SPATIAL ANALYSIS OF POTENTIALLY PREVENTABLE PNEUMONIA AND ASTHMA HOSPITALIZATIONS FOR CHILDREN IN THE TEXAS COASTAL BEND AREA

A Thesis

by

NA LIN

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This thesis meets the standards for scope and quality of
Texas A&M University-Corpus Christi and is hereby approved.

Yuxia (Lucy) Huang, PhD
Chair

Pamela Meyer, PhD Committee Member	Lei Jin, PhD Committee Member

May 2017

ABSTRACT

Pneumonia and asthma, two common Ambulatory Care Sensitive Conditions (ACSCs), were two top reasons for the admission of children to the hospitals and emergency rooms in the United States in 2011. Pneumonia and asthma are potentially preventable if the child's environment is properly managed. Underlying vulnerabilities such as low socioeconomic status (SES) and proximity to air pollution play an important role in ACSCs hospitalization. Pneumonia and asthma are two common reasons for hospitalizations among children and missed school days in Texas Coastal Bend Area. This thesis examines the relationships between neighborhood socioeconomic characteristics, meteorological conditions and children ACSCs hospitalization, including pneumonia and asthma among children age 0-17 in this area.

Hospital discharge data from 2007 to 2009 based on Zip Code Tabulation Area (ZCTA) were examined along with American Community Survey (ACS) data, air pollution data from Environmental Protection Agency (EPA) and temperature data from National Climatic Data Center (NCDC). Hotspot and Local Moran's I analyses were applied to identify the concentrations of the illnesses. Two regressions (OLS and GWR) were applied to identify factors that contribute the most to ACSCs hospitalization. Pearson's correlation was calculated to examine the relationship between meteorological condition and child hospitalization for asthma and pneumonia. A human subject survey was conducted to examine the relationships between neighborhood environment and children asthma cases.

The main finding was that children from families with health insurance, children from single father families and children from poor families were more likely to visit hospital for ACSCs and pneumonia care. "Hispanic families" and especially "Hispanic families with father

but no mother” also contributed most to child hospitalization for ACSCs and pneumonia, suggesting that family preventative health care education is needed for Hispanic families and particularly Hispanic fathers.

Air pollution and temperature analysis revealed that high concentrations of Ozone and Sulfur Dioxide likely cause pneumonia and asthma hospitalization of children. Combined with dramatic change in temperature, air pollution played an important role in the hospitalization of pneumonia and asthma plagued children in the coastal bend area.

The human subject survey showed that the time children spent outdoors was highly positive correlated with asthma rate.

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CHAPTER I: INTRODUCTION

1.1. BACKGROUND

Pneumonia and asthma, two common Ambulatory Care Sensitive Conditions (ACSCs), contribute substantially to childhood hospitalization. ACSCs are conditions that are preventable and easily treated and would not have required the admission to a hospital had primary care been used (Purdy S. et al., 2009). These conditions include chronic conditions such as asthma and diabetes, and acute conditions such as bacterial pneumonia and urinary infections. Asthma is a disease that narrows the airways our bodies use to carry air to the lungs, causing difficulty in breathing. It is an even more chronic illness among children because they have narrower airways compared to adults and they breathe more air per pound of body weight and spend more time outdoors than adults (Gasana et al., 2012). World Health Organization (WHO) estimates that about 235 million people are suffering from asthma, and the number is increasing (WHO, 2013). Action needs to be taken to control this disease. In the United States, 24,633,000 people have asthma which is 7.8% of the total population, one in every 13 Americans. Among the 24,633,000 patients, 6,188,000 are children which is about 1/4 of the asthma population of the United States (CDC, 2017).

Pneumonia is a lung disease caused by bacterial, viral or fungal infections of the lung. It was the leading cause of death for children in 15 low income countries like China, Pakistan and India where it accounts for 70% of all deaths in children under 5 in 2015 (UNICEF, 2016). Pneumonia accounted for the death of 920,136 children worldwide (WHO, 2016). Newborns with pneumonia could have been saved with vaccines widely available for bacterial pneumonia and more by public health programs to teach parents about the role of household cleanliness in combating bacteria based diseases. In 2011, pneumonia was the most common reason for the admission of children to the hospitals and emergency rooms in the United States (Weiss et al., 2014).

The cost of treatment of pneumonia for children was about 109 million US dollars (WHO, 2016). The Center for Disease Control (CDC) study of the United States discovered that most of these cases were viral pneumonia cases rather than bacterial (Jain et al., 2015). Viral pneumonia is spread by contact with infected people most often in a hospital environment, and bacterial pneumonia is spread by bacteria in a dirty living environment. It is entirely possible that children admitted to the hospitals with a respiratory problem like asthma contracted pneumonia in the hospital and were discharged with a pneumonia treatment plan and prognosis. However, pneumonia is also a preventable disease. Besides antibiotics and adequate nutrition, addressing the environmental factors can also prevent pneumonia in children.

