Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_____ ____04/20/2023___

Haydn Michael McLaughlin

Examining the Relationship Between Exposure to Community Violence and ER Asthma Visit Rate in Metro Atlanta from 2015-2021

By

Haydn Michael McLaughlin
MPH

Hubert Department of Global Health

Dr Felipe Lobelo
Committee Chair

Johnathan A. Edwards MSPH
Committee Member

Examining the Relationship Between Exposure to Community Violence and ER Asthma Visit Rate in Metro Atlanta from 2015-2021

By

Haydn M. McLaughlin

B.S., Public Health

Furman University, 2020

Thesis Committee Chair: Felipe Lobelo MD., PhD.

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 Health
2023

Abstract

Examining the Relationship Between Exposure to Community Violence and ER Asthma Visit Rate in Metro Atlanta from 2015-2021

By
Haydn M. McLaughlin

While community violence is widely studied for its impact on public health, the potential association between exposure to community violence and asthma prevalence has not been extensively explored. This study presents a secondary analysis of longitudinal data to investigate the relationship between exposure to community violence and emergency room (ER) asthma visit rates in Metro Atlanta from 2015 to 2021. We utilized data from the Atlanta Police Department on reported violent crime incidents and previously surveilled ER asthma visit rates from the Georgia Department of Public Health. Geospatial analysis techniques, specifically Moran's Local I, were employed to assess the spatial distribution of violent crime and ER asthma visit rates across counties.

Results from the secondary analysis revealed a moderate positive association between exposure to community violence and ER asthma visit rates in Metro Atlanta. The findings suggest that community violence may exacerbate asthma-related outcomes by contributing to chronic stress and adversely impacting access to healthcare and resources for asthma management. These results emphasize the importance of addressing community violence as a public health issue and implementing targeted interventions to reduce violence and improve asthma outcomes in affected communities.

Examining the Relationship Between Exposure to Community Violence and ER Asthma Visit Rate in Metro Atlanta from 2015-2021

By

Haydn M. McLaughlin

B.S., Public Health

Furman University, 2020

Thesis Committee Chair: Felipe Lobelo MD., PhD.

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 Health
2023

Acknowledgements

I would like to thank my thesis committee, Dr Felipe Lobelo MD, PhD, and Alex Edwards MSPH, for their mentorship and assistance throughout my time at the Emory Rollins School of Public Health and for their help with this project.

I would also like to thank my family and friends for their support and encouragement through this project and over the past two years.

I would not be where I am today without the help and guidance you all have provided over the years,

Thank you all.

Table of Contents

I. Introduction

A. Background

Asthma is a chronic respiratory condition that affects millions of individuals worldwide, posing a significant burden on public health [1,2]. The prevalence of asthma has increased over the past few decades, leading to increased morbidity, mortality, and healthcare costs [3}. To address this public health issue, it is essential to understand the various factors that contribute to the development and exacerbation of asthma.

One key aspect to consider is the social determinants of health (SDOH), which are the conditions in which people are born, grow, live, work, and age [4]. These determinants have been shown to play a substantial role in the development and management of asthma [5]. Factors such as socioeconomic status [6], race [7], and neighborhood characteristics [8] can influence the likelihood of an individual developing asthma and experiencing poor health outcomes.

A growing body of evidence suggests that exposure to community violence (ECV) may be an important social determinant of health that is associated with asthma prevalence [9]. Community violence can lead to increased stress and anxiety, which may in turn exacerbate respiratory conditions such as asthma [10]. Exposure to violence may result in changes to an individual's physical environment, as communities with high rates of violence often have decreased access to resources such as green spaces and healthcare services [11]. Living in neighborhoods with greater violence also changes how residents behave, including caretakers smoking indoors, which can increase asthma risk as well [12]. Further exploring this relationship has the potential to contribute to the understanding of the epidemiology of asthma.

B. Research Question

Given the potential relationship between community violence and asthma prevalence, this paper seeks to answer the following research question:

Is there significant spatial correlation between Exposure to Community Violence and Asthma in Metro Atlanta at the county level?
By examining the association between these two variables, this study aims to provide valuable insights into the effect of social determinants of health on respiratory health in adults in Metro Atlanta.

C. Purpose of the Study

The primary purpose of this study is to explore the relationship between community violence and asthma prevalence in the Metro Atlanta area. By investigating this relationship, we aim to achieve the following goals:

Identify patterns and correlations between community violence and asthma rates in Metro Atlanta: Understanding the potential association between community violence and asthma prevalence in the Metro Atlanta area is crucial for comprehending the broader landscape of social determinants of health and their impact on respiratory health outcomes within this specific urban context. By examining the spatial and temporal patterns of these two variables in Metro Atlanta counties, our secondary analysis seeks to provide evidence that could contribute to a more comprehensive understanding of the factors influencing asthma prevalence in the region.

Inform the discourse on the effects of exposure to community violence (ECV) on asthma among Metro Atlanta adults: The results of this study could be utilized to guide public health policies and interventions aimed at addressing the burden of asthma in the Metro Atlanta area. By elucidating the potential influence of community violence on asthma rates, policymakers and healthcare providers may become better equipped to develop targeted strategies to mitigate the impact of community violence and other social determinants of health on emergency room asthma visit rates. This could potentially lead to more effective resource allocation and improved health outcomes for individuals and communities affected by asthma in Metro Atlanta.

Overall, the purpose of this study is to contribute to the growing body of knowledge surrounding the relationship between ECV and asthma with specific focus on the Metro Atlanta area. By achieving the outlined goals, this research has the potential to inform future studies on spatial correlations between ECV and asthma; leading to improvements in the lives of our fellow Atliens affected by asthma.

D. Burden of Asthma

The prevalence of asthma has been on the rise in recent years, with approximately 8.3% of the U.S. population affected as of 2019 [13]. In Georgia, the prevalence of asthma is even higher than the national average, at 9.4% [14]. In particular, the metropolitan Atlanta area has a higher prevalence of 10.2%, which is a cause for concern [15].

Socioeconomic and racial disparities in asthma prevalence are also evident. In Georgia, African Americans have an asthma prevalence of 13.9% compared to 7.4% for Caucasians [14]. Furthermore, individuals living below the poverty line are more likely to develop asthma, indicating a link between social determinants of health and asthma.

Asthma, even when treated, can result in hospitalizations, emergency department visits, and missed school or work days. In Georgia, the age-adjusted asthma hospitalization rate is higher than the national average, with the metropolitan Atlanta area contributing significantly to these hospitalization rates [14]. Fulton and DeKalb counties have the highest hospitalization rates for asthma in the metropolitan Atlanta area [15].

Despite advancements in asthma management, asthma mortality in Georgia remains higher than the national average, with a rate of 14.2 deaths per million in 2019 [13]. There are significant disparities in mortality rates, with African Americans in Georgia experiencing a mortality rate more than three times higher than Caucasians [14].

The economic burden of asthma in the United States is substantial, with direct and indirect costs estimated to be $81.9 billion annually [16]. In Georgia alone, the annual direct medical costs associated with asthma exceed $1 billion [14]. The high prevalence of asthma and associated healthcare utilization in the metropolitan Atlanta area contribute significantly to these costs, emphasizing the need for better management and prevention strategies. The data suggests that addressing the socioeconomic and racial disparities in asthma prevalence and healthcare utilization may be critical in reducing the overall burden of asthma in Georgia.

E. Asthma and Exposure to Violence

Exposure to violence is a significant social determinant of health that has been linked to the incidence and severity of asthma [17]. While there are many different types of violence, including intimate partner violence and child abuse, community violence has specifically been associated with asthma incidence and exacerbation.

Children living in high-violence neighborhoods are more likely to develop asthma than those in low-violence neighborhoods [18]. Exposure to violence has also been linked to psychological distress, which can trigger asthma symptoms and make controlling asthma more difficult [19].

