ethnic minorities in the Kansas City Metro Area.

Notwithstanding, another critical social stressor that impacts health is house-cost burden. For instance, A 20-point increase in house-cost burden between 2000 and 2008–2012 was linked to a 16% increase in mortality through 2019 (Graetz et al., 2024). According to a study of 10,000 residents of Philadelphia and the four surrounding counties, individuals who lived in unaffordable housing were more likely to have poor self-rated health (AOR 1.75, 95%CI 1.33,2.29), arthritis (AOR 1.92, 95%CI 1.56,2.35), hypertension (AOR 1.34, 95%CI 1.07,1.69), non-adherence to prescription drugs (AOR 2.68, 95% CI 1.95, 3.70), and cost-related healthcare non-adherence (AOR 2.94, 95% CI 2.04, 4.25) (Pollack et al., 2010). These suggest the positive association between house-cost burden and health outcomes. However, there is limited to no literature on the direct relationship between house-cost burden and asthma prevalence.

Even though there has been this wide empirical knowledge about the predictors of asthma, across the globe and more specifically, the United States, more studies are still required at some geographic levels. Most of these studies are either national by state, or state by county, of metro areas. However, for a more effective policy formulations, it is imperative to undertake these studies at lower level such as census tracts to ascertain and establish the relationship that exist at that level too. Considering PM2.5 concentration as the lead causal factor of asthma, Los Angeles County was used for this study. The county is a vital location to investigate the socio-ecological predictors of asthma due to its longstanding issues with air pollution and asthma disparities, hence, this study. To achieve this aim and considering what found in the literature review, the hypotheses tested in this study are 1) PM2.5 is a positive predictor of asthma risk in Los Angeles County, 2) African-Americans in Los Angeles County have increased risk of asthma infection, 3) People below poverty line in Los Angeles County have an increased risk of asthma infection, and 4) house cost burden households in Los Angeles County have an increased risk of asthma infection. These answer questions such as 1) Does PM2.5 increase the risk of getting asthma in Los Angeles County? and 2) What are the socio-economic factors that increase the risk of asthma in Los Angeles County?

2.Materials and Methods

2.1 Study setting

Los Angeles County was used for this study. As aforementioned, the study was conducted at the census tracts level to have more detailed and specific scope to improve policy formulations in the county and in similar counties. The LA county is in the southern part of California state, in the United States as shown in figure 1. It has 2,498 census tracts. Currently, the county has about 10 million residents and covers about 4753 square miles with a population density of 2425.6 people per square mile (ACS-2019). According to the US census bureau, on the racial front, 35.43% are whites alone, Black or African American (7.81%), American Indian and Alaska (1.27%), Asian Alone (15.03%), Native Hawaiian and Other Pacific Islander Alone (0.22%), Some Other Race Alone (23.56%), and Two or More Races (16.68%). Also, about 36.57% of households are house cost burdened. Over the years, the county has consistently been noted as one of the polluted counties in the United States (Aiyer et al., 2025; Delamater et al., 2012). Over 1.2 million of its residents are reported to have asthma, which is among the highest rates in California (Douglas et al., 2019). This makes it critical and empirically relevant to conduct this study to support public health policies.