Pneumonia and asthma are similar in some symptoms such as coughing, wheezing, chest pain and shortness of breath which account for the most missed school days. They are also the two most common causes of child hospitalization in the Texas Coastal Bend area. There are approximately 617,000 children with asthma in Texas and there were 25,158 hospitalization discharges due to asthma in Texas in 2012 at the cost was 652.5 million dollars (Texas Department of State Health Services, 2017). Texas has a management plan and a local CDC office that maintains data on the disease and conducts statistical research on that data. In addition, the Texas office tailors its management plans to the specific population. Recently a management plan was implemented in the Rio Grande valley targeting asthma sufferers with information on how to minimize their symptoms and obtain information for managing their condition in real time from the agency's information outlets (CDC, 2017). The CDC and state, city, private and public health agencies long ago determined that the cost of managing asthma is far less than the cost of doing nothing at all. As a result, the CDC has developed asthma management plans in thirty-six states to provide real time information to asthma sufferers so that they can manage their illness in such a way as to reduce the debilitating symptoms of the disease and so decrease the periods of absence from work and school (Hester et al., 2015).

By and large, pneumonia and asthma are managed diseases well into the second phase of pharmacological research in the United States and Texas. Other countries are equally developed as WHO and CDC share their experience freely with similar systems globally (Anagnostou, Brough and Swan, 2016). Research on the causes of asthma and pneumonia is well advanced. In some areas public health institutions and municipal health agencies conduct research, such as that proposed herein, annually as their public actuaries have determined such research to be cost effective. There are no shortages of models, surveys and research designs upon which to base our research. However, there are not many papers studying the associations between childhood ACSCs hospitalization, meteorological condition and socioeconomic measurements. Researchers studied the association of exposure to fine particles and lung function in children who live near two power plants in southern Israel and found out that children living near power plants have decreased pulmonary function (Peled et al., 2005). Another studied deprivation and hospitalization among children and concluded that ACSCs rate is higher in rural, deprived areas (Hale, 2016). Researcher also studied the temperature change and its effect on respiratory system in children and concluded that large temperature change in consecutive days increases the risk of child mortality (Guo et al., 2011). We conducted this study of pneumonia and asthma among children in the coastal bend region of Texas, in the hope that the cities and counties involved or perhaps the state will help themselves to our work and continue to produce such research, and better, systematically as is done by other states.

1.2. POTENTIAL TRIGGERS

Industrialization and technology brought us the great convenience of the ubiquitous labor saving devices as well as air pollution. High density internal combustion motor driven traffic, oil refineries, coal/oil/gas fired electricity generating plants and more pollute the air in ways harmful to human health.

Ambient (outdoor) and indoor pollution are two of the major triggers of chronic respiratory and lung diseases (WHO, 2017). The CDC has long recognized that asthma is caused by home and industrial air pollution, as well as (to a much lesser extent) such well known naturally occurring allergens as flower pollen and molds. Smoke is another major polluting factor that triggers asthma and exacerbates pneumonia. Toxins from tobacco damage the cells and the smoke is absorbed by the lungs which causes lung diseases such as Chronic Obstructive Pulmonary Disease (COPD) and it increases the risk for respiratory infections. Second-hand smoke triggers asthma attacks (CDC, 2014). According to WHO, there are more than 600,000 non-smokers that are exposed to second-hand smoke. Death from smoking or second-hand smoking continues to rise around the world.

Psychosocial stress caused by family violence, low education levels and low household income combined with living in a poor neighborhood make life difficult for young children. Low socio-economic status (SES) may worsen asthma, as such neighborhoods are known to have a higher morbidity rate (Gold and Wright, 2005; Mielck et al., 1996).

1.3. STUDY AREA AND NEEDS FOR THE STUDY

The Texas Coastal Bend area is located along the south Texas coast (Figure 1.1) with a population of approximately 615,390 (Table 1.1). It radiates out from Corpus Christi and includes 15 counties, Aransas, Bee, Brooks, Duval, Goliad, Jim Hogg, Jim Wells, Karnes, Kenedy, Kleberg, Live Oak, McMullen, Nueces, Refugio and San Patricio. Nueces County, is the most populated county with a population of 352,060 which accounts 57.2% of the total coastal bend area population (Table 1.1) and includes refinery row and the Port of Corpus Christi, an export hub for food and south Texas oil and gas. There are multiple oil refineries (Figure 1.1; only major ones are listed) among the 15 counties, most are in Corpus Christi, Nueces County, but there is one large refinery in Three Rivers, Live Oak County and another smaller one in Ingleside, San Patricio County. A large new refinery for producing gasoline is being built in Duval County (Tobben, 2017) and many new petroleum related manufacturers are building factories along Corpus Christi bay near the center of our study (Hunt, 2015).