The relationship between exposure to violence and asthma incidence is complex and multifactorial. Chronic stress, inflammation, and altered immune function are all possible pathways through which exposure to violence can affect asthma risk and outcomes [20]. Furthermore, research has shown that exposure to violence can have a cumulative effect on asthma incidence and severity. For instance, children who have experienced multiple forms of violence, such as exposure to community violence and intimate partner violence, may be at higher risk of developing asthma than those who have experienced only one form of violence [21].

Several studies have investigated the link between exposure to community violence and asthma prevalence and exacerbations. A longitudinal study by Wright et al. (2004) found that children who experienced violence in their community had a higher risk of developing asthma, with a dose-response relationship observed between the level of violence exposure and asthma incidence [22]. Similarly, a study by Subramanian et al. (2009) found that higher neighborhood-level violent crime rates were associated with a greater likelihood of asthma prevalence among adults [23].

Overall, exposure to violence is a significant risk factor for the development and exacerbation of asthma, and understanding the mechanisms through which violence affects asthma outcomes is critical for developing effective interventions to reduce the burden of asthma in affected populations [24].

II. Review of the literature around the relationship between exposure to community violence and asthma

Exposure to community violence and asthma have been linked through multiple studies, indicating a complex relationship between the two factors. Szyszkowicz, Kousha, and Castner (2017) conducted a review which established that the connection between violence exposure and asthma can be both direct and indirect [25]. The direct association is primarily due to biological responses, while indirect associations stem from increased susceptibility to air pollution and behavioral changes leading to higher exposure to indoor pollutants and allergens. Additionally, Flanigan, Sheikh, and DunnGalvin (2017) found that children born to mothers exposed to stressors during pregnancy, including violence, had increased risks of early-onset wheeze, persistent wheeze, and asthma [29].

Investigating the relationship between traffic-related air pollution and asthma, Clougherty et al. (2007) discovered that the association was only significant among urban children with above-median exposure to community violence [24]. This study emphasizes the importance of considering violence exposure when examining the effects of air pollution on asthma in urban areas. In a multilevel analysis, Wright et al. (2004) determined that medium and high levels of community violence increased the risk of asthma in comparison to low levels [26]. Notably, the increased risk persisted for African Americans even after controlling for individual- and neighborhood-level confounders.

Suglia, Duarte, and Sandel (2010) found that children whose mothers experienced chronic intimate partner violence (IPV) and housing disarray had increased odds of developing asthma compared to those not exposed to these risks [27]. Moreover, exposure to cumulative or multiple stressors increased the risk of developing asthma more than a single stressor. In a case-control study conducted in Puerto Rico, Rosas-Salazar et al. (2016) discovered that exposure to gun violence was associated with asthma in children aged 9-14 years old, with those exposed to

gun violence and afraid to leave their homes due to violence having 3.2 times greater odds of asthma [29].

These findings indicate that exposure to community violence can have substantial impacts on asthma risk, particularly in disadvantaged populations. The evidence suggests that public health interventions should extend beyond the biomedical model to address asthma in these communities. By understanding the complex relationship between violence and asthma, more effective strategies can be developed to reduce the burden of asthma on individuals and communities affected by violence [25, 26, 28].

These study's findings underscore the need to address the social determinants of health, such as exposure to violence, housing conditions, and social vulnerability, in efforts to prevent and reduce the burden of asthma, particularly in disadvantaged communities. Further research is needed to understand the complex mechanisms underlying the relationship between exposure to violence and asthma, as well as to identify effective interventions that consider the social and environmental stressors faced by these populations. Overall, these studies highlight the urgent need for approaches that address the social determinants of health and improve respiratory health outcomes for individuals facing variable asthma risk factors.

III. Methodology

This section details the methodology employed in this study to investigate the relationship between asthma and violent crime in the Metro Atlanta area from 2015 to 2021. The research design, location, and data sources utilized are described to provide a comprehensive understanding of the approach taken.

A. Study Design

The study design consisted of a secondary analysis of data collected on asthma and violent crime rates in the Metro Atlanta area from 2015 to 2021. This approach allowed for an examination of existing data sources to draw conclusions about potential associations between the two variables.

B. Location and Description of Population

The analysis was conducted in the Metro Atlanta statistical area as defined by the Georgia Department of Public Health[31]. This area includes 28 counties, and the data utilized in this study spanned from 2015 to 2021[31]. The focus on the Metro Atlanta area was chosen due to its diverse and sizable population, making it an ideal setting for investigating the relationship between asthma and violent crime rates [32]. Further, relationships between asthma and community violence exposure have been found to exist at the neighborhood level in Boston [24], so there was interest in if this pattern existed at the county level in Atlanta.

C. Data Sources

Several data sources were used to gather the necessary information for this study. The Georgia Bureau of Investigation annual violent crime reports provided violent crime data by county[33], while the Georgia Online Analytical Statistical Information System (OASIS) supplied the asthma data[34]. Additionally, the Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI) shapefiles were employed to obtain the SVI scores, percentage of uninsured individuals, population data, and geographic information for mapping purposes[35].

Asthma ER Visit Rate: This is used as a proximal measure of Asthma that was available at the county level from the GADPH Oasis data resource. This is a good proximal measure for asthma prevalence rates as it highlights cases where symptoms were severe enough to require medical care and is verified for accuracy by hospital records.

Exposure to Community Violence / Violent Crime Rate: For the purposes of this study, exposure to community violence is defined as the combined rates of violent crimes per 10,000 residents, including robbery, assault, battery, sexual assaults, and murders for each county.

Asthma to Violent Crime Rate ratio's (AVCR): A ratio value for the asthma to violent crime rates at the same per 10,000 residents level in each county

D. Research Design

To determine whether there is a correlation between the asthma-violent crime rate ratio (AVCR) across the 28 Metro Atlanta counties, Local Moran's I coefficients for spatial autocorrelation were calculated [36]. This statistical method was chosen as it is an effective way to measure spatial clustering, which can help identify potential associations between the variables under investigation [37]. By calculating Local Moran's I coefficients, the study aimed to provide

evidence of any spatial patterns or relationships between asthma rates and violent crime rates in the Metro Atlanta area [38].

E. Procedures

To investigate the relationship between emergency room (ER) asthma visit rates and community violence, the following procedures were employed:

Dependent Variable: The dependent variable in this study was ER asthma visit rates per 10,000 residents in each county per year.

Independent Variable: The independent variable was compiled community violence data per 10,000 residents in each county per year.

Other Variables of Interest and to Describe Study Population: Additional variables were used to provide a comprehensive understanding of the study population. These variables included the Social Vulnerability Index (SVI) score and the percentage of uninsured individuals in each county.

F. Plans for Data Analysis

Data analysis was conducted using R statistical packages rgdal, sf, terra, ggplot, spdep, tmap, tmaptools, ggsn, gridextra, and writexl. The following steps were taken to analyze the data:

1) Data from OASIS asthma ER visit rates and GBI violent crime reports were compiled.
2) Plots of Asthma ER visit rates (Y) and Community violent crime rates (X) were created, along with their respective R-squared values.
3) Pearson correlation coefficients for AVCR for each county from 2015-2021 were calculated and saved

4) County maps of Asthma ER Visit to Violent Crime Rate Ratios (AVCR) were generated for each year after merging AVCR data with corresponding SVI shapefiles and exported
5) Local Moran's I and P-values were computed and saved into appropriate tables
6) Maps of Local Moran's I and P-values were created and exported

G. Ethical Considerations

This study is not considered direct human subjects research as the data used is not identifiable and is publicly available. As the data cannot be traced back to any particular persons due to being aggregated to the county level we can be confident in the ethicality of this secondary analysis.

H. Limitations

One of the limitations of this study is that previous research examining similar trends has been conducted at the census tract or smaller level. However, the data used in this study was only available at the county level to ensure that it was sufficiently de-identified. As a result, there is less accuracy in the spatial autocorrelation analysis than if we were able to pull census tract or neighborhood level data. Future research could benefit from obtaining more granular data while still maintaining the necessary privacy and ethical standards.

Another limitation in this study was inadequate time to properly explore all possible correlates of asthma and violent crime rates. The inclusion of the SVI data created many possibilities for analysis but the impending deadline for this project limited the analyses that could be conducted. Future projects could expand their analysis to include the impact of SVI score, hospital density, percentage of unemployed or uninsured persons, race variables, or others that were mentioned as being possibly related to one’s risk of developing asthma.

IV. Results

In this results section, we present the findings of our analysis on the relationship between community violence and asthma ER visit rates in the Metro Atlanta area. Our investigation delves into the spatial autocorrelation of this relationship, accounting for local factors and temporal trends to provide a comprehensive understanding of the associations between these variables. Through the examination of descriptive statistics, Asthma ER Visit Rate to Community Violent Crime Rate Ratios (AVCR), Pearson Correlation Coefficients, and Local Moran's I values, we aim to uncover patterns and relationships that can inform future research and targeted interventions. Additionally, we explore other factors, such as population size, percentage of uninsured individuals, and Social Vulnerability Index scores, to highlight the diverse socio-economic landscape of the Metro Atlanta area and its potential influence on the relationship between ER asthma visit rates and community violent crime rates.

Findings

The analysis of Metro Atlanta population data reveals that there is a varying relationship between community violence and asthma ER visit rates across different counties and years. Findings include:

1. Asthma ER visit rates and community violent crime rates differ greatly across Metro Atlanta counties, with the highest average ratio observed in Rockdale County and the lowest in Jasper County.

2. The relationship between ER asthma visit rates and community violent crime rates may change over time and could be influenced by many factors in each county.

3. AVCR Pearson's correlation coefficients differ among Metro Atlanta counties, with some showing strong positive correlations, others showing negative correlations, and some showing no significant correlation.

4. Local spatial autocorrelation of asthma ER visit rates to community violent crime rate ratios vary across different counties and years, with some areas showing significant clustering of similar or dissimilar values, while others show no significant local spatial autocorrelation.

These variations highlight the importance of considering local factors and temporal trends when examining the relationship between ER asthma visit rates and community violent crime rates. The data analysis also revealed much about the Metro Atlanta Populus, including population figures, the Social Vulnerability Index Scores and percentage of uninsured persons in each county.

There is wide variability in the average population across Metro Atlanta counties, with Fulton County having the highest population and Heard County having the lowest. The percentage of uninsured individuals varies significantly across the counties as well, with Clayton County having the highest percentage and Fayette County having the lowest. The Social Vulnerability Index (SVI) scores, which measure the social vulnerability of a community, also show great variability across the counties. This variation could impact the relationship between asthma rates and violent crime rates, suggesting that different counties within the Metro Atlanta area experience varying levels of social vulnerability that could play a moderating role in the Asthma - Violent Crime Exposure relationship.

These additional findings emphasize the diverse socio-economic landscape of the Metro Atlanta area and suggest that these factors could play a role in the relationship between ER Asthma Visit Rates and Community Violent Crime rates.

V. Discussion

Our findings shed light on the complex relationship between exposure to community violence and asthma ER visit rates in the Metro Atlanta area. This study adds to the growing body of literature that suggests an association between these variables (albeit a moderate one) [26-28, 30], highlighting the importance of considering spatial and temporal factors in understanding the connections between community violence and health outcomes, such as asthma [33].

In line with previous research, we found considerable variability in both asthma ER visit rates and community violent crime rates across different counties in the Metro Atlanta area (Table 1) [26, 27]. This variability underscores the importance of considering local contexts and socio-economic factors when investigating the relationship between these variables [31]. Our results show that some counties experienced stronger positive correlations between asthma ER visit rates and community violent crime rates, while others exhibited weaker or negative correlations (Table 3) [28, 30]. This suggests that the relationship between exposure to community violence and asthma may be influenced by various factors in each county, such as population density, socioeconomic status, access to healthcare, and social vulnerability [33].

Our analysis of the Social Vulnerability Index (SVI) scores further supports the idea that socio-economic factors play a role in shaping the relationship between community violence and asthma [33]. The observed variation in SVI scores across different counties indicates that the communities in the Metro Atlanta area face varying levels of social vulnerability, which could impact the prevalence of asthma and the exposure to community violence [32].

The spatial autocorrelation analysis using Local Moran's I values (Table 4) revealed both patterns of clustering and dispersion of AVCR values across different counties and years [36, 37]. We observed some significant clustering of similar AVCR values, suggesting that areas with higher rates of community violence and asthma ER visits may be geographically concentrated [38].

These findings align with previous studies that have reported geographic clustering of asthma prevalence and community violence exposure [28, 30], emphasizing the importance of targeted interventions in areas with higher risk. This trend was not universal across all counties.

It is important to consider the limitations of our study, which primarily relies on largely pre-pandemic data collected for surveillance purposes outside of this study's purview [33]. The use of aggregate-level data may mask individual-level relationships and introduce ecological fallacy, as we cannot infer individual-level associations based on area-level findings [29]. This is of import as it has been previously asserted that exposure to violence must be direct or at the neighborhood level; not the kind of indirect exposure one may have at the county level [26, 27]. This study also did not include a formal analysis of Social Vulnerability Index (SVI) scores, though a cursory examination of them over space and time points to the importance of socio-economic factors in this relationship. Future research should incorporate community to individual-level data to better understand the direct effects of exposure to community violence on asthma outcomes [28, 30].

In conclusion, our study contributes to the understanding of the relationship between exposure to community violence and asthma ER visit rates in the Metro Atlanta area [26-28, 30]. We found that while there is some moderate positive correlation between violent crime rates and asthma ER visit rates, the influence of the large spatial polygons used (counties) muddied the relationships that have been previously established at the neighborhood level [31]. Further research should continue to explore the underlying mechanisms linking exposure to community violence and asthma, as well as the role of various socio-economic factors in moderating this relationship [28, 30]. Our findings have important implications for public health interventions, as they highlight the plausibility of a relationship between exposure to community violence and the need for ER asthma visits in Metro Atlanta at a smaller geographic level (census tract, neighborhood, etc.) [26, 27, 30].

VI. Conclusions

Findings shed light on the complex relationship between exposure to community violence and asthma ER visit rates in the Metro Atlanta area, demonstrating considerable variability across different counties and over time. This variability highlights the significance of spatial, temporal, and SDOH factors in shaping the connections between Community Violence and Asthma. Furthermore, our investigation of the spatial autocorrelation analysis using Local Moran's I values supports the idea that geographic clustering plays a crucial role in this relationship. Considering these findings, future research should focus on examining trends at a smaller geographic scale and incorporate more linear regression analyses to determine other variables that may significantly influence the relationship between community violence and asthma. This approach could help inform targeted interventions and improve health outcomes for vulnerable populations affected by both community violence and asthma.

Tables and Descriptions

Metro Atlanta County	Average Population	Percentage Uninsured	Average Asthma ER Visit Rate	Average Violent Crime Rate	SVI Score
Bartow	101,942	15.6	460	292.160	0.791
Carroll	113,756	15.5	482	292.858	0.563
Cherokee	230,629	13.3	230	83.377	0.949
Coweta	135,625	10.7	343	372.921	0.911
Dawson	22,939	13.4	216	127.148	0.987
Fayette	109,495	7.7	228	80.319	0.981
Haralson	28,667	15.6	505	516.752	0.690
Heard	11,571	14.3	358	171.072	0.639
Jasper	13,571	15.5	446	345.996	0.652
Lamar	18,195	18.1	443	253.260	0.766
Pike	17,843	16.6	245	82.160	0.943
Spalding	64,006	16.9	706	574.686	0.348
Walton	87,436	12.8	450	206.732	0.924
Barrow	73,340	16.8	479	355.392	0.835
Butts	23,479	15.8	562	282.568	0.671
Douglas	138,283	15.6	775	283.561	0.760
Forsyth	203,841	9.9	159	59.418	0.994
Fulton	996,757	13.7	653	687.035	0.722
Meriwether	21,195	16.7	486	298.366	0.215
Newton	103,901	13.5	681	358.916	0.627
Paulding	149,830	12.5	509	177.455	0.962
Pickens	29,992	12.7	305	199.082	0.918
Rockdale	87,569	17.4	642	254.177	0.620
Cobb	728,388	15.4	449	253.537	0.867
Henry	214,171	13.1	384	188.724	0.829
DeKalb	723,902	17.1	682	565.420	0.551
Gwinnett	874,242	18.3	398	173.277	0.798
Clayton	270,269	22.7	739	548.344	0.184

Table 1 presents the descriptive information about the Metro Atlanta population examined in the secondary analysis. This table provides a summary of the average population, percentage of uninsured individuals, average Asthma ER visit rate, average violent crime rate, and the Social Vulnerability Index (SVI) score for each county in the Metro Atlanta area.

Overall, the average population across the counties in the Metro Atlanta area varies widely, with Fulton County having the highest population at 996,757 residents and Heard County having the lowest at 11,571 residents. The percentage of uninsured individuals also varies across the counties, with Clayton County having the highest percentage of uninsured individuals at 22.7% and Fayette County having the lowest at 7.7%.

The average Asthma ER visit rate across the Metro Atlanta counties ranges from a low of 159 visits per 10,000 residents in Forsyth County to a high of 775 visits per 10,000 residents in Douglas County. The average violent crime rate similarly varies, with the lowest rate of 59.418 per 10,000 residents in Forsyth County and the highest rate of 687.035 per 10,000 residents in Fulton County.

The SVI score, which measures the social vulnerability of a community, ranges from 0.184 in Clayton County to 0.994 in Forsyth County. This variability in SVI scores indicates that different counties within the Metro Atlanta area experience varying levels of social vulnerability, which could impact the relationship between asthma rates and violent crime rates.

Metro Atlanta County	2015 AVCR	2016 AVCR	2017 AVCR	2018 AVCR	2019 AVCR	2020 AVCR	2021 AVCR	2015-2021 Average AVCR
Bartow	1.243	1.235	3.886	2.226	5.545	1.377	1.539	2.436
Carroll	2.029	1.570	1.462	1.386	3.053	1.031	1.137	1.667
Cherokee	3.358	2.375	2.773	3.229	5.839	1.156	1.349	2.868
Coweta	1.520	1.758	1.431	1.927	0.718	0.274	0.294	1.132
Dawson	1.816	2.116	1.305	1.627	1.522	0.698	0.574	1.380
Fayette	3.017	3.611	2.477	2.852	3.005	1.766	1.890	2.660
Haralson	0.927	1.035	1.132	1.057	0.842	1.004	1.079	1.011
Heard	2.900	2.994	2.299	1.531	2.086	1.190	0.838	1.977
Jasper	1.520	1.225	0.944	1.104	0.673	0.620	0.691	0.968
Lamar	1.298	1.431	1.932	1.480	2.806	4.148	3.647	2.392
Pike	2.832	3.081	2.395	2.214	2.269	2.277	2.301	2.481
Spalding	1.115	1.348	1.217	1.155	1.692	0.743	0.879	1.164
Walton	2.557	2.564	2.019	1.760	4.245	1.828	2.353	2.475
Barrow	1.880	0.847	1.178	1.257	10.424	1.604	1.724	2.702
Butts	2.030	1.457	1.237	1.965	2.091	2.266	2.507	1.936
Douglas	3.271	2.613	2.636	3.489	3.554	1.767	1.956	2.755
Forsyth	2.361	3.217	2.801	3.135	2.430	1.332	1.665	2.420
Fulton	0.750	0.787	1.072	1.442	1.811	0.688	0.833	1.055
Meriwether	1.403	1.422	1.191	1.349	1.378	1.858	1.936	1.505
Newton	1.861	1.875	1.916	2.124	5.380	1.079	1.185	2.203
Paulding	3.707	4.752	4.043	4.434	2.707	1.194	1.474	3.187
Pickens	2.463	1.947	1.620	1.110	1.341	0.801	0.703	1.426
Rockdale	2.065	2.118	2.231	2.515	4.100	5.395	6.844	3.610
Cobb	1.685	1.827	1.857	2.146	1.984	0.935	1.248	1.669
Henry	1.642	2.263	1.948	2.654	5.331	1.125	1.127	2.299
DeKalb	1.137	1.284	1.413	1.374	1.797	0.554	0.643	1.172
Gwinnett	1.928	1.798	1.905	2.031	2.432	4.424	5.209	2.818
Clayton	1.172	1.107	1.178	1.349	3.550	0.916	0.988	1.466

Table 2 displays the ER Asthma Visit Rate (AVR) to Community Violent Crime Rate (CVCR) ratios (AVCR) for each Metro Atlanta County between 2015 and 2021. It also shows the average AVCR for each county across the entire seven-year period.

The average AVCR across 2015-2021 varies among the Metro Atlanta counties. The highest average AVCR of 3.610 was observed in Rockdale County, while the lowest average AVCR of 0.968 was observed in Jasper County. This suggests that the relationship between ER asthma visit rates and community violent crime rates differs across the Metro Atlanta area.

Furthermore, the AVCRs fluctuate within each county throughout the seven-year period. For instance, in Barrow County, the AVCR increased significantly from 0.847 in 2016 to 10.424 in 2019, before dropping to 1.604 in 2020. Similarly, in Gwinnett County, the AVCR increased from 1.798 in 2016 to 5.209 in 2021. These fluctuations indicate that the relationship between ER asthma visit rates and community violent crime rates may change over time and could be influenced by various factors in each county.

In some counties, the AVCR remains relatively stable across the years, such as DeKalb County, where the AVCR ranges from 0.554 in 2020 to 1.797 in 2019. In contrast, other counties, such as Rockdale County, experience more drastic changes in their AVCR, with values ranging from 2.065 in 2015 to 6.844 in 2021.

These variations in AVCR, both between different counties and across years within a county, highlight the importance of considering local factors and temporal trends when examining the relationship between ER asthma visit rates and community violent crime rates.

Metro Atlanta County	Pearson Correlation Coeffecient for AVCR Values 2015-2021
Barrow	-0.174977283
Bartow	-0.247543736
Butts	0.518203275
Carroll	-0.326987657
Cherokee	-0.11545538
Clayton	-0.181451896
Cobb	0.352839493
Coweta	0.622849254
Dawson	0.559790624
DeKalb	0.137201814
Douglas	0.200183581
Fayette	0.285772714
Forsyth	0.497173194
Fulton	0.171458243
Gwinnett	0.870313101
Haralson	0.008077545
Heard	0.722274748
Henry	-0.114650428
Jasper	0.733410116
Lamar	0.736794806
Meriwether	0.646048163
Newton	-0.208605619
Paulding	0.703056269
Pickens	0.860864975
Pike	0.560122308
Rockdale	0.963886674
Spalding	-0.20743214
Walton	-0.475203051

Table 3 presents the Pearson Correlation Coefficient values for the AVCR (Asthma ER Visit Rate to Community Violent Crime Rate Ratios) across the 2015-2021 period for each Metro Atlanta County. The Pearson Correlation Coefficient is a measure of the strength and direction of the linear relationship between two variables, with values ranging from -1 to 1. A value close to 1 indicates a strong positive correlation, a value close to -1 indicates a strong negative correlation, and a value close to 0 suggests no correlation.

The correlation coefficients in this table show a wide range of values, suggesting varying relationships between the AVCR values from 2015 to 2021 across different counties in the Metro Atlanta area. Some counties exhibit strong positive correlations, such as Rockdale County with a correlation coefficient of 0.9639, indicating that as the years progress, the AVCR tends to increase. Similarly, Pickens County (0.8609) and Gwinnett County (0.8703) show strong positive correlations.

On the other hand, some counties exhibit negative correlations, such as Walton County with a correlation coefficient of -0.4752, suggesting that as the years progress, the AVCR tends to decrease. However, these negative correlations are generally weaker than the positive correlations observed in other counties.

Several counties show correlation coefficients close to zero, such as Haralson County (0.0081) and Cherokee County (-0.1155), indicating that there is no strong linear relationship between the AVCR values across the years in these areas.

In summary, Table 3 illustrates that the relationships between AVCR values across the years from 2015 to 2021 differ among Metro Atlanta counties. Some counties show a strong positive correlation, some show a negative correlation, and others show no significant correlation. This highlights the importance of considering local factors and temporal trends when examining the relationship between ER asthma visit rates and community violent crime rates.

COUNTY	2015 AVCR LMI	2015 AVCR LMI p-value	2016 AVCR LMI	2016 AVCR LMI p-value	2017 AVCR LMI	2017 AVCR LMI p-value	2018 AVCR LMI	2018 AVCR LMI p-value
Barrow	-0.045	0.637	-0.273	0.806	-0.061	0.964	0.112	0.821
Bartow	-1.019	0.029	-0.685	0.095	2.126	0.025	0.249	0.059
Butts	-0.040	0.127	0.236	0.312	0.349	0.288	0.014	0.391
Carroll	0.016	0.489	-0.173	0.340	-0.140	0.548	-0.287	0.333
Cherokee	-0.606	0.436	-0.064	0.723	0.252	0.460	-0.090	0.990
Clayton	0.611	0.130	0.140	0.663	0.339	0.334	0.098	0.711
Cobb	-0.241	0.142	-0.073	0.341	-0.085	0.003	0.213	0.005
Coweta	0.088	0.650	0.009	0.904	0.227	0.289	0.039	0.215
Dawson	-0.207	0.090	0.083	0.297	-0.480	0.289	-0.271	0.298
DeKalb	0.667	0.112	0.324	0.285	0.197	0.422	-0.001	0.948
Douglas	0.132	0.756	0.190	0.528	0.233	0.544	0.786	0.265
Fayette	-1.464	0.024	-1.479	0.094	-0.631	0.074	-0.670	0.197
Forsyth	-0.012	0.989	-0.332	0.677	-0.212	0.756	0.144	0.737
Fulton	-0.344	0.529	-0.190	0.711	-0.113	0.796	-0.243	0.196
Gwinnett	0.017	0.505	0.043	0.568	0.001	0.669	-0.004	0.789
Haralson	-1.569	0.107	-1.381	0.067	-1.064	0.135	-1.275	0.120
Heard	-0.319	0.744	-0.403	0.644	-0.293	0.415	0.236	0.535
Henry	0.238	0.134	-0.155	0.184	-0.023	0.198	-0.244	0.456
Jasper	0.028	0.922	0.303	0.576	0.525	0.492	-0.062	0.980
Lamar	-0.012	0.973	0.018	0.927	-0.010	0.508	0.168	0.605
Meriwether	0.155	0.675	-0.052	0.916	0.268	0.557	0.223	0.577
Newton	0.004	0.943	0.009	0.860	-0.002	0.475	0.000	0.984
Paulding	-0.436	0.766	-1.133	0.450	0.983	0.195	0.230	0.586
Pickens	0.127	0.686	0.004	0.874	-0.351	0.097	-0.479	0.466
Pike	-1.014	0.111	-0.793	0.269	-0.365	0.311	-0.215	0.153
Rockdale	-0.022	0.635	-0.005	0.945	-0.037	0.858	-0.007	0.976
Spalding	0.171	0.519	-0.023	0.986	0.211	0.371	0.029	0.825
Walton	-0.047	0.941	-0.234	0.473	-0.018	0.792	0.006	0.950

COUNTY	2019 AVCR LMI	2019 AVCR LMI p-value	2020 AVCR LMI	2020 AVCR LMI p-value	2021 AVCR LMI	2021 AVCR LMI p-value
Barrow	0.569	0.563	0.034	0.064	-0.013	0.039
Bartow	-0.033	0.967	0.077	0.325	0.055	0.412
Butts	-0.035	0.887	-0.015	0.993	-0.091	0.730
Carroll	-0.008	0.160	0.213	0.194	0.201	0.192
Cherokee	-0.398	0.513	0.178	0.164	0.127	0.209
Clayton	-0.038	0.746	0.278	0.208	0.253	0.237
Cobb	-0.219	0.326	0.153	0.466	0.076	0.580
Coweta	0.475	0.206	0.332	0.346	0.356	0.295
Dawson	-0.066	0.912	0.296	0.443	0.295	0.489
DeKalb	-0.126	0.655	-0.677	0.067	-0.705	0.035
Douglas	-0.082	0.528	-0.084	0.288	-0.063	0.408
Fayette	0.004	0.267	-0.125	0.109	-0.078	0.143
Forsyth	0.017	0.883	-0.029	0.779	-0.009	0.707
Fulton	0.054	0.661	0.099	0.534	0.045	0.716
Gwinnett	-0.159	0.150	0.661	0.272	1.076	0.109
Haralson	0.075	0.874	0.186	0.564	0.144	0.644
Heard	0.258	0.412	0.250	0.264	0.468	0.283
Henry	0.045	0.823	-0.080	0.594	-0.136	0.425
Jasper	-0.406	0.654	-0.067	0.938	-0.059	0.942
Lamar	0.053	0.378	0.345	0.641	0.156	0.763
Meriwether	0.582	0.179	-0.096	0.488	-0.059	0.470
Newton	0.152	0.670	-0.236	0.186	-0.272	0.105
Paulding	0.002	0.965	0.094	0.463	0.046	0.545
Pickens	-0.521	0.282	0.272	0.430	0.307	0.428
Pike	0.194	0.340	0.337	0.292	0.120	0.578
Rockdale	0.213	0.312	0.620	0.343	0.957	0.183
Spalding	0.122	0.491	-0.150	0.535	-0.044	0.873
Walton	0.760	0.007	0.281	0.006	0.631	0.002

Table 4
This table presents Local Moran's I correlation coefficients and associated p-values for each county's AVCR (Asthma ER Visit Rate to Community Violent Crime Rate Ratios) from 2015 to 2021. Local Moran's I is a measure of local spatial autocorrelation, which assesses how similar or dissimilar a particular location is compared to its neighboring locations. Positive Local Moran's I values indicate that a location has similar values to its neighbors (either high or low), while negative values indicate dissimilar values (a high value surrounded by low values or vice versa). A value close to 0 suggests no significant local spatial autocorrelation. A smaller p-value (typically less than 0.05) indicates that the observed spatial pattern is less likely to have occurred by chance, and there is significant local spatial autocorrelation.

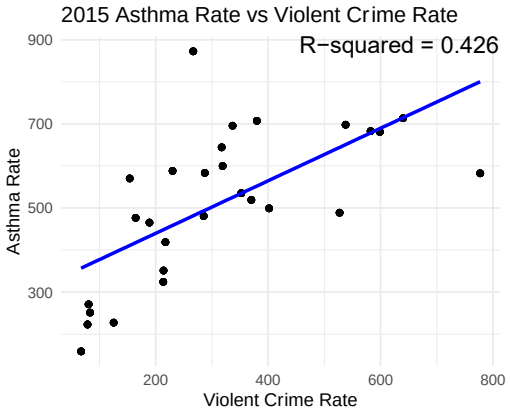
The table shows a wide range of Local Moran's I values and corresponding p-values across different counties and years. Some key observations are:

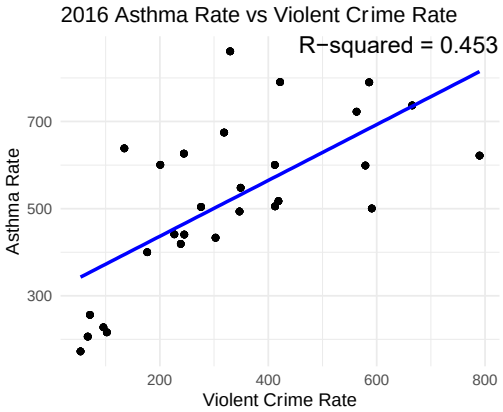
1. In Bartow County, there is a significant positive Local Moran's I value of 2.126 in 2017 with a p-value of 0.025, suggesting a significant clustering of similar AVCR values in this county and its neighboring areas for this year.

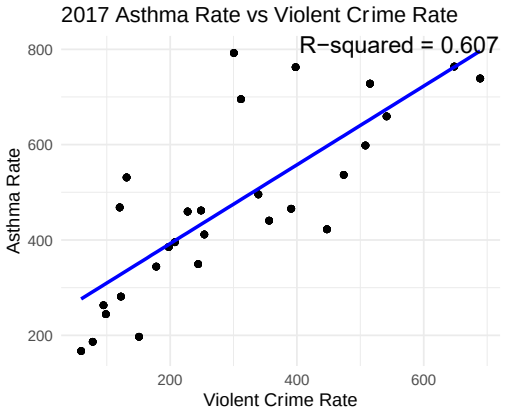
2. Fayette County has significant negative Local Moran's I values in 2015 and 2016, with values of -1.464 (p-value = 0.024) and -1.479 (p-value = 0.094), respectively. These values indicate a significant spatial pattern of dissimilar AVCR values between Fayette County and its neighboring areas during these years.

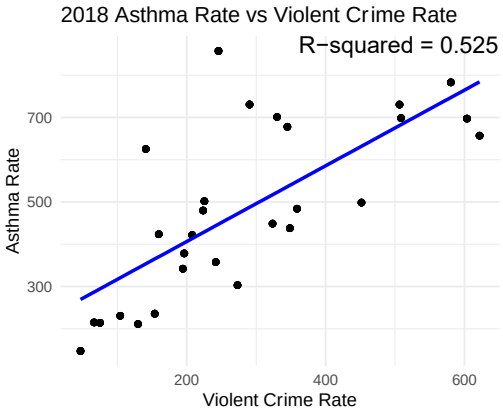
3. Walton County shows a significant positive Local Moran's I value in 2019, 2020, and 2021, with values of 0.760 (p-value = 0.007), 0.281 (p-value = 0.006), and 0.631 (p-value = 0.002), respectively. These values suggest a significant clustering of similar AVCR values in Walton County and its neighboring areas during these years.

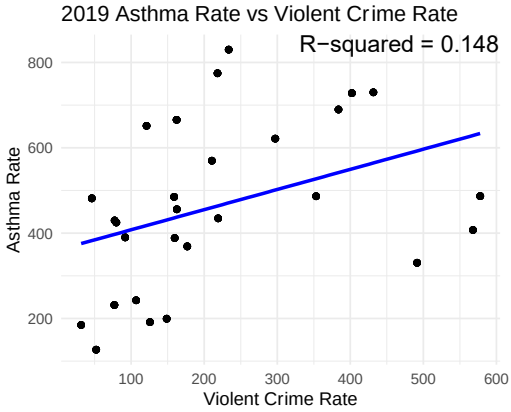
In summary, this table illustrates that the local spatial autocorrelation of AVCR values varies across different counties and years. In some cases, significant clustering of similar or dissimilar AVCR values is observed, while in other cases, no significant local spatial autocorrelation is found. This information can be helpful for identifying patterns and areas that may require further investigation or targeted interventions.

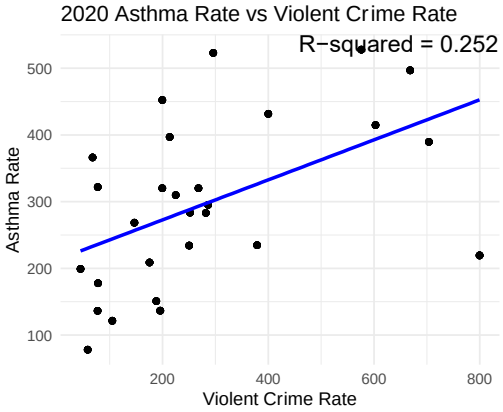


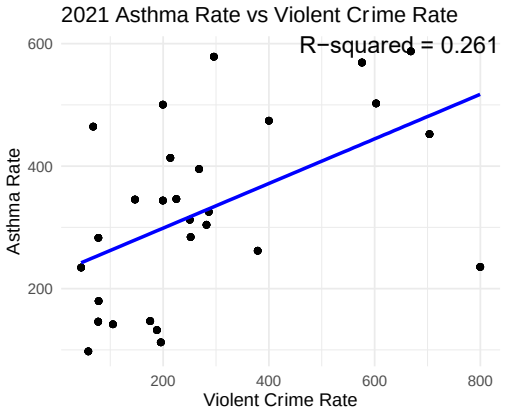






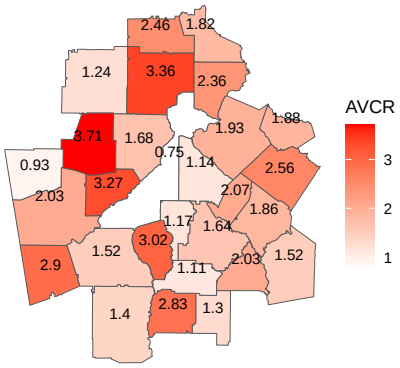




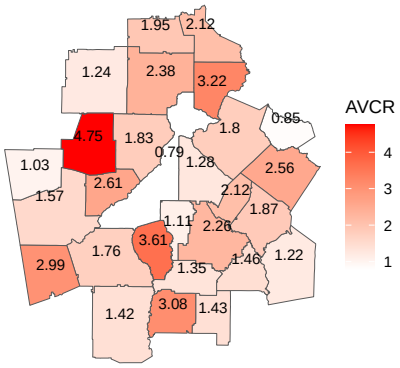


Graphs of Asthma ER Visit Rates to Violent Crime Rates and R Squared Values for 2015-2021

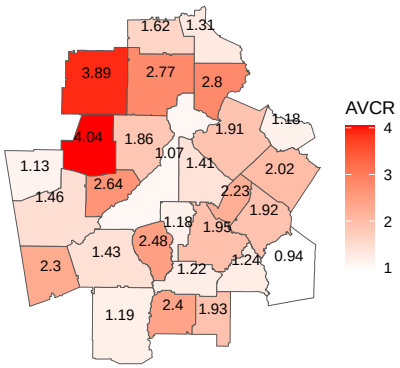
2015 Asthma : Violent Crime Rate Ratios



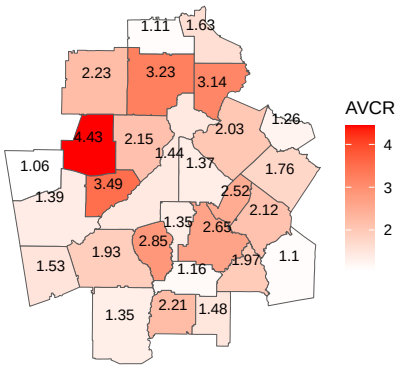
2016 Asthma : Violent Crime Rate Ratios



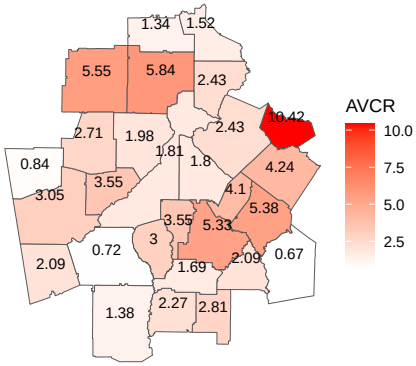
2017 Asthma : Violent Crime Rate Ratios



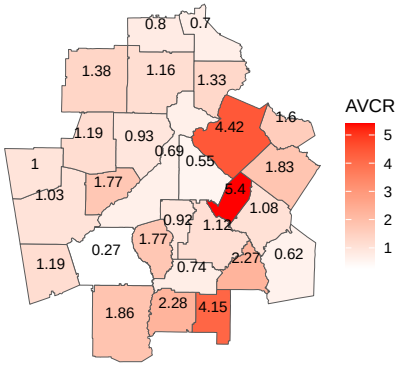
2018 Asthma : Violent Crime Rate Ratios



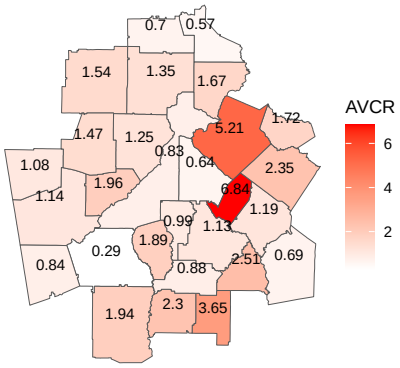
2019 Asthma : Violent Crime Rate Ratios



2020 Asthma : Violent Crime Rate Ratios

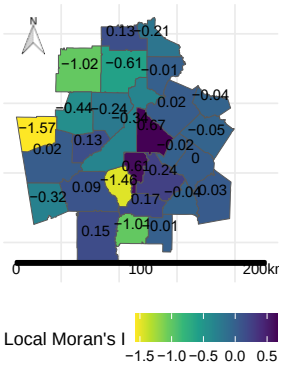


2021 Asthma : Violent Crime Rate Ratios

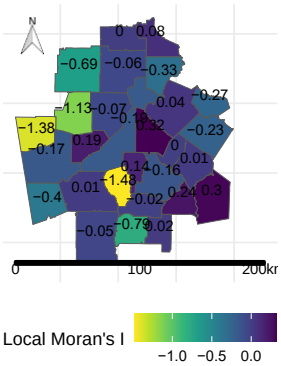


Maps of AVCR Rate Ratios Across Metro Atlanta

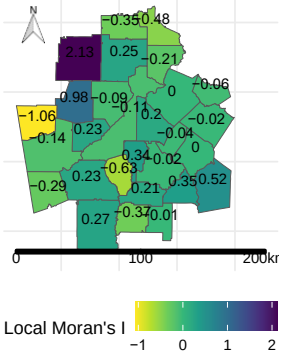
2015 AVCR Local Moran's I



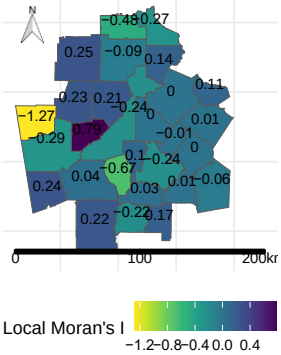
2016 AVCR Local Moran's I



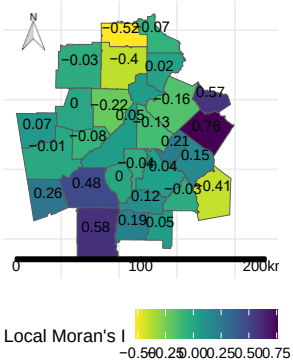
2017 AVCR Local Moran's I



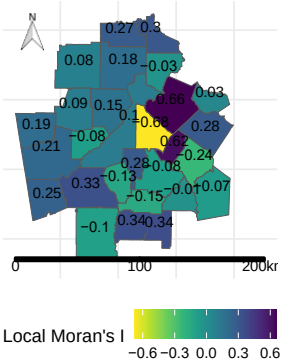
2018 AVCR Local Moran's I



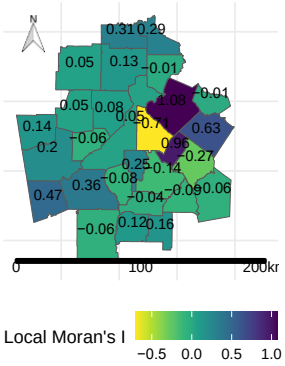
2019 AVCR Local Moran's I



2020 AVCR Local Moran's I

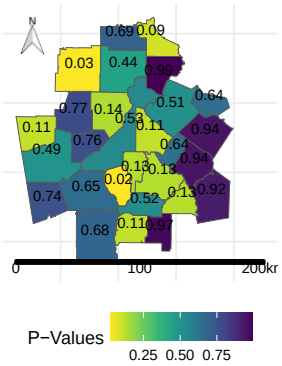


2021 AVCR Local Moran's I

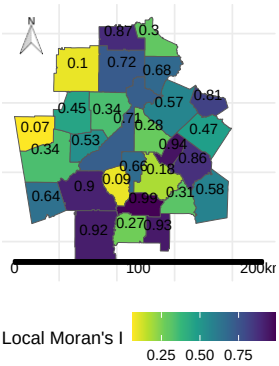


Local Moran's I Spatial Autocorrelation Values for AVCR in Metro Atlanta 2015-2021

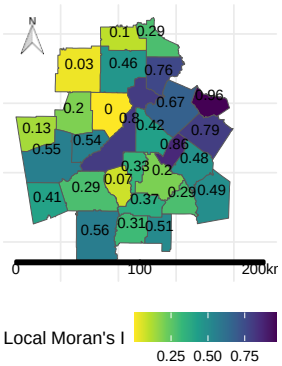
2015 AVCR Local Moran's I P−Values



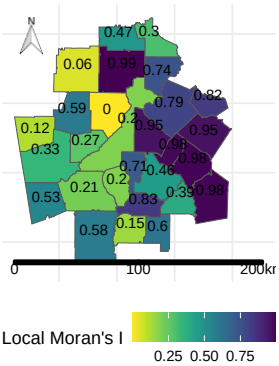
2016 AVCR Local Moran's I P−Values



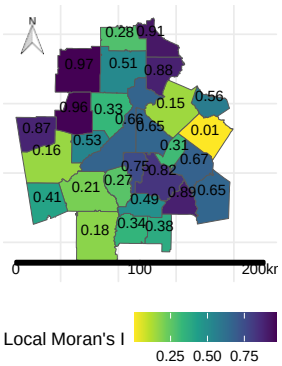
2017 AVCR Local Moran's I P−Values



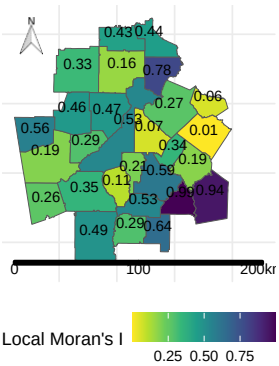
2018 AVCR Local Moran's I P−Values



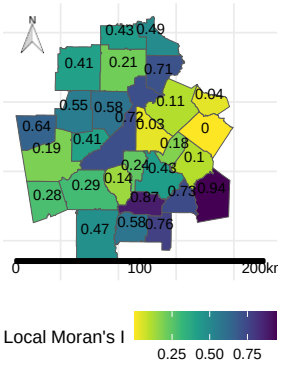
2019 AVCR Local Moran's I P−Values



2020 AVCR Local Moran's I P−Values



2021 AVCR Local Moran's I P−Values



P-Values for Metro Atlanta AVCR Autocorrelations 2015-2021

References

1. Akinbami LJ, Moorman JE, Liu X. Asthma prevalence, health care use, and mortality: United States, 2005-2009. National health statistics reports. 2011 Jan 12;(32):1-14. https://stacks.cdc.gov/view/cdc/12410

2. Lai CK, Beasley R, Crane J, Foliaki S, Shah J, Weiland S. Global variation in the prevalence and severity of asthma symptoms: Phase Three of the International Study of Asthma and Allergies in Childhood (ISAAC). Thorax. 2009 Jun 1;64(6):476-83.

3. Kong T, Cabrera-Muffly C, Wise SK. The Impact of Sinonasal Anatomic Variants on the Development of Chronic Rhinosinusitis with Nasal Polyps. Journal of Allergy and Clinical Immunology: In Practice. 2022 Jan 1;10(1):211-8.

4. Williams DR, Sternthal M. Understanding racial-ethnic disparities in health: Sociological contributions. Journal of Health and Social Behavior. 2010 Mar;51(1_suppl):S15-S27.

5. Gupta RS, Carrión-Carire V, Weiss KB. The widening black/white gap in asthma hospitalizations and mortality. Journal of Allergy and Clinical Immunology. 2006 Feb 1;117(2):351-8.

6. Bryant-Stephens T. Asthma disparities in urban environments. Journal of Allergy and Clinical Immunology. 2009 Jun 1;123(6):1199-206.

7. Cakmak S, Dales RE, Judek S. Respiratory health effects of air pollution gases: Modification by education and income. Archives of Environmental & Occupational Health. 2006 Jan 1;61(1):5-10.

8. Wright RJ, Subramanian SV. Advancing a multilevel framework for epidemiologic research on asthma disparities. Chest. 2007 Nov 1;132(5_suppl):757S-69S.

9. Clougherty JE, Kubzansky LD, Spengler JD, Levy JI. Ancillary benefits for caregivers of children with asthma participating in an environmental intervention study to alleviate asthma symptoms. Ciência & Saúde Coletiva. 2010 Apr;15(4):2083-93. https://doi.org/10.1590/S1413-81232010000400020

10. Wright RJ, Subramanian SV. Advancing a multilevel framework for epidemiologic research on asthma disparities. Chest. 2007 Nov;132(5 Suppl):757S-769S. doi: 10.1378/chest.07-2232. PMID: 17998332.

11. Clougherty JE, Kubzansky LD, Spengler JD, Levy JI. Ancillary benefits for caregivers of children with asthma participating in an environmental intervention study to alleviate

asthma symptoms. Ciência & Saúde Coletiva. 2010 Apr;15(4):2083-2093. doi: 10.1590/S1413-81232010000400020.

12. Cutts BB, Darby KJ, Boone CG, Brewis A. City structure, obesity, and environmental justice: an integrated analysis of physical and social barriers to walkable streets and park access. Soc Sci Med. 2009 Nov;69(9):1314-1322. doi: 10.1016/j.socscimed.2009.07.034. Epub 2009 Aug 25. PMID: 19716251.

13. Wilson KM, Klein JD, Blumkin AK, Gottlieb M, Winickoff JP. Passive Smoking and Children's Health. Pediatrics. 2011 Jan;127(1):85-92. doi: 10.1542/peds.2010-1811. Epub 2010 Dec 20. PMID: 21173109.

14. Centers for Disease Control and Prevention (CDC). Most Recent National Asthma Data. [Internet]. [updated 2021 May 11; cited 2022 Apr 18]. Available from: https://www.cdc.gov/asthma/most_recent_national_asthma_data.htm

15. Georgia Department of Public Health. Asthma in Georgia. [Internet]. [updated 2021 Aug 16; cited 2022 Apr 18]. Available from: https://dph.georgia.gov/asthma-georgia

16. Georgia Asthma Control Program. Asthma Prevalence and Burden in the Metro Atlanta Region. [Internet]. [updated 2021 Jun 17; cited 2022 Apr 18]. Available from: https://dph.georgia.gov/asthma-prevalence-and-burden-metro-atlanta-region

17. Nurmagambetov T, Kuwahara R, Garbe P. The Economic Burden of Asthma in the United States, 2008-2013. Ann Am Thorac Soc. 2018 Mar;15(3):348-356. doi: 10.1513/AnnalsATS.201706-447OC. PMID: 29461863.

18. Williams DR, Sternthal M, Wright RJ. Social determinants: taking the social context of asthma seriously. Pediatrics. 2009 Mar;123 Suppl 3:S174-84. doi: 10.1542/peds.2008-2233G. PMID: 19221156.

19. Suglia SF, Duarte CS, Sandel MT, Wright RJ. Social and environmental stressors in the home and childhood asthma. J Epidemiol Community Health. 2010 Jul;64(7):636-642. doi: 10.1136/jech.2008.086355. Epub 2009 Nov 30. PMID: 19948898.

20. Wright RJ. Stress and atopic disorders. J Allergy Clin Immunol. 2005;116(6):1301-6.

21. Suglia SF, Ryan L, Laden F, Dockery D, Wright RJ. Violence exposure, a chronic psychosocial stressor, and childhood lung function. Psychosom Med. 2008;70(2):160-9.

22. Wright RJ, Mitchell H, Visness CM, Cohen S, Stout J, Evans R, et al. Community violence and asthma morbidity: the Inner-City Asthma Study. Am J Public Health. 2004;94(4):625-32.

23. Subramanian SV, Kennedy MH. Perception of neighborhood safety and reported childhood lifetime asthma in the United States (U.S.): a study based on a national survey. PLoS One. 2009;4(6):e6091.

24. Clougherty JE, Levy JI, Kubzansky LD, Ryan PB, Suglia SF, Canner MJ, et al. Synergistic effects of traffic-related air pollution and exposure to violence on urban asthma etiology. Environ Health Perspect. 2007;115(8):1140-6.

25. Szyszkowicz M, Kousha T, Castner J. Violence and Asthma: A Review. Environ Res. 2017;154:88-94.

26. Wright RJ, Mitchell H, Visness CM, Cohen S, Stout J, Evans R, et al. Community Violence and Urban Childhood Asthma: A Multilevel Analysis. Environ Health Perspect. 2004;112(14):1401-8.

27. Suglia SF, Duarte CS, Sandel MT. Social and Environmental Stressors in the Home and Childhood Asthma. J Epidemiol Community Health. 2010;64(7):636-42.

28. Flanigan C, Sheikh A, DunnGalvin A. Exposure to Violence, Psychosocial Stress, and Asthma. Am J Respir Crit Care Med. 2017;195(7):946-947.

29. Rosas-Salazar C, Han YY, Beavers SF, Gebretsadik T, Smith SJ, Añazco AS, et al. Gun Violence, African Ancestry, and Asthma: A Case-Control Study in Puerto Rican Children. Chest. 2016;149(6):1436-44.

30. Georgia Department of Public Health. Metro Atlanta Statistical Area [Internet]. Atlanta (GA): Georgia Department of Public Health; [cited 2023 Apr 18]. Available from: https://dph.georgia.gov/metro-atlanta-statistical-area

31. Metro Atlanta Asthma and Crime Dataset. Data from 2015-2021. APD Open data, https://opendata.atlantapd.org/.

32. United States Census Bureau. QuickFacts: Atlanta city, Georgia [Internet]. Suitland (MD): United States Census Bureau; [cited 2023 Apr 18]. Available from: https://www.census.gov/quickfacts/fact/table/atlantacitygeorgia/PST045221

33. Georgia Bureau of Investigation. Annual Violent Crime Reports [Internet]. Decatur (GA): Georgia Bureau of Investigation; [cited 2023 Apr 18]. Available from: https://gbi.georgia.gov/annual-violent-crime-reports

34. Georgia Department of Public Health. Online Analytical Statistical Information System (OASIS) [Internet]. Atlanta (GA): Georgia Department of Public Health; [cited 2023 Apr 18]. Available from: https://oasis.state.ga.us

35. Centers for Disease Control and Prevention. Social Vulnerability Index (SVI) Shapefiles [Internet]. Atlanta (GA): Centers for Disease Control and Prevention; [cited 2023 Apr 18]. Available from: https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html

36. Anselin, L. (1995). Local Indicators of Spatial Association—LISA. Geographical Analysis, 27(2), 93-115.

37. ESRI. (n.d.). How Spatial Autocorrelation (Global Moran's I) works. Retrieved April 18, 2023, from https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/h-how-spatial-autocorrelation-moran-s-i-spatial-st.htm

38. Guo, D. (2015). Spatial Analysis for the Social Sciences. Cambridge: Cambridge University Press.