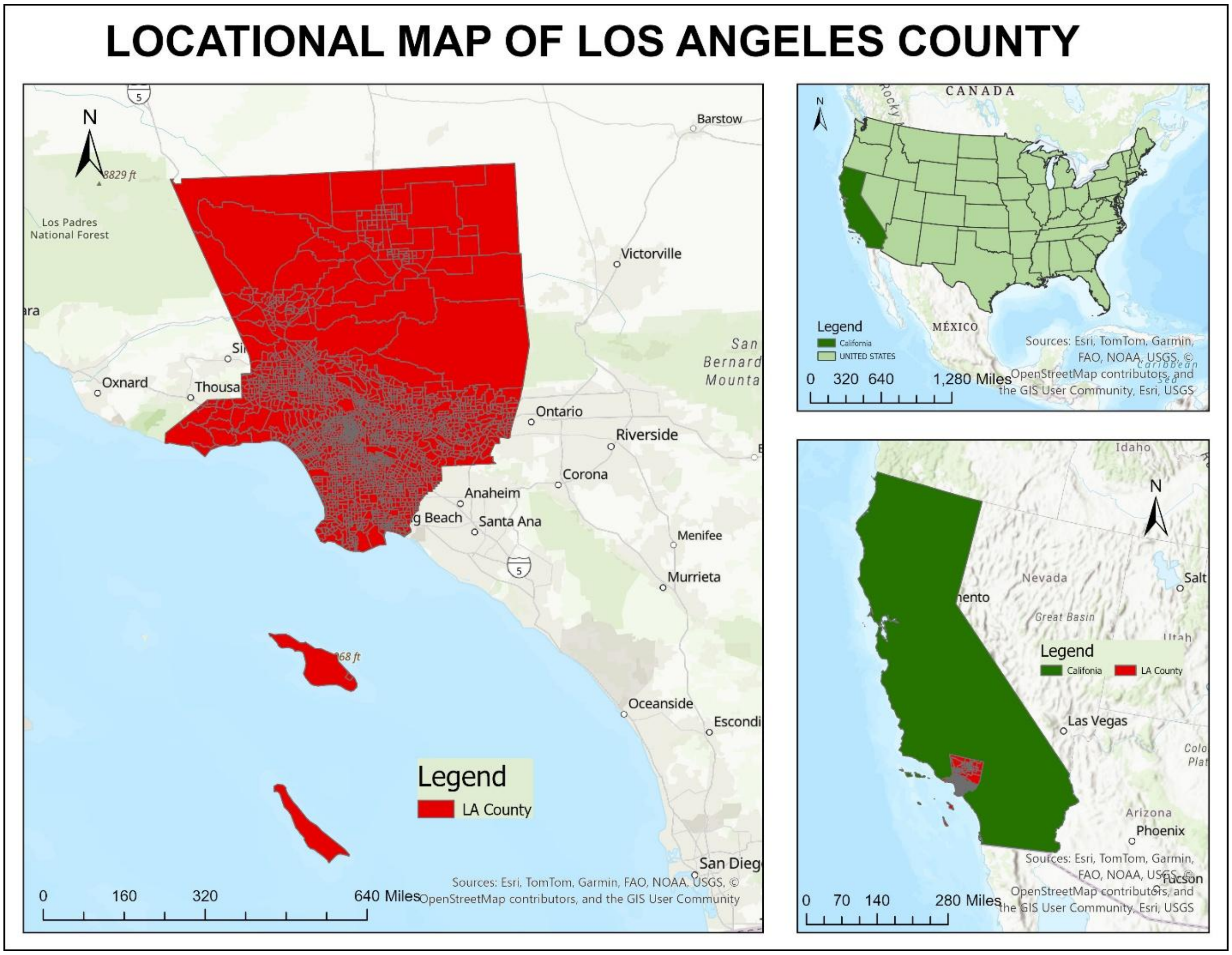


Figure 1Locational Map of LA County

Source: Author, 2025

2.2 Data sources

The data for this study were mainly obtained from the state of California Office of Environmental Health Hazard Assessment (OEHHA) and the US census Bureau through social explorer. This was mainly because their site hosts all the data needed to successfully achieve the research objectives. Specifically, data that were obtained from the OEHHA are Age-adjusted rate of emergency department visits for asthma, Annual mean PM2.5 concentrations up till 2020, 2019 ACS population estimates of the percent of population living below two times the federal poverty level, Percent housing-burdened low-income households, and 2019 ACS population estimates of the percent per census tract of those who identify as non-Hispanic white, and 2019 ACS population estimates of the percent per census tract of those who identify as non-Hispanic African American or black. In order to improve the reliability and accuracy of findings, the data was checked and cleaned to remove invalid entries, by using ArcGIS Pro. Also, data about the profile of the entire county such as population, race, poverty rate, and house-cost burden were obtained from the US census bureau through social explorer.