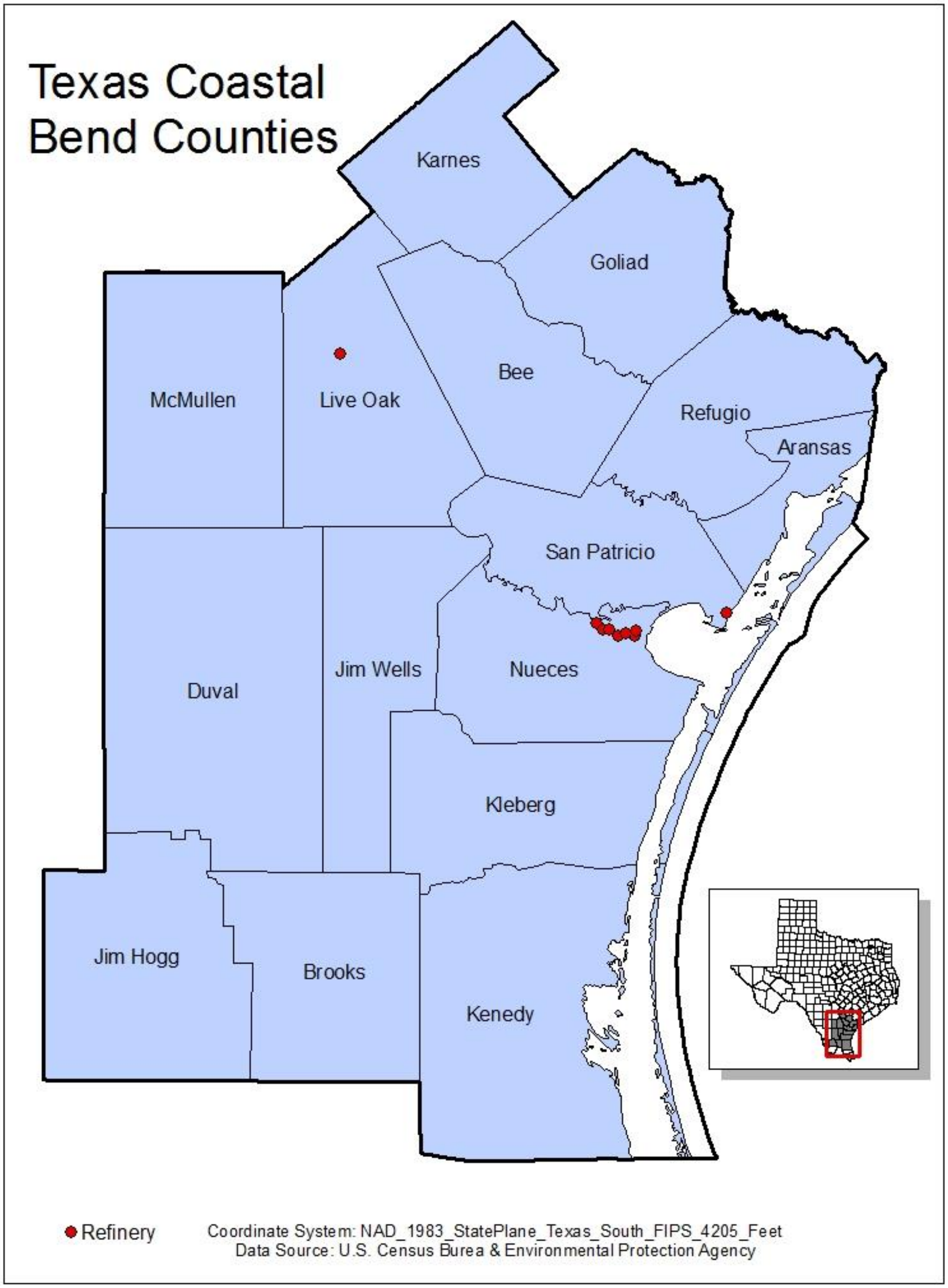


Figure 1.1. Study Area: Texas Coastal Bend Counties and Locations of Major Refineries

Table 1.1. Coastal Bend Counties Population

County	Pop.
Aransas	24,292
Bee	32,659
Brooks	7,221
Duval	11,577
Goliad	7,410
Jim Hogg	5,239
Jim Wells	41,461
Karnes	14,879
Kenedy	565
Kleberg	32,029
Live Oak	11,873
McMullen	778
Nueces	352,060
Refugio	7,277
San Patricio	66,070
Total	615,390

*Data was obtained from U.S. Census Bureau 2015

The Agency for Toxic Substances and Disease Registry (ATSDR), a federal public health agency which has conducted a public health assessment research, has detailed the type of factories that make up "refinery row" in Figure 1.2. The public health assessment research was conducted by ATSDR, CDC and National Center for Environmental Health (NCEH), blood and other samples were collected from residents from the Corpus Christi neighborhoods of Dona Park and Hillcrest which were used to determine if the pollutions from refineries has adverse health effects (birth defect, cancer and asthma etc.) for the residents living in the refinery row area (Figure 1.2) (ATSDR, 2011). The "Refinery Row Area" is defined as the north side of Corpus Christi, Texas (ATSDR, 2016).

Refineries are substantially associated with industries such as plastics production, gas liquefaction and transport, aluminum, iron and steel production and fabricating and a substantial land, sea and air transport industry. There were 33,297,619 motor vehicles in Texas in 2014 according to Texas Department of Motor Vehicles (Table 1.2). In addition to the above, there is a full-fledged, multi-tiered structure of support industries in the Corpus Christi bay and port area. High pneumonia and asthma diagnosis among children in the coastal bend area suggest that oil and gas related pollution from local refineries might be a major factor.

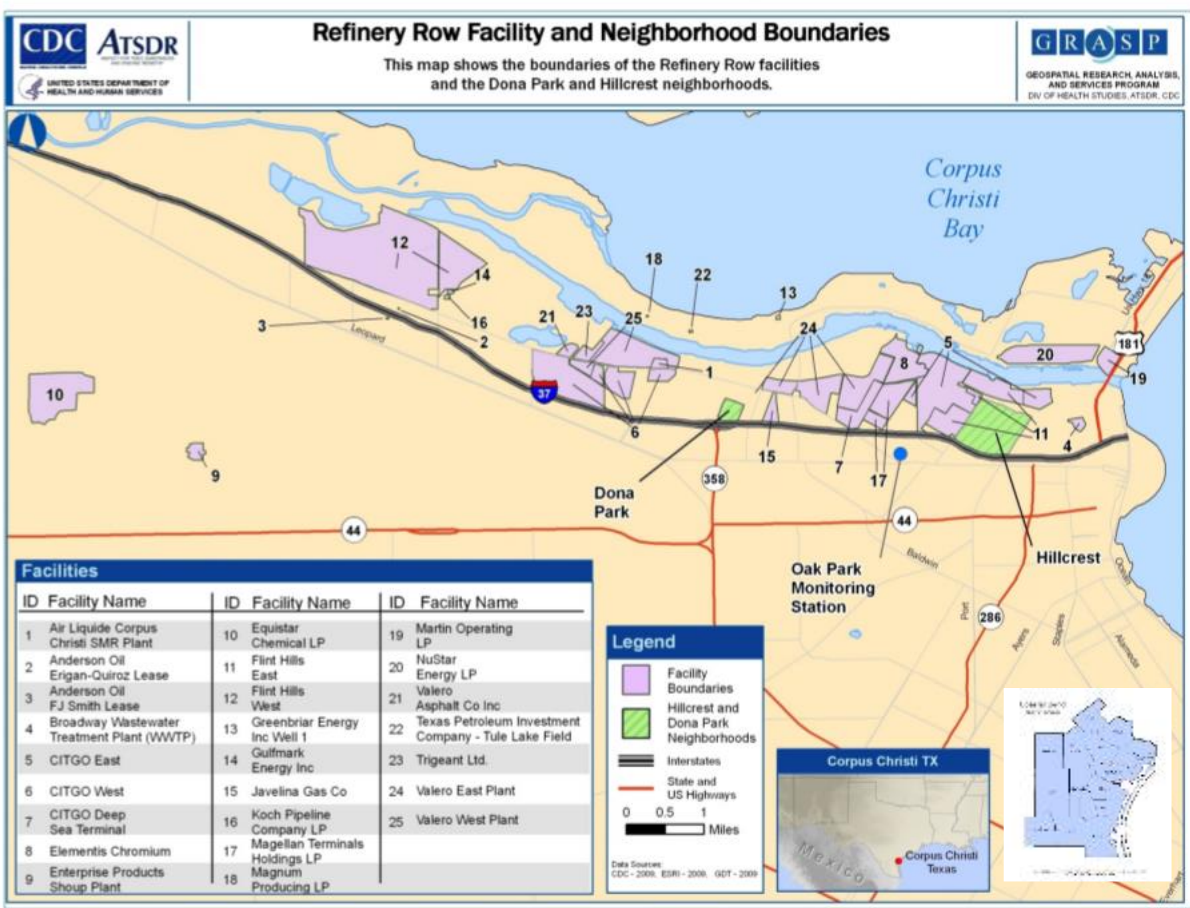


Figure 1.2. Refinery Row Facilities and Neighborhood Boundaries: Credit of ATSDR

Table 1.2. Texas Motor Vehicle Records 2014

Records	Archival Records	Active Records
66,195,537	32,897,918	33,297,619

*Data was obtained from Texas Department of Motor Vehicles 2014

ACSCs have been used as an index to evaluate the quality and quantity of primary care. Plenty of studies report that children from poor families and children without health insurance have limited access to physician care (Halfon, Newacheck, and St. Peter, 1992). ACSCs especially pneumonia and asthma diminish the quality of life for children. Shortness of breath, chest pain, wheezing and coughing make it hard for them to fall asleep which causes fatigue and limits the child's ability to exercise and play. ACSCs including pneumonia and asthma are preventable if the child's living conditions are properly managed. Underlying vulnerabilities such as low socioeconomic status and proximity to air pollution play an important role in children respiratory hospitalization (Cakmak, 2016). Although Texas is gaining its wealth from the natural resources, children in Texas have an average poverty rate of 24% compared to 20% for the United States. Texas coastal bend area has a poverty rate of 28% (Table 1.3) which is above that of both Texas and the USA, as a whole (US. Census Bureau, 2012). Under the circumstances, we conduct this study to examine if there is any relationship between ACSCs, pneumonia, asthma and meteorological and SES measurements.

Table 1.3. United States, Texas and Texas Coastal Bend Area Children Poverty Rate Comparison, 2012

	Total children pop.	Children poverty pop.	Children poverty rate
U.S.	73,979,859	15,188,844	20.53%
Texas	6,849,329	1,678,992	24.51%
Texas Coatal Bend Area	152,186	42,477	27.91%

*Data was obtained from American Community Survey, U.S. Census Bureau, 2012

1.4. PURPOSE, RESEARCH QUESTIONS AND HYPOTHESES OF THE STUDY

The purpose of this study is to (1) visualize the spatial distribution of ACSCs, especially pneumonia and asthma, discharges in the Texas coastal bend area by locating the hot spot and cold spot of the illness, (2) determine if there is a relationship between neighborhood SES conditions and ACSCs, pneumonia and asthma hospital discharges among children age 0-17 in the Texas Coastal Bend Area, (3) determine if there is a relationship between meteorological conditions and ACSCs, pneumonia and asthma hospital discharges among children age 0-17 in the Texas Coastal Bend Area and (4) model and visualize the spatial variations of each exploratory variable. The key questions in the study that need to be answered are listed below.

1. Where are the hot spots for ACSCs, pneumonia and asthma hospital discharge in the coastal bend counties?
2. Are children with low SES more likely to have pneumonia and asthma?
3. Are meteorological conditions associated with childhood pneumonia and asthma?
4. Are neighborhood factors significant to asthma?

The hypotheses of the study are: (1) The hot spot areas of ACSCs, pneumonia and asthma are located around the refinery row, (2) Children with low SES such as low income and no insurance are more likely to have pneumonia and asthma in the study area, (3) Higher concentrations of air pollutants such as Ozone (O_3), Sulfur Dioxide (SO_2) and particle matter (PM) are positively associated with a growing hospital discharge rate of child pneumonia and asthma patients. In addition, dramatic change in temperature also directly influences the child hospital discharge rate and (4) neighborhood factors play a significant role in childhood asthma.

In this thesis, we will identify the hot spot areas of ACSCs, pneumonia and asthma; examine the SES factors and determine if there is any relationship between Low SES such as low income, no insurance and the discharge rate for ACSCs, pneumonia and asthma child patients; examine air pollutants and temperature change to determine if poor meteorological condition plays an important role in the discharge rate of child pneumonia and asthma patients in the Texas coastal bend area; and examine the neighborhood factors from a human subject survey to determine if neighborhood and living condition are significant to asthma in children.

1.5. LIMITATIONS

Child discharge data was obtained from all area hospital systems in the Texas coastal bend area and assembled by zip code. However, their data might not be complete which in turn could mean that the pneumonia and asthma data might not be complete either. Even though the ACSCs were selected with great care, some cases might be missing. Hospital data is on zip code level, individual data is not available. A human subject questionnaire was used to collect data to access the relationships between neighborhood factors and asthma. The sample size may not be large enough to accurately represent the relationships between neighborhood living conditions and childhood asthma.

1.6. ETHICAL CONSIDERATIONS

"Asthma Survey for Adult Parent/Guardian of Children in Nueces County Texas" (Appendix B), was used to collect neighborhood living condition data in person and online. The survey targeted adult Nueces County residents. The purpose of conducting the survey was to collect neighborhood data in support of the study to further understand how neighborhood factors and living conditions may affect the health of the children. The survey focused on those factors mentioned above for asthma since asthmatic data was not analyzed for SES from US census bureau data. The survey was approved by Texas A&M University Corpus Christi Institutional Review Board (HSRP #21-17). Data collected through the questionnaires and the consent form (Appendix A) are and will be kept confidential.

CHAPTER II: LITERATURE REVIEW

2.1. SOCIOECONOMIC FACTORS

Ambulatory Care Sensitive Conditions (ACSCs) are preventable medical problems for properly diagnosed and treated children. Underlying vulnerabilities play an important role in ACSCs hospitalization. The underlying vulnerabilities includes for example, low income, low education, unemployment and lack of health insurance (Hale, Probst, and Robertson, 2016). Researchers found that poor children do not receive routine care (Halfon, Newacheck, and St Peter, 1992). Children with no health insurance are less likely to visit the doctor for acute conditions (Newacheck, Stoddard, and St Peter, 1992). Researchers also point out that lack of primary medical care and a poor quality social and physical urban environment are two major factors that are associated with increased morbidity in urban children who suffer from asthma (Gale et al., 2011). Child emergency room visits in the United States in 2011were primarily the result of pneumonia and its symptoms (Weiss et al., 2014).

Psychosocial stress caused by multiple factors can also trigger asthma. Family violence, low education levels and low household income combined with living in a poor neighborhood result in stressful lives for young children. Low socio-economic status (SES) may worsen asthma (Qian, Ritz, and Wilhelm, 2009). It is also reported that the low SES neighborhood has higher morbidity rate (Gold and Wright, 2005; Mielck et al., 1996). In this thesis, we examine the relationships between social environments and ACSCs and pneumonia. Socioeconomic factors such as household income, parent's education, parent employment, poverty level, children disability and health insurance coverage were all taken into consideration.

2.2. METEOROLOGICAL FACTORS

2.2.1 Air Pollution

According to the World Health Organization (WHO), exposure to indoor air pollution almost doubles the risk of bacteriological pneumonia for children (WHO, 2016). The increased risk for pneumonia and asthma is highly associated with higher exposure levels to nitrogen dioxide (NO_2) and Ozone (O_3) (Vieira et al., 2012). In addition to these two elemental compounds, exposure to high levels of nitrogen oxide (NO), carbon monoxide (CO), sulfur dioxide (SO_2) and associated particulate matter (PM) also increases the risk of asthma (Gasana et al., 2012). Among all the particulate matter, numerous studies have shown that those with aerodynamic diameters less than 2.5 ($PM_{2.5}$) and 10 (PM_{10}) micro-meter are extremely harmful to child pulmonary function and most likely to cause pneumonia and asthma exacerbation (Hwang et al.; Kang et al.; Peled et al.; Qian, Ritz, and Wilhelm, 2009; Urman et al., 2014). These elements and compounds are the components of today's industrial pollution and we shall examine their effect on childhood pneumonia and asthma in this study.

Smoking is known to have many harmful effect for human including second-hand smokers. "Second-hand smoke" contains more than 7,000 chemicals, including hundreds that are toxic and about 70 that can cause cancer" (CDC, 2017). According to WHO, there are more than 600,000 non-smokers that are exposed to second-hand smoke. Death from smoking or second-hand smoking will rise to more than 8 million by 2030 (CDC, 2017). We looked at indoor pollution such as smoking and other common indoor pollutants in analyzing both childhood pneumonia and asthma in the coastal bend area of Texas through a human subject survey.

2.2.2 Temperature Variation

Climate is changing, the temperature gap is getting larger and larger and it is also getting more and more unstable. Super hailstorm pounded Dallas in May (NIASM, 2014) while November snow storms precipitated seventy inches of snow in Buffalo as climate change driven extreme storms become more common (Holthaus, 2014).

Multiple studies have revealed that daily temperature variation is associated with hospital visits for childhood pneumonia and asthma. Both too low and too high temperatures have been reported to be associated with increased pneumonia incidences. Study has indicated that large diurnal temperature range (DTR) and temperature change between two neighboring days (TCN) can have an adverse impact on mortality and affect the human respiratory system especially among children (Guo et al., 2011; Kan et al., 2007; Lin et al., 2013; Xu et al., 2013). Dramatic changes in temperature also raise stress on the respiratory system (Song et al., 2008). Children are less capable of regulating body temperature because their bodies are not as well developed as adults and so they are more vulnerable to extreme temperature variation both hot to cold and cold to hot (Xu et al., 2014). All these studies indicate that sharp temperature change causes increased child hospitalization for pneumonia and asthma.

2.3 NEIGHBORHOOD AND LIVING ENVIRONMENT FACTORS

There are many studies that show people from deprived neighborhoods have poorer health than those from affluent areas (Diez Roux, 2001; Pickett and Pearl, 2001; Yen and Syme, 1999). Most likely a poorer neighborhood is a more polluted area and a poor neighborhood also has lower education, lower income, fewer children covered with health insurance and a higher crime rate. One study found that parents who perceive a neighborhood to be safe have lower rate of asthma (Camacho-Rivera et al., 2014). Poor neighborhoods were found to be positively related to higher asthma hospitalization rates. However, some studies found no association between asthma and neighborhood characteristics or family income (Liu, Riner and Saha, 2005). In this study, we conducted a human subject survey to discover the relationships between asthma and neighborhood and living environment factors, if there is any. Besides neighborhood conditions, diet such as consumption of fresh fruit, vegetable can protect children from asthma while lack of exercise increases the chance of asthma attack (Camargo et al., 2007; Lucas and Platts-Mills, 2005).

CHAPTER III: METHODOLOGY

3.1. DATA AND DATA SOURCE

3.1.1 Child Hospitalization Data and Selection of ACSCs

Hospital ACSCs, pneumonia and asthma discharge data for the period of September 1, 2007 to August 31, 2009 was obtained from all area hospital systems in the Texas Coastal Bend area, including Corpus Christi Medical Center, Driscoll Children's Hospital and Christus Spohn Hospital. The data includes home zip code, patient's home county, discharge data, patient's age, patient's gender, principal diagnosis code, principal diagnosis description, etc. The data was aggregated by Zip Code Tabulation Area (ZCTA) based on the data availability.

The potential preventable conditions and their corresponding ICD-9 codes are listed in Table 3.1 (AHRQ, 2017). These conditions are divided into "chronic" and "acute". Chronic conditions include asthma, epileptic convulsions, cellulitis, diabetes, iron deficiency anemia, failure to thrive, congestive heart failure, chronic obstructive pulmonary disease and hypertension. Acute conditions include angina, gastroenteritis, dehydration, hypoglycemia, bacterial pneumonia, immunization related and preventable conditions, kidney/urinary infection, severe ear, nose and throat infections.

3.1.2 Boundary Data

County boundary and the ZCTA boundary data are acquired from United States Census Bureau TIGER/Line Shape files.

Table 3.1. List of Ambulatory Care Sensitive Conditions (ACSCs) for Children

Condition	ICD-9CM Code(s)
All conditions	(Primary disgnosis)
Chronic conditions	
Asthma	493 (493.*)
Grand mal and other epileptic convulsions	345, 780.3
Cellulitis	681, 682,683, 686
Diabetes	250.1, 250.2, 250.3, 250.8, 250.9, 250.0
Iron deficiency anemia	280.1, 280.8, 280.9
Failure to thrive	783.4
Congestive heart failure	428, 402.01, 402.11, 402.91, 518.4
Chronic obstructive pulmonary disease	491, 492, 494, 496, 466.0 [466.0] only with secondary diagnosis of 491, 492, 494, and 496
Hypertension	401.0, 401.9, 402.00, 402.10, 402.9
Acute conditions	
Angina	411.1, 411.8, 413
Gastroenteritis, Dehydration, Hypoglycemia	558.9, 276.5, 251.2
Bacterial pneumonia	481, 482.2, 482.3, 482.9, 483, 485, 486
Immunization-related and preventable conditions	033, 037, 045, 320.0, 390, 391
Kidney/urinary infections	590, 599.0, 599.9
Severe ear, nose and throat infections	382, 462, 463, 465, 472.1

*Data was obtained from Agency for Healthcare Research and Quality (AHRQ https://archive.ahrq.gov/data/safetynet/billappb.htm)

3.1.3 Socioeconomic Status Data

Neighborhood socioeconomic data at the zip code level from "2012 ACS 5-year estimates" dataset was obtained from American Community Study (ACS) by US Census Bureau with "5-Digit ZIP Code Tabulation Areas fully within/partially within Texas" selected. A total of twelve tables (Table 3.2) that are related to the socioeconomic factors (children population, poverty, health insurance, disability and parent employment) were downloaded for the State of

Texas on ZCTA level and then further narrowed down to coastal bend counties. Among all the tables, table “population under 18 years by age” is used to normalize ill children population in each ZCTA to prevent bias. The method of normalization is provided in section 3.2.2.

3.1.4 Air Pollutant Data

Air Pollutant data was obtained from The United States Environmental Protection Agency (EPA, 2017) from September 1, 2007 to August 31, 2012. The pollutants include ozone (O_3) in parts per million (ppm), particle matter with aerodynamic diameters less than 2.5 micrometer ($PM_{2.5}$) in micrograms per cubic meter (ug/m^3), particle matter with aerodynamic diameters less than 10 micrometer (PM_{10}) micrograms per cubic meter (ug/m^3), and sulfur dioxide (SO_2) in parts per billion (ppb).

3.1.5 Temperature Data

The 15 Texas Coastal Bend Counties are located in both the South Central Division (Division 7) and the Southern Division (Division 9). Monthly temperature data for both divisions from September 1, 2007 to August 31, 2012 was obtained from National Climatic Data Center (NCDC, 2017) through National Oceanic and Atmospheric Administration (NOAA). Two categories of temperature data are available from the dataset obtained from NCDC. One category has monthly average temperature and the other provides both minimum and maximum temperature for each month.

Table 3.2. Socioeconomic Categories from U.S. Census Bureau, American Community Survey (ACS)

Table Name	Description
Number of Disabilities	Age by number of disabilities
Grandparents living with own grandchildren under 18 years in households	Grandparents living with own grandchildren under 18 years by responsibility for own grandchildren by presence of parent of grandchildren and age of grandparent
Health Insurance Coverage	Health insurance coverage status by sex by age
Health Insurance Coverage (Hispanic)	Health insurance coverage status by age (Hispanic or Latino)
Parent Employment	Age of own children under 18 years in families and subfamilies by living arrangements by employment status of parents
Poverty by Family Type	Poverty status in the past 12 months of families by family type by presence of related children under 18 years by age of related children
Poverty by Family Type (Hispanic)	Poverty status in the past 12 months of families by family type by presence of related children under 18 years by age of related children (Hispanic or Latino)
Poverty Status	Poverty status in the past 12 months by sex by age
Poverty Status (Hispanic)	Poverty status in the past 12 months by sex by age (Hispanic or Latino)
Population under 18 years	Population under 18 years by age
Sex by Age (Hispanic)	Sex by age (Hispanic or Latino)
SSI and other government help	Receipt of supplemental security income (SSI), cash public assistance income, or food stamps/SNAP in the past 12 months by household type for children under 18 years in households

3.1.6 Neighborhood and Living Environment Data

Neighborhood and living environment data was collected through a human subject questionnaire called “Asthma Survey for Adult Parent/Guardian of Children in Nueces County Texas” which is approved by the Texas A&M Institutional Review Board (IRB). Public parks with playgrounds are the main survey locations which were randomly picked in south, north, west and east side of Corpus Christi, Nueces County. The procedure of data collecting follows the IRB protocol. Researchers visited the the public parks in Corpus Christi. Researchers explained to the potential participants about the study and asked if they were willing to participate in the survey. If the potential participants agreed, they were asked about their age and whether they were Nueces County residents or not. If they were 18 years or older and were residents of Nueces County, an informed consent form was handed to them. The participants were assured that the information will be kept confidential and they can withdraw the survey at any time. Participants were also encouraged to ask any questions when they read the consent form. After they read, signed and returned the consent form, a questionnaire in paper form was given to them to complete and a copy of the information part of the consent form was offered to them for their files. The consent form can be found in appendix A and the questionnaire in appendix B.

3.2. SPATIAL ANALYSIS

3.2.1 Spatial Patterns of ACSCs, Pneumonia and Asthma

Getis-Ord Gi*, also known as Hotspot Analysis, was used to identify the hot spots of ACSCs, pneumonia, and asthma rate which was calculated in section 3.2.2 and was used as inputs for hotspot analysis. This method shows a set of weighted features, identifies statistically significant hot spots and cold spots but not outliers. A high positive z-score and small p-value indicates a spatial clustering of high values. A low negative z-score and small p-value indicates spatial clustering of low values. The higher/lower the z-score, the more intense the clustering. A z-score of zero indicates the clustering is not significant (ArcGIS Pro, 2017). This method generates a 90%, 95% and 99% confidence interval of both hot spot and cold spot.

Anselin Local Moran's I, is also known as Cluster and Outlier Analysis, was then used to identify the outliers and further identify the clusters of the above-mentioned illnesses. It identifies clusters of weighted features and the spatial outliers from the data. This method calculated the local Moran's I value, a z-score and p-value. With a statistically significant z-score and p-value, a positive I value indicates that a feature has a neighbor with similar values. For example, a cluster of high/low values. A negative I value indicates that a feature is surrounded by dissimilar values (low value is surrounded with high value, vice versa). This is considered to be an outlier (ArcGIS Pro, 2017). Local Moran' I and Hotspot Analysis were performed in ArcGIS 10.4.1.

3.2.2 Associations between Socioeconomic Status and ACSCs, Pneumonia, and Asthma

The relationships between neighborhood socioeconomic characteristics and ACSCs, pneumonia, and asthma hospitalizations among children were examined through regression analysis. Patient and socioeconomic data were first normalized to prevent bias.

The dependent variable, ACSCs in each ZCTA, was normalized by using the formula below:

$$Percentage\ of\ ACSCs\ children\ population\ =$$

$$\frac{ACSCs\ children\ population}{total\ children\ population} * 1000$$

where the total children population was obtained from section 3.1.3. Since the percentage was very small, the equation was times 1000 instead of 100. Two other dependent variables, pneumonia and asthma were normalized in the same manner as ACSCs.

The exploratory factors namely socioeconomic factors were normalized by using similar formula:

$$Percentage\ of\ each\ socioeconomic\ factor\ per\ zip\ code =$$

$$\frac{each\ socioeconomic\ factor}{total\ children\ population} * 100$$

A logarithm transformation was then applied to explanatory factors to detect marginal changes in the explanatory variables in terms of percentage changes in the dependent variable. There are 110 ZCTAs with a total of 10,146 ACSCs cases, a total of 2,360 pneumonia cases, and a total of 1,945 asthma cases in the coastal bend counties. After combining this with exploratory variables, there were 105 ZCTAs left. ZCTAs that did not have any ACSCs and 4 outliers were also excluded which further narrowed down the sample size. Thus, a total of 84 ZCTAