ASSESSING THE RELATIONSHIP BETWEEN SOCIODEMOGRAPHIC VARIABLES AND ADULT ASTHMA RATES AT THE COUNTY REGIONAL-DIVISION LEVEL IN THE CONTIGIOUS UNITED STATES

A Thesis
by
CAITLYN DUNCAN

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Abstract

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Caitlyn A. Duncan

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Asthma is one of the most common diseases in the world, affecting over 260 million people worldwide (Fuchs, 2020). According to the Centers for Disease Control and Prevention (CDC), approximately 25 million Americans have asthma, equating to eight percent of the adult population and seven percent of the child population (CDC, 2020). While many studies have examined the association between childhood asthma and sociodemographic risk factors, a limited number of studies have strictly focused on adult asthma. This study aims to understand some of the spatial determinants of adult asthma by assessing the relationship between sociodemographic variables and adult asthma rates at the county regional-division level in the contiguous United States. Correlation tests and multiple linear regression models were run for each of the independent variables in all nine U.S. divisions. Findings revealed that the percentage of impoverished adults was the most significant indicator of adult asthma, with all p-values being less than 0.01. Additionally, the variables of percent of minority population and percent of educational attainment below a high school degree were significant indicators of adult asthma in five of the nine regions. Future research should incorporate additional asthma risk factors, such as genetic and environmental predispositions, in order to more comprehensively examine risk

factors associated with adult asthma. Ultimately, results from this study highlight locations where public health interventions can be explored that aim to mitigate the unequal burden of adult asthma.

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I am extremely grateful for my five and a half years at Appalachian State University and all of the amazing people I have met along the way. I owe many thanks to my thesis advisor, professor, and mentor, Dr. Kara Dempsey. Taking her course my sophomore year allowed me to discover my love and passion for the field of geography. Her vivacious energy and constant effort to create a safe and compassionate space for learning will continue to be an inspiration for me as I move forward with my personal life and career. Without her support and encouragement this thesis would not be possible. I am also incredibly thankful for committee member Dr. Elizabeth Shay. Dr. Shay was my academic advisor throughout my undergraduate career and continuously encouraged me to take advantage of the opportunities around me. She also was a part of my first-ever research endeavor as an undergraduate student, which allowed me to discover my passion for research and led me to completing this thesis. I would also like to extend a thank you to committee member and chair of the Department of Geography and Planning, Dr. Saskia van de Gevel. Dr. van de Gevel has been a supportive figure for me throughout my journey as a geographer and researcher, and never fails to make me laugh when I need it most.

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inspiration for me throughout my graduate experience and has offered her support and reassurance throughout every step in my thesis process.

Lastly, I am eternally grateful for my parents, Greg and Deanna Duncan, and my older siblings Erin, Chris, and Will. Without their unwavering love and support I would not be the person or student I am today.

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Foreword

The main body of this thesis is formatted in accordance with the guidelines for manuscript submission to Health and Place. Health and Place is an interdisciplinary journal dedicated to the study of all aspects of health and health care in which place or location matters.

1. Introduction

Asthma is a chronic health condition that affects a person's airways and lungs and can cause shortness of breath, wheezing, chest tightness, and frequent coughing (CDC, 2020). As of 2022, the total prevalence of asthma in the United States is approximately 7.8 percent (CDC, 2020). While asthma affects all groups, nationwide surveys conducted in the United States have found significant racial/ethnic, as well as socioeconomic disparities in the burden of asthma (Leong et al., 2012). These patterns align with robust strands of social epidemiological literature that identify social determinants as fundamental drivers behind health inequalities (Alvarez et al., 2022). These findings are bolstered by the recent push to incorporate concepts associated with the environmental justice movement in academic research, which aims to bring attention to the disproportionate exposure of vulnerable populations to hazardous conditions.

Many scholarly studies have focused on assessing the prevalence and risk factors associated with childhood asthma, despite adults having a higher prevalence of asthma, which is 8.4 percent compared to 5.8 percent for children (AAFA, 2019). This may be because, over the last 50 years, the increase in the global prevalence, morbidity, mortality, and economic burden associated with asthma has been most pronounced in children (Braman, 2006). Many of these studies focus specifically on the transition of asthma from childhood to adulthood. Despite this, the course of the disease is still considered to be highly unpredictable and inconsistent across individuals (Gerritsen J, 2002). The optimal clinical evaluation of asthma has been under debate for decades as the diagnosis of the disease is oftentimes not straightforward and can be especially challenging in older adults (Cavallazzi et al., 2018).

Previous studies have utilized a variety of analytic approaches to quantitatively evaluate some of the risk factors associated with asthma (Stern et al., 2020). Because asthma is an illness

that results from both genetic predisposition and environmental exposures, it is difficult to comprehensively examine the complex associations that are known to contribute to asthma risk and burden. However, genetics and individual behavior contribute less to asthma risk than social and structural determinants and inequities (AAFA, 2019). In the United States, the burden of asthma falls disproportionately on Black, Hispanic, and American Indian peoples, with these groups having the highest asthma rates, hospitalizations, and deaths. Compared to white Americans, Black Americans are approximately 1.5 times more likely to have asthma and five times more likely to visit the emergency department due to asthma difficulty. When sex is factored in, black women have the highest rates of death due to asthma (AAFA, 2019).

Efforts to reduce these disparities often focus on designated priority populations, such as communities of color, low-income populations, and individuals living in rural and inner-city communities. Of course, these groups are not mutually exclusive, and disparities also occur within subgroups of these populations. For example, there are observed differences among Hispanic populations in health outcomes and health care based on language, length of time residing in the country, and immigration status. (Ndugga and Artiga, 2021). Although the Affordable Care Act, signed into law in 2010, led to large gains in health coverage across groups, minority and low-income populations remain at increased risk of being uninsured, perpetuating the barriers they face to accessing health care (Buchmueller et al., 2016).

The objective of this study is to identify spatial trends in adult asthma rates in the United States related to sociodemographic variables of age, educational attainment, poverty, and race. Figures showing the distribution of each variable at the county level for the contiguous United States have been inserted below (Figures 1-5). While sociodemographic risk factors alone cannot predict adult asthma, they have been found to contribute more to asthma risk than genetics and

individual behavior (AAFA, 2019). Findings from this study will provide health and social service professionals with vital information that can be used to improve targeted adult asthma interventions at the local and regional levels.

This study was conducted at the county regional-division level based on the United States Census Bureau Regions and Divisions classification (Table 1). Although the United States can claim to provide among the world's highest quality healthcare, it functions as a collection of local systems, which operate under different budgets, eligibility criteria, and financial systems (Brookings Blueprints for American Renewal and Prosperity, 2020). Because of this, when assessing health conditions, it is imperative to do so at a fine spatial scale, such as the census tract, zip-code tabulation, or county-level geography. This study was conducted at the county level within each of the nine region-divisions to ensure the results could be used for targeted adult asthma interventions at both the county and regional level. Throughout the remainder of this paper, the region-divisions based on the U.S. Census Bureau classification will be referred to as "divisions".

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Declarations of interest: none
Keywords: Adult Asthma, Sociodemographic Risk Factors, Multiple Linear Regression, Health Geography

Abstract

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1. Introduction

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Figure 1. Distribution of dependent adult asthma variable.

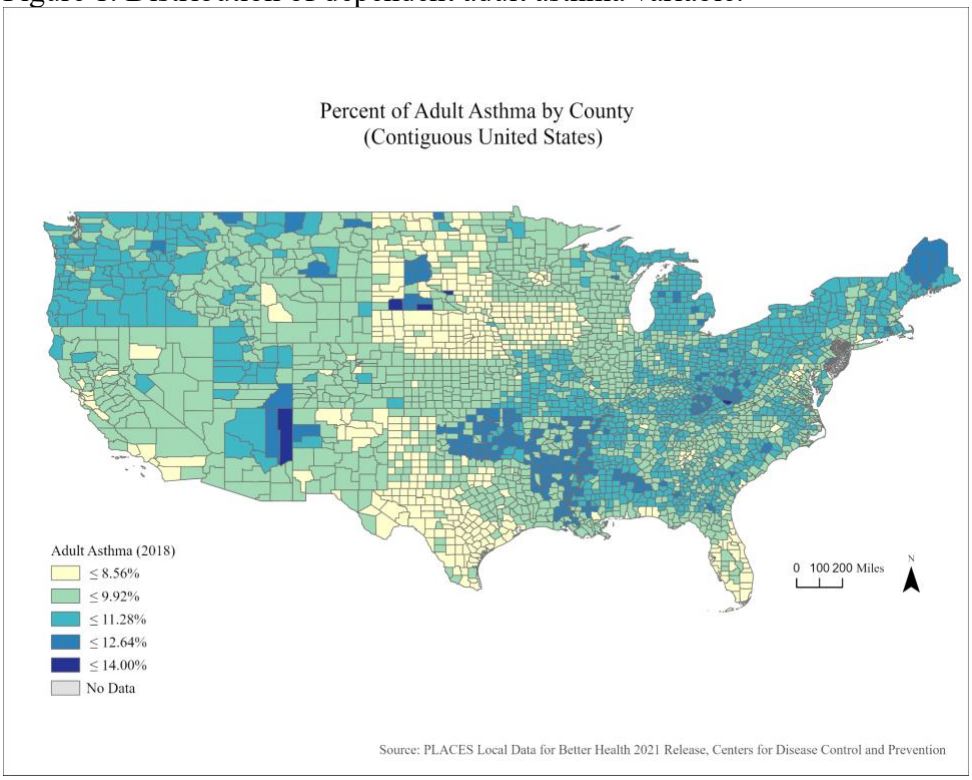


Figure 2. Distribution of independent age variable.

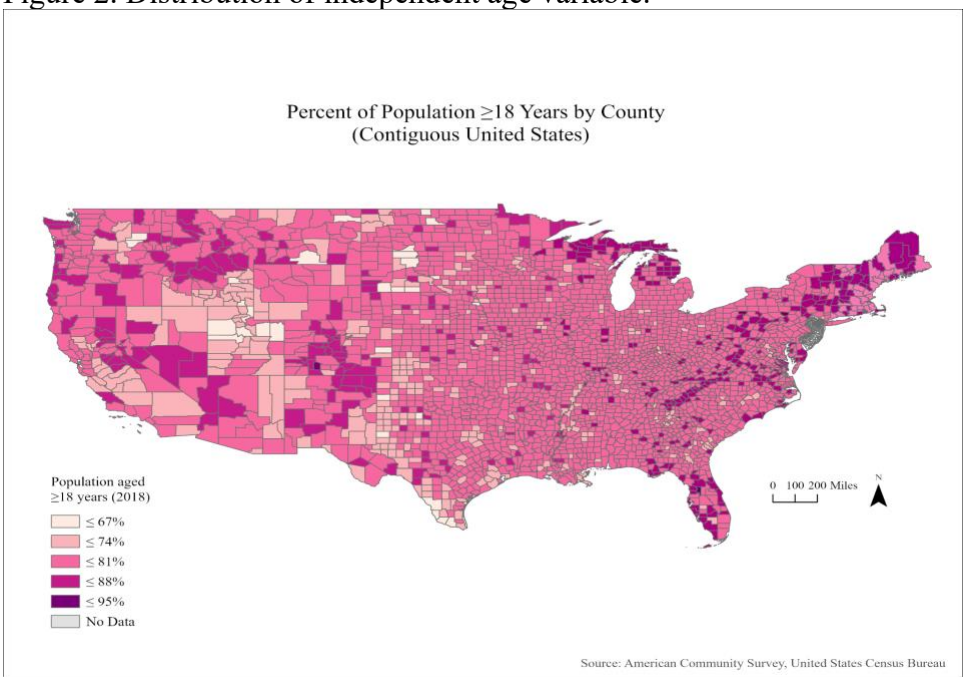


Figure 3. Distribution of independent educational attainment variable.

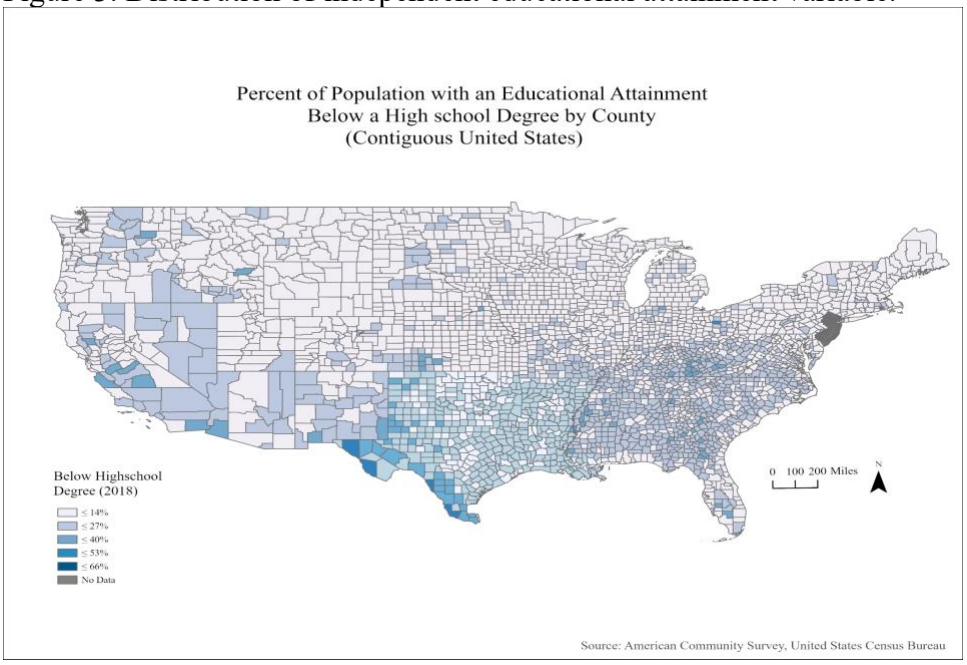


Figure 4. Distribution of independent poverty variable.

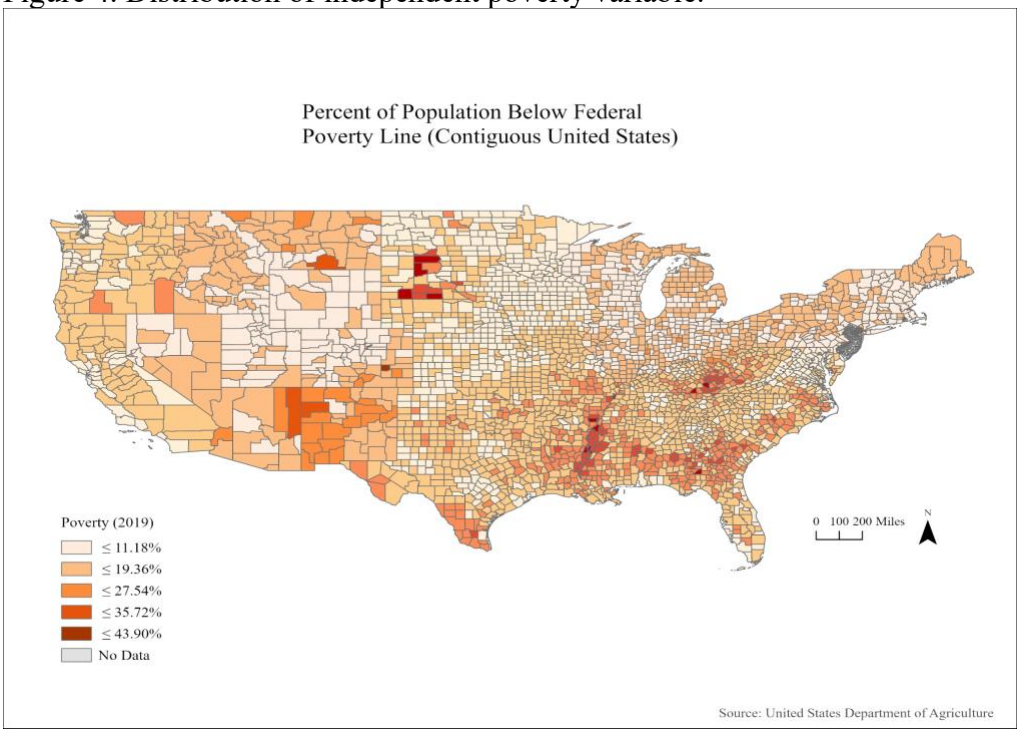
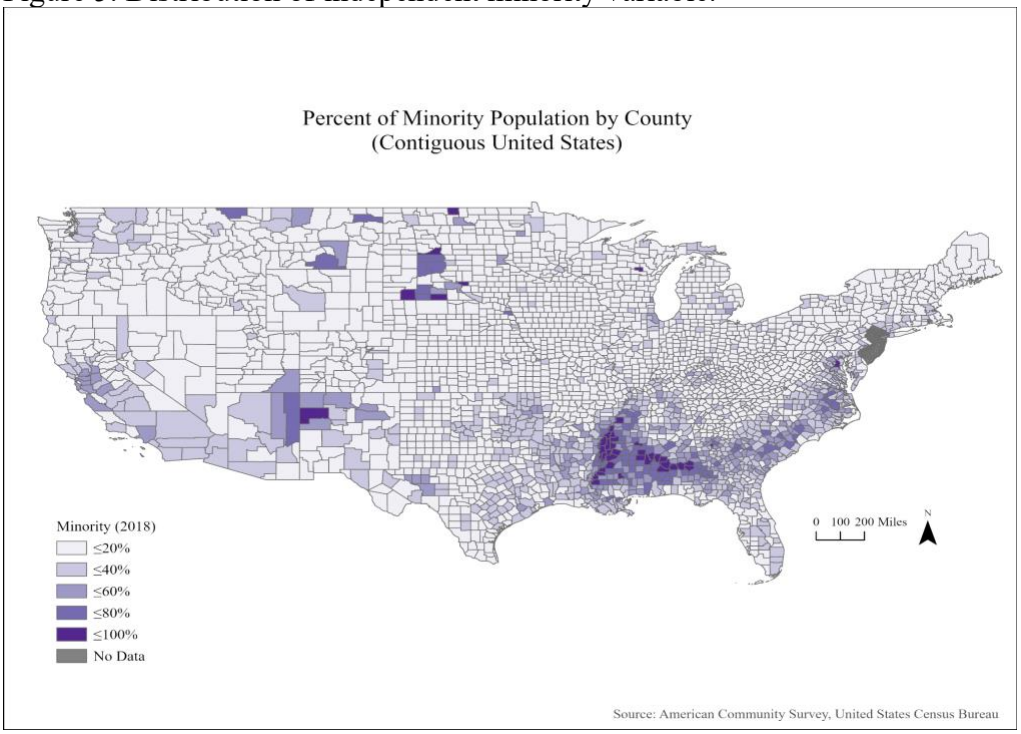


Figure 5. Distribution of independent minority variable.



This study was conducted at the county regional-division level based on the United States Census Bureau Regions and Divisions classification (Table 1). Although the United States can claim to provide among the world's highest quality healthcare, it functions as a collection of mini systems, which operate under different budgets, eligibility criteria, and financial systems (Brookings Blueprints for American Renewal and Prosperity, 2020). Because of this, when assessing health conditions, it is imperative to do so at a fine spatial scale, such as the census tract, zip-code tabulation, or county-level geography. This study was conducted at the county level within each of the nine divisions to ensure the results could be used for targeted adult asthma interventions at both the local, county level, and regional levels. Throughout the remainder of this paper, the region-divisions based on the U.S. Census Bureau classification will be referred to as "divisions".

2. Background

Like most health concerns, asthma incidence follows spatial patterns of systematic inequality in the United States. Because the distribution of vulnerable groups is commonly spatial in nature, geography plays an essential role in identifying spatial risk factors associated with negative health outcomes such as asthma. Sociodemographic risk factors frequently consist of census county indicators such as socioeconomic status, racial and ethnic composition, poverty rates, educational attainment, etc. (Roche et al., 2022). These variables are commonly used due to their ease of accessibility and fine spatial scale. However, it is important to note that these measures cannot fully capture the wide range of individual-level experiences within these geographies.

While racial and ethnic disparities in asthma burden have been well documented for decades, there are few intervention methods that have been proven to effectively bridge these gaps. Several factors that have the potential to explain these disparities have been proposed and explored, including access to healthcare, parental well-being, clinician bias, and more (Hughes et al., 2017). Additionally, it has been suggested that observed racial and ethnic disparities may stem from socioeconomic status (SES) across groups and that the observed racial and ethnic contributions to poor asthma outcome would be diminished if studies could more accurately account for SES (Hughes et al., 2017). However, SES is a complex and multifaceted concept, and defining the measure with a single measure (such as income) may not sufficiently capture the variation of SES among groups. Due to this limitation, some studies have attempted to assess SES using more robust measures.

In recent decades, the relationship between SES and educational attainment has been well documented. Research has indicated that children from low-SES communities develop academic skills more slowly than children from higher-SES groups (Morgan et al., 2009). This leads to increased dropout rates and low social mobility, affecting children's future career prospects into adulthood. This can lead to the perpetuation of the low-SES status of the community (American Psychological Association, 2017). Because of this, educational attainment is often used, in addition to income, as an indicator of socioeconomic status.

Geography and Health

In recent years, increasing attention has been dedicated to social determinants of health, or the factors aside from clinical health care that influence trends in health outcomes across multiple geographies and populations (Braveman and Gottlieb, 2014). This is not to say that

clinical health care does not influence health outcomes, but rather that it is not the only determinant of health. Extensive research has demonstrated the association between poor health outcomes and poor social conditions, so much so that the magnitude of health inequality in an area can be used as an indicator of the degree of social and economic hardship in that area (Social Determinants of Health Equity, Marmot 2014). This finding supports the importance of incorporating spatial analysis methods when assessing health disparities since vulnerable populations tend to live in different areas than non-vulnerable populations.

Spatial location plays a key role in shaping the multidimensional risk factors of poor health outcomes. Where a person lives and works directly influences their health experiences and their access to the social, built, and natural environments that affect a person's physical and mental health (Dummer, 2008). Effective public health interventions require a robust geographic context in order to ensure that they are representative of the unique needs of the community they are serving. While epidemiological studies focus on the biology of poor health, health geography is interested in exploring the social, cultural, and political contexts of health within a given geography (Dummer, 2008).

3. Material and methods

2.1. Data & Variables

County-level estimates of current asthma prevalence among adults aged ≥18 years were obtained from PLACES, a collaboration between CDC, the Robert Wood Johnson Foundation, and the CDC Foundation. PLACES reports small area estimates of multiple chronic disease measures for the United States (Division of Population Health, National Center for Chronic Disease Prevention and Health Promotion, 2022). Adult asthma data came from the 'Local Data

for Better Health, County 2021 release', which uses Behavioral Risk Factor Surveillance System (BRFSS) 2019 or 2018 data, Census Bureau 2019 or 2018 data, and American Community Survey (ACS) 2015 or 2014 five-year estimates (Division of Population Health, National Center for Chronic Disease Prevention and Health Promotion, 2022). County population, age, educational attainment, and race data were obtained from the 2018 ACS five-year estimate using the tidycensus package in R (Kyle Walker and Matt Herman, 2021). Lastly, 2019 county-level poverty data were obtained from the United States Department of Agriculture (USDA), which uses the Census Bureau's Small Area Income and Poverty Estimates (SAIPE). This sociodemographic data from the U.S. Census Bureau and USDA was merged with adult asthma data from the PLACES dataset by county FIPS.

We identified four possible risk factors based on previous studies that have identified social inequities as being large contributors to asthma risk. These variables include percent of population aged ≥18 years, percent of minority population, percent of educational attainment below high school degree, and percent of population below the poverty line. These variables were added to adult asthma rates at the county level and were divided into nine divisions based on the United States Census Bureau Regions and Divisions classification, shown in Table 1.

Table 1. United States Census Bureau Regions and Divisions.

Region I: Northeast	**Region 2: Midwest**	**Region 3: South**	**Region 4: West**
Division 1: New England - Connecticut - Maine - Massachusetts - New Hampshire - Rhode Island	***Division 3: East North Central*** - Indiana - Illinois - Michigan - Ohio - Wisconsin	***Division 5: South Atlantic*** - Delaware - District of Columbia - Florida - Georgia - Maryland	***Division 8: Mountain*** - Arizona - Colorado - Idaho - New Mexico - Montana - Utah - Nevada - Wyoming

- Vermont		- North Carolina - South Carolina - Virginia - West Virginia	
Division 2: Middle Atlantic - New Jersey - New York - Pennsylvania	***Division 4: West North Central*** - Iowa - Kansas - Minnesota - Missouri - Nebraska - North Dakota - South Dakota	***Division 6: East South Central*** - Alabama - Kentucky - Mississippi - Tennessee	***Division 9: Pacific*** - California - Oregon - Washington
		Division 7: West South Central - Arkansas - Louisiana - Oklahoma - Texas	

2.2. Analysis

All analysis was conducted within R, a language and environment for statistical computing. To begin, histograms of the independent sociodemographic variables were plotted for each of the nine U.S. divisions in order to visualize their distribution. Each independent variable was normally distributed apart from the minority variable. A Pearson's correlation test was conducted for the three parametric variables and a Kendall rank correlation was conducted for the nonparametric minority variable for each division. The results of the correlation tests are

shown in Table 2. The variables with a correlation coefficient between 0.00 to 0.30 (0.0 to -0.30) were deemed negligible based on the guide for interpreting correlation coefficient size provided by the National Library of Medicine (Mukaka, 2012). The resulting p-values were ranked from least to most significant ($p<0.1$, $p<0.05$, $p<0.01$ respectively). All variables with both a negligible correlation coefficient and non-significant p-value were excluded from the subsequent multiple linear regression model (these are struck through in Table 2).

Table 2. The results of the correlation tests. $p<0.1$ *, $p<0.05$ **, $p<0.01$ ***

Division	**Variables & Test**	**Correlation Coefficient**	**P-value**
New England	Minority & Asthma (Kendall)	-0.2321522	0.006633 ***
	Educational attainment below HS & Asthma (Pearson)	0.4487821	0.0001395 ***
	Poverty & Asthma (Pearson)	0.6490916	2.833e-09 ***
	~~Population ≥18 years & Asthma (Pearson)~~	~~0.1019539~~	~~0.4117~~
East North Central	~~Minority & Asthma (Kendall)~~	~~0.03027066~~	~~0.3543~~
	Educational attainment below HS & Asthma (Pearson)	0.3809925	< 2.2e-16 ***
	Poverty & Asthma (Pearson)	0.6140506	< 2.2e-16 ***
	Population ≥18 years & Asthma (Pearson)	0.0798423	0.09552 *
South Atlantic	Minority & Asthma	0.1730628	6.469e-10

	(Kendall)		***
	Educational attainment below HS & Asthma (Pearson)	0.5199876	< 2.2e-16 ***
	Poverty & Asthma (Pearson)	0.6349167	< 2.2e-16 ***
	~~Population ≥18 years & Asthma (Pearson)~~	~~-0.009986575 S~~	~~0.8092~~
Mountain	Minority & Asthma (Kendall)	-0.1233533	0.002575 **
	~~Educational attainment below HS & Asthma (Pearson)~~	~~-0.06468787~~	~~0.2798~~
	Poverty & Asthma (Pearson)	-0.1327888	0.02602 **
	Population ≥18 years & Asthma (Pearson)	0.09844679	0.09958 **
Middle Atlantic	Minority & Asthma (Kendall)	-0.3602557	4.161e-09 ***
	Educational attainment below HS & Asthma (Pearson)	0.1878033	0.03307 **
	Poverty & Asthma (Pearson)	0.457785	4.91e-08 ***
	~~Population ≥18 years & Asthma (Pearson)~~	~~0.0855632~~	~~0.335~~
West North Central	Minority & Asthma (Kendall)	0.1808707	4.004e-11 ***
	Educational attainment below HS & Asthma (Pearson)	0.5292175	< 2.2e-16 ***

	Poverty & Asthma (Pearson)	0.7018604	< 2.2e-16 ***
	Population ≥18 years & Asthma (Pearson)	-0.2896673	2.066e-13 ***
East South Central	~~Minority & Asthma (Kendall)~~	~~0.04912939~~	~~0.1716~~
	Educational attainment below HS & Asthma (Pearson)	0.7119078	< 2.2e-16 ***
	Poverty & Asthma (Pearson)	0.8191711	< 2.2e-16 ***
	~~Population ≥18 years & Asthma (Pearson)~~	~~-0.02794533~~	~~0.5951~~
Pacific	Minority & Asthma (Kendall)	-0.3833127	1.225e-10 ***
	Educational attainment below HS & Asthma (Pearson)	-0.2058089	0.01747 **
	Poverty & Asthma (Pearson)	0.4395751	1.199e-07 ***
	~~Population ≥18 years & Asthma (Pearson)~~	~~0.1020527~~	~~0.2425~~
West South Central	Minority & Asthma (Kendall)	0.2943637	< 2.2e-16 ***
	Educational attainment below HS & Asthma (Pearson)	-0.1307437	0.004524 ***
	Poverty & Asthma (Pearson)	0.4766552	< 2.2e-16 ***

	Population ≥18 years & Asthma (Pearson)	0.1577666	0.0005976 ***

To determine significant predictors of adult asthma, a multiple linear regression model was constructed for each division with the independent variables that had a significant correlation coefficient and p-value. The results of the multiple linear regression models are shown in Table 3. A Global Moran's I test was run on the residuals of each division regression model in order to test for spatial autocorrelation in the results. The p-values of the Global Moran's I test were found to be statistically insignificant, meaning that the spatial distribution of the variables is the result of random spatial processes and does not require a spatial regression model to correct spatial autocorrelation in the model residuals.

Table 3. The results of the multiple linear regression models. p<0.1 *, p<0.05 **, p<0.01 ***

Division	**Predictors**	**Estimate**	**Std error**	**P-value**	**Adjusted R-squared**
New England	% Poverty	0.155731	0.248714	3.08e-05 ***	0.52
	% Minority	-0.033550	0.034671	0.000133 ***	
	~~% Below HS Degree~~	~~0.055899~~	~~0.033841~~	~~0.103552~~	
East North Central	% Poverty	0.114433	0.009161	< 2e-16***	0.3935
	~~% ≥18 years~~	~~-0.011021~~	~~0.011021~~	~~0.33880~~	
	% Below HS Degree	0.008264	0.008264	0.00344 **	
South Atlantic	% Poverty	0.0847517	0.0077514	-2e-16 ***	0.409

	~~% Minority~~	~~0.0003542~~	~~0.0017473~~	~~0.83943~~	
	% Below HS Degree	0.0219249	0.0073987	0.00317 **	
Mountain	~~% Poverty~~	~~-0.16988~~	~~0.17265~~	~~0.3260~~	0.03117
	~~% Minority~~	~~-0.12465~~	~~0.07162~~	~~0.0829~~	
	~~% ≥18 years~~	~~0.18582~~	~~0.15321~~	~~.2262~~	
Middle Atlantic	% Poverty	0.101022	0.012116	1.17e-13 ***	0.5443
	% Minority	-0.027732	0.002828	< 2e-16 ***	
	% Below HS Degree	0.029633	0.012625	0.0205 *	
East South Central	% Poverty	0.003271	0.003271	< 2e-16 ***	0.6858
	% ≥18 years	0.009023	0.009023	1.62e-05 ***	
Pacific	% Poverty	0.111716	0.017598	3.41e-09 ***	0.5276
	% Minority	-0.037154	0.004855	4.06e-12 ***	
	~~% Below HS Degree~~	~~-0.013597~~	~~0.009297~~	~~0.146~~	
West North Central	% Poverty	0.106900	0.008086	< 2e-16 ***	0.54
	% Minority	0.007241	0.003350	0.0311 *	
	~~% ≥18 years~~	~~-0.008951~~	~~0.010666~~	~~0.4017~~	
	% Below HS Degree	0.044751	0.006708	5.69e-11 ***	
West South	% Poverty	0.108940	0.010048	< 2e-16 ***	0.3914

Central	% Minority	0.017940	0.003074	1.00e-08 ***	
	~~% ≥18 years~~	~~-0.013365~~	~~0.012597~~	~~0.289~~	
	% Below HS Degree	-0.050796	0.006536	5.01e-14 ***	

4. Results

The results of the linear multiple regression models indicated that at least two of the four independent sociodemographic variables were significant predictors of adult asthma for eight of the nine divisions. The most significant predictor of adult asthma across all divisions was the poverty variable, with statistically significant results in eight of the nine divisions. Both the percent of minority population and percent of population with an educational attainment below a high school degree were significant predictors of adult asthma for five of the region divisions. Lastly, percent of the population above 18 was significant for only one of the region divisions.

Poverty Variable

The percent of population in poverty variable was a significant predictor of adult asthma in the New England, East North Central, South Atlantic, Middle Atlantic, East South Central, Pacific, West North Central, and West South Central divisions. The resulting p-values for each of the eight divisions was the most significant compared to the other independent variables, with all p-values being less than 0.01. The percent of population in poverty variable was not a significant predictor of adult asthma in the Mountain division.

Minority Variable

The percent of minority population variable was a significant predictor of adult asthma in the New England, Middle Atlantic, Pacific, West North Central, and West South Central divisions. All p-values for significant minority predictors were less than 0.01, apart from the West North Central division which had a p-value of less than 0.1.

Educational Attainment Variable

The percent of population with an educational attainment below a high school degree was a significant predictor of adult asthma in the East North Central, South Atlantic, Middle Atlantic, West North Central, and West South Central divisions. The p-values for the educational attainment variable ranged for each of the divisions. The Middle Atlantic had a p-value less than 0.1, while the East North Central and South Atlantic divisions had a p-value less than 0.05. The West North Central and West South Central divisions had the most significant p-values, both below 0.01.

Age Variable

The percent of the population aged ≥18 years was a significant predictor of adult asthma only in the East South Central division. For this region, the age variable indicator had the most significant p-value, below 0.01.

5. Discussion

In this study, correlation tests and multiple linear regression models identified a subset of spatial determinants of adult asthma at the county, division level across the contiguous U.S. using data from 2018-2019. Significant geographic disparities in adult asthma rates were found in divisions with higher percentages of poverty. Educational attainment of less than a high school

degree was also found to be a significant indicator of adult asthma in the majority of divisions. The minority variable was found to be a significant predictor of adult asthma in the majority of divisions; however, the relationship was not positive across the divisions. In three of the five divisions, the minority variable had a negative association with adult asthma.

5.1. Multiple Linear Regression Model Results for each Division

New England Division: The multiple linear regression model for the New England division found that adult asthma was positively associated with poverty and total minority population. Both variables had the highest p-value significance, below 0.01. The R-squared value for this division's model was 0.52.

East North Central Division: In the East North Central division, the multiple linear regression model found that adult asthma was positively associated with poverty and educational attainment below a high school degree. These variables had p-values below 0.01 and 0.05 respectably. The R-squared value for this model was 0.3935.

South Atlantic: The multiple linear regression model for the South Atlantic division found that poverty and educational attainment below a high school degree were positively associated with adult asthma. These variables had p-values below 0.01 and 0.05 respectably. This model had a R-squared value of 0.409.

Mountain: None of the independent variables considered in this study were found to be significant predictors of adult asthma in the Mountain division. This model also resulted in the least significant R-squared value, 0.03117.

Middle Atlantic: In the Middle Atlantic division, the multiple linear regression model found that poverty, total minority population, and educational attainment below a high school degree were associated with adult asthma. Both the educational attainment variable and poverty variable had a positive relationship with adult asthma, with p-values less than 0.1 and 0.01 respectably. Conversely, the minority variable had a negative relationship with adult asthma, with a highly significant p-value less than 0.01.

East South Central: The multiple linear regression model for the East South Central division found that population aged ≥18 years and poverty were positively associated with adult asthma. Both variables had a highly significant p-value less than 0.01. The R-squared value for this division's model was 0.5443.

East South Central: The multiple linear regression model for the East South Central division found that poverty and population aged ≥18 years were positively associated with adult asthma. Both variables had a highly significant p-value less than 0.01. This model also had the highest R-squared value, of 0.6858.

Pacific: In the Pacific division, the poverty and minority variables were found to be associated with adult asthma, with both models having p-values less than 0.01. While

poverty had a positive relationship with asthma, the minority variable had a negative association with asthma. The R-squared value for this model was 0.5276.

West North Central: The multiple linear regression model for the West South Central division found that poverty, minority population, and educational attainment below high school degree were positively associated with adult asthma. Both the poverty and educational attainment variables had p-values less than 0.01, and the minority variable had a p-value of less than 0.1. This model had a R-squared value of 0.54.

West South Central: In the West South Central division, the poverty, minority population, and educational attainment below a high school degree variable were associated with adult asthma. The minority and poverty variables were positively associated with asthma, while the minority variable was negatively associated with asthma. All p-values were highly statistically significant with p-values less than 0.01. The R-squared value for this model was 0.3914.

This study's findings that lower educational attainment and higher rates of poverty are positively associated with adult asthma support the well-documented association between poor health outcomes and poor social conditions in the United States (Social Determinants of Health Equity, Marmot 2014). However, this study also found educational attainment below a high school degree to be negatively associated with adult asthma in one division- West South Central. Notably, the minority population variable was also found to be negatively associated with adult asthma in three divisions- New England, Middle Atlantic, and Pacific. These findings contradict

the association between poor health outcomes and poor social conditions in the U.S. and suggest that sociodemographic variables, such as race and educational attainment, interact differently with health outcomes in different geographies. Because of this, it is imperative that local-level health interventions are driven by local, fine-scale data rather than national findings.

Strengths & Limitations

This study aimed to identify spatial trends in adult asthma rates in the contiguous United States by assessing the relationship between sociodemographic variables and adult asthma rates. We were able to identify statistically significant predictors of asthma in eight of the nine divisions. By conducting the analysis at the county level within each division, this study can provide more insight for public health and policymakers in outreach methods that aim to decrease the burden of adult asthma.

There were several limitations in this study that should be considered when interpreting the results. While sociodemographic variables have been found to contribute more to asthma risk than genetics and individual behavior, these factors are still associated with asthma (AAFA, 2019). This study did not consider any genetic or clinical predictors of adult asthma and should not be used to draw conclusions on physical risk factors associated with adult asthma. The PLACES dataset used for adult asthma rates is subject to systematic errors due to the data design, specifically from noncoverage, nonresponse, and measurement bias. Additionally, the questionnaire for the adult asthma estimates requires a doctor diagnosis, and there is no way to validate this based on responses from participants (PLACES, CDC). Several studies have shown that the continuous nature of American Community Survey data collection and the resulting

sample size affects the validity of the report, specifically for rural areas (Greiman, 2017). Lastly, the county-level poverty estimates sourced from the USDA were calculated using a 90% confidence interval.

6. Conclusion

This study related sociodemographic determinants to spatial variation in adult asthma across the U.S. in the years 2018-2019. In eight of the nine divisions, findings revealed that counties with a greater proportion of impoverished individuals were associated with higher rates of adult asthma. In three of the nine divisions, counties with a greater proportion of minority individuals were associated with lower risks of asthma. Conversely, in two of the nine divisions, counties with a greater percentage of minority individuals were associated with higher risks of asthma. In five of the nine divisions, a greater percentage of the population with an educational attainment below a high school degree was associated with higher rates of asthma. Future research should incorporate additional asthma risk factors, such as genetic and environmental predispositions, in order to more comprehensively examine risk factors associated with adult asthma. Ultimately, results from this study highlight locations where public health interventions can be explored that aim to mitigate the unequal burden of adult asthma.

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Vita

Caitlyn Anne Duncan was born and raised in a small town outside of Charlotte, North Carolina. After graduating from Mooresville High School in Mooresville, North Carolina in June 2017, Caitlyn chose to attend Appalachian State University in Boone, North Carolina.

As an undergraduate student, Caitlyn majored in Community and Regional Planning with a minor in Geography and a certificate in Geographic Information Systems (GIS). During the summer between her sophomore and junior year Caitlyn participated in a research project with Dr. Elizabeth Shay and Appalachian State University's Research Institute for Environment, Energy, and Economics. This opportunity allowed Caitlyn to discover her passion for research, inspiring her to pursue a master's degree in Geography at Appalachian. Caitlyn graduated Summa Cum Laude with a Bachelor of Science in Community and Regional Planning in Spring 2021 and began her full-time graduate education in August 2021. Upon graduating with a Master of Arts in Geography in December 2022, Caitlyn plans to pursue a career in geography with the ultimate goal of obtaining a Ph.D. in the future.