2.3 Analytical techniques

The five key analytical techniques used to visualize and/or analyze the data are choropleth mapping, scatterplots, Ordinary Least Squares (OLS), Geographically Weighted Regression (GWR), and Spatial Autocorrelation (Anselin, 1995). Firstly, beginning with the basics, to understand the relationship between the suggested predictors of asthma (i.e. PM2.5, Poverty rate, House cost burden, and race), I made choropleth maps using graduated colors for the predictors and asthma. I moved further to add scatter plots to highlight the relationship more. PM2.5 concentration was categorized by using the distribution of the concentration across the county and also considered the US EPA Air Quality Index threshold. Also, to stress the environmental variable (PM2.5) a hot spot and cold spot analysis was done for both the PM2.5 concentration and asthma ED visits. Having done these, it was imperative to further quantify and validate the results, I then used OLS and GWR to achieve this. I started by using OLS and then to GWR to maximize my opportunities of getting accurate results, hence I did model fit analysis on them. The GWR turned out to be the best model since it had the highest R2 and Adjusted R2, and a lesser AIC value, as indicated in table 1. In doing the GWR, I used the Number of Neighbors neighborhood type (kernel) whose bandwidth (Neighborhood selection method) was found by the Golden search methodology.

Moreover, to further evaluate whether the patterns identified are dispersed, clustered, or random, I run an autocorrelation (Global Moran's I) on the residuals from the GWR models for all the four predictor variables. With this, the Moran's I, the z-score and the p-value were interpreted to check for any autocorrelation.

	OLS (global model)	**GWR** (local model)
R2	0.4700	0.8666
Adj-R2	0.4689	0.8153
AIC	20750.3653	18810.5760

Table 1: model fit diagnostics of OLS and GWR

Source: Author, 2025.

3. Results

From 2, there is a varying structured concentration of PM2.5 concentration across the county from north to south. There is high concentration of PM2.5 concentration in the southern part of the county. However, asthma ED visits report a varied distribution across the county which does not follow the trends of the PM2.5 concentration. The scatterplot makes this more pronounced by indicating a negative relationship. Also, the hot and cold spot analysis has two hot spots. Largely, the northern parts and parts of the western parts are cold spot for PM2.5. Just a portion of the southern and western parts are hot spots. With respect to asthma, there are three identified hot spots. Hot spot analysis shows a bit of relationship because two of the hot spots for both variables correlate, i.e the hot spots in the southern and western parts as shown in figure 3.

On the racial font, the county has higher concentration whites across the census tracts. It records its moderate to highest concentrations in the eastern, northern, central and western parts of the county. This does reflect the distribution of asthma ED visits. The scatterplot shows a negative relationship between percentage of whites and asthma ED visits (figure 4). African-Americans on the other hand shows an opposite trend (figure 5). There are low levels of African-Americans across the county, with few concentrations in the southern part. And the scatterplot indicates a positive relationship between percentage of African-Americans and asthma ED visits.

Furthermore, according to figure 7, house cost burden varies across the county but records it highest around the central to southern parts and moderately high values in the north-eastern parts. This shows a similar trend with the distribution of asthma ED visits. Moreover, the scatterplot shows a positive relationship between house cost burden and asthma ED visits. Similarly, poverty rate shows almost the same trends as shown in figure 6. However, the scatterplot shows a greater positive relationship between poverty rate and asthma ED visits compared to house cost burden.

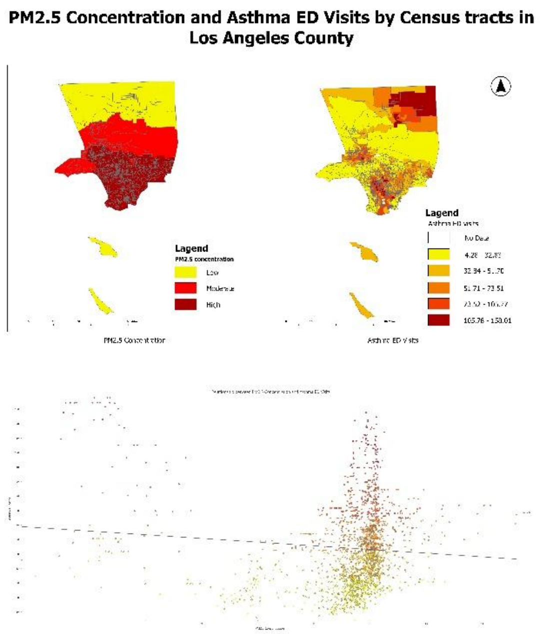


Figure 2: Relationship between PM2.5 concentration and asthma
Source: Author, 2025

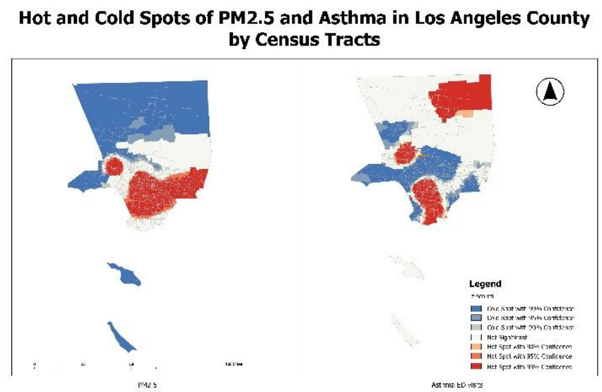
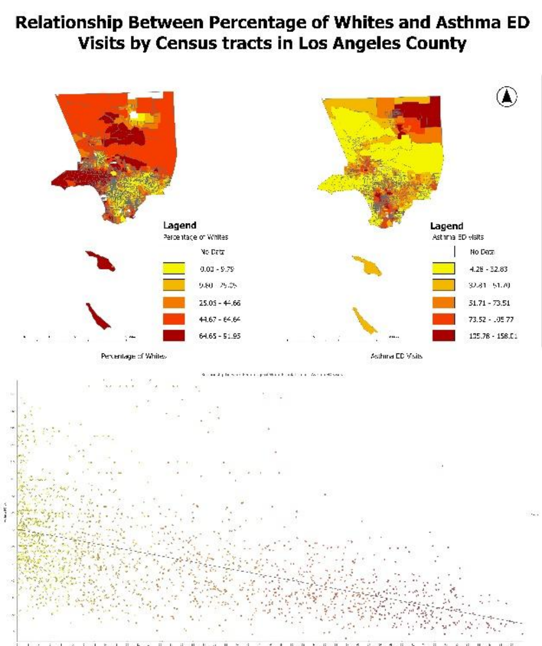


Figure 3: Hot and cold spots of PM2.5 concentration and asthma
Source: Author, 2025



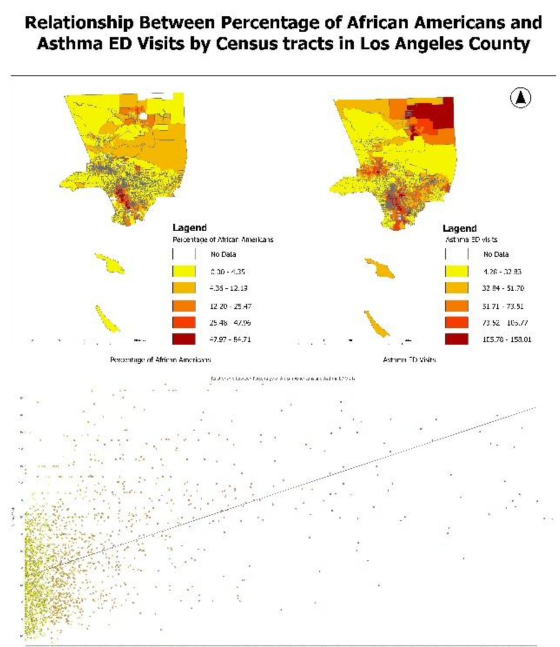


Figure 4: Relationship between percentage of whites and asthma
Source: Author, 2025

Figure 5: Relationship between of African-Americans and asthma
Source: Author, 2025

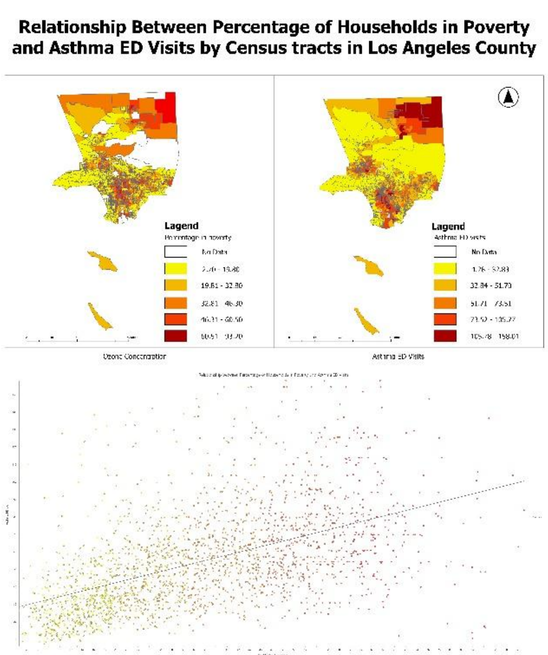


Figure 6: Relationship between poverty rate and asthma
Source: Author, 2025

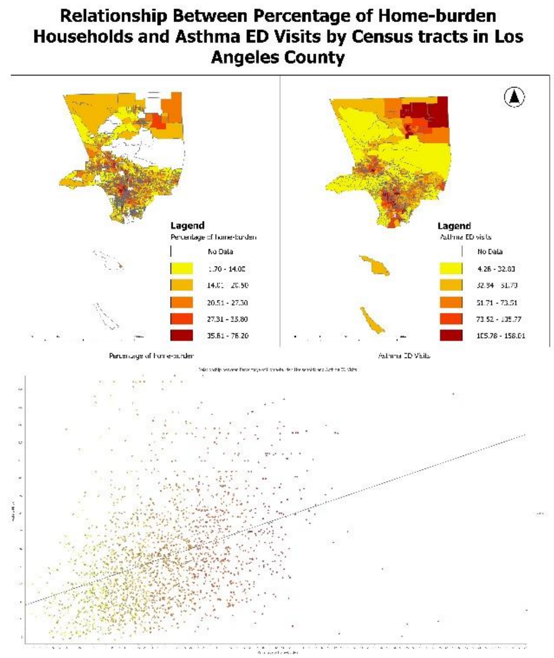


Figure 7: Relationship between house cost burden and asthma
Source: Author, 2025

3.2 Model performance and influence of predictors across the county

As already explained in section 2.3, the GWR was used to further evaluate and validate the result. This section presents the performance levels of the models with various variables and their influence across the county. This was done using the coefficient of estimates produced by the GWR. Also, the R2 is mapped to visualize the general performance level of models across the county. Similar to the findings in section 3.1, PM2.5 is generally a negative predictor of asthma (figure 8). However, it is a positive predictor in just a few positions of the southern part. Also, African-Americans is generally a positive predictor of asthma across the county (figure 9). But in some areas, especially in the eastern through the central to western parts it is a negative predictor. Percentage of Whites on the other hand is widely a negative predictor across the county, with just very few in the southern part where it is a positive predictor (figure 10).

Poverty rates largely show a negative influence across the county (figure 11). However, there are considerable number of tracts where it is a positive predictor especially in the eastern and northern parts. Figure 12 shows that house cost burden is a positive predictor in the central to southern tracts. Generally, the model performs very well throughout the county. Largely, it explains about 61% to 90% of the variation in asthma variations across census tracts in the county (figure 13). Finally, the Moran's I results indicate that the results of the GWR are clustered and not randomly or dispersed. And considering the z-score of 4.572088 in table 2, there is 1% chance that these clustered results could emerge randomly. Also, the p-value of 0.000005 affirms the results is statistically significant.

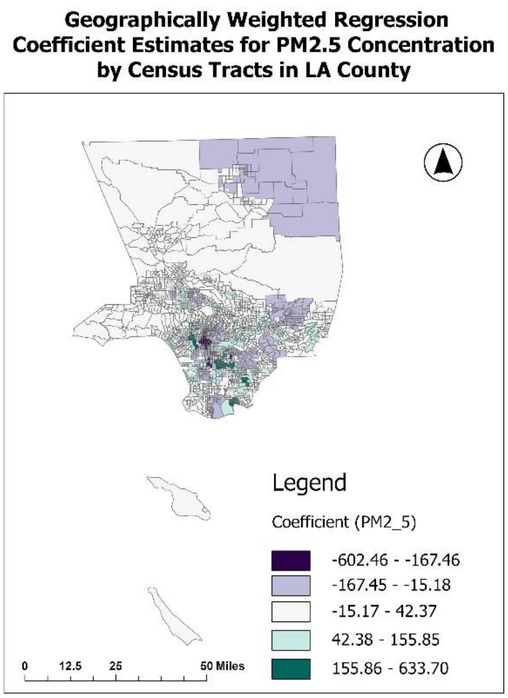


Figure 8: GWR coefficient estimates for PM2.5
Source: Author, 2025

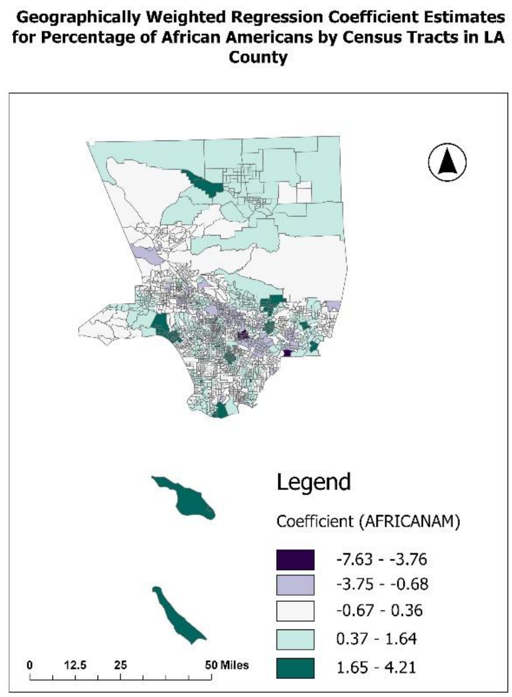


Figure 9: GWR coefficient estimates for African-Americans
Source: Author, 2025

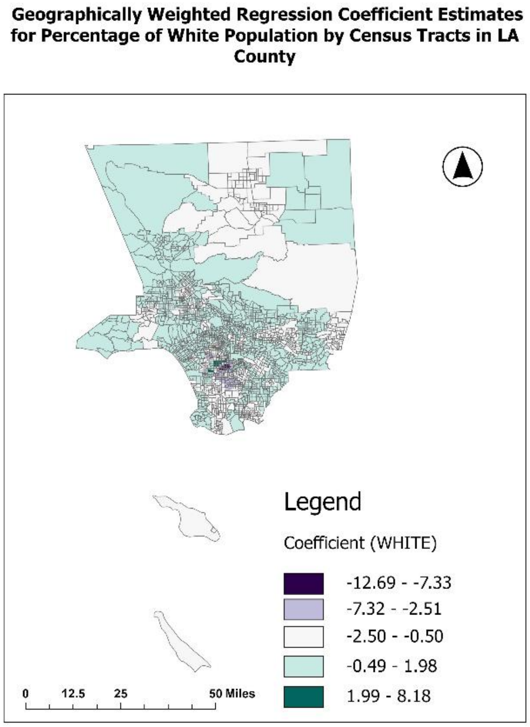


Figure 10: GWR coefficient estimates for Whites

Source: Author, 2025

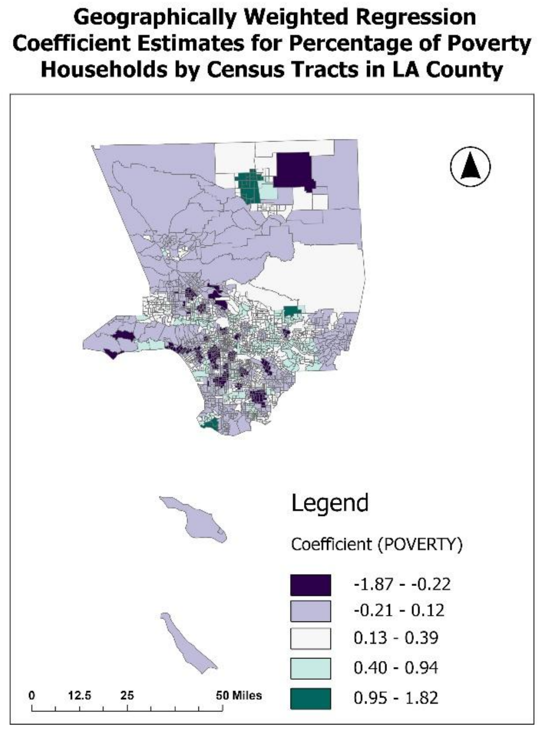


Figure 11: GWR coefficient estimates for poverty rate

Source: Author, 2025

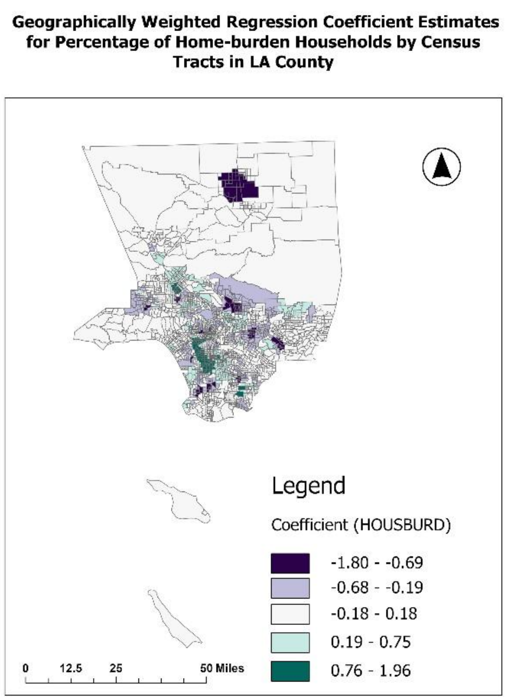


Figure 12: GWR coefficient estimates for house cost burden

Source: Author, 2025

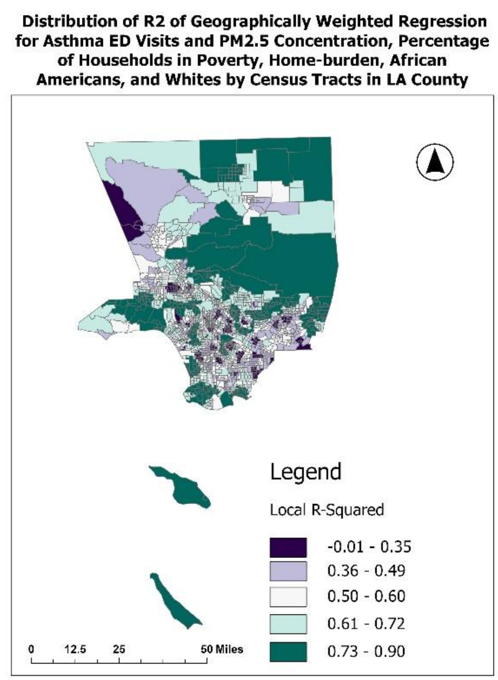
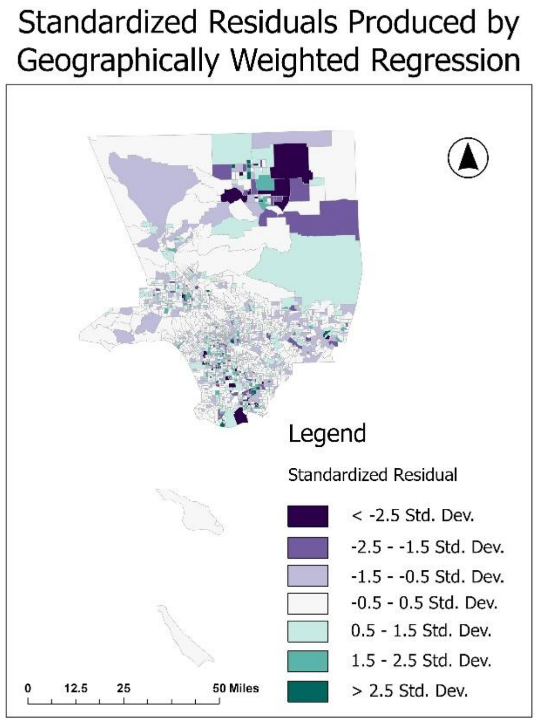


Figure 13: R2 distribution for the GWR

Source: Author, 2025



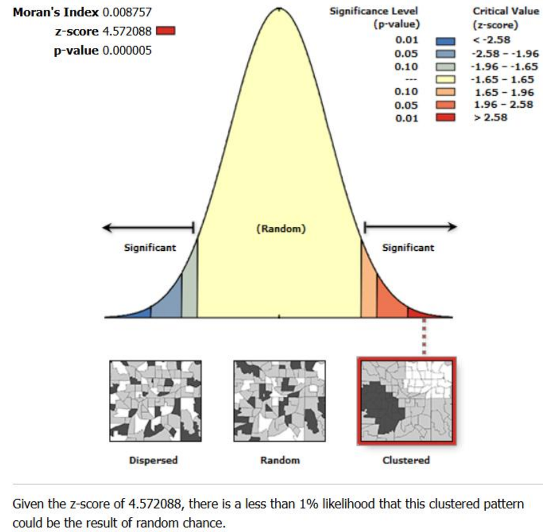


Figure 14: Standardize Residual produced by GWR

Source: Author, 2025

Figure 15: Spatial autocorrelation report

Source: Author, 2025

Spatial autocorrelation (Moran's I)	
Moran's Index	0.008757
z-score	4.572088
p-value	0.000005

Table 2: Moran's I report

Source: Author, 2025

4. Discussion

The negative relationship between PM2.5 and asthma ED visits suggest that PM2.5 is not a predictor of asthma risk in Los Angeles County. This finding inversely relates with the position of literature as noted by some scholars that higher PM2.5 concentration is associated with higher asthma prevalence (Shu et al., 2024, Fan et al.,2016). Also, Loftus et al., (2015) found that a rise in PM2.5 concentration leads to increase in reported cases of asthma symptoms (Loftus et al., 2015). This shows that LA County has different experiences with respect to this phenomenon. However, it might be due to that fact, the analysis is based on census tracts wide concentration and not specific exposure to certain physical features that may increase risk. Because the coefficient estimates suggest certain parts have positive relationships.

On the racial front, the negative relationship between percentage of white population and positive relationship between percentage of African-Americans show that race is a good predictor of asthma ED visits in LA County. This corroborates with the wider literature as it is general note that white people have lower odds of asthma than African-Americans. For instance, Black and Latino Americans face a disproportionate burden of SDoH and have a higher incidence of asthma morbidity and prevalence compared to White Americans (Grant et al., 2022, Wesley et al., 2024).

Furthermore, the positive relationship between house cost burden and asthma ED visits is instructive that households in LA County that suffer house cost burden are stressed health wise and are made susceptible to asthma infections. This relationship is largely concentrated in the central to southern part of the county. This resonates with several other findings in literature that posit that house cost burden households are vulnerable and have higher risk of contracting diseases. For example, Pollack et al., (2010) found that house cost burden households have increased odds of getting arthritis, hypertension, and poor self-rated health.

Last but not least, the positive relationship between poverty rate and asthma ED visits points out that residents of LA county who are living two times below the federal poverty level have increased risk of getting asthma. This finding is in line with the wider literature which posits that poverty is a health stressor and affects the health compliance of people. It corroborates with the findings of Keet et al.,(2015) that prevalence of asthma inner-cities at the census tracts level was 12.9% compared to 10.6% for non-inner cities, nevertheless, the results was not statistically significant after controlling for race and age. Also, individuals or households living above the national poverty levels reports lower odd of asthma (Assari & Moghani Lankarani, 2018).

5. Conclusion and recommendations

The substantially revealed the predictors of asthma ED visits in LA County. However, they reject the null hypothesis that PM2.5 is a positive predictor of asthma in LA County, by suggesting that it has a negative relationship with asthma ED visits. Notwithstanding, the study failed to reject the null that African-Americans in Los Angeles County have increased risk of asthma infection;; People below poverty line in Los Angeles County have an increased risk of asthma infection, and; and house cost burden households in Los Angeles County have an increased risk of asthma infection.

It is instructive to note that socio-economic conditions in LA County strongly affect health outcomes of residents, especially asthma. Therefore, there is a need for policies that target vulnerable populations such as African-Americans, House cost burden households, and households living two times below the federal poverty level. Moreso, special attention should be giving to census tracts in the southern to central part of the county as there is elevated risk there, and most of the variables have their positive coefficient estimates there. Further studies should consider using exposure to certain physical features that may have increased PM2.5 release or exposure rather than using census tract level concentration.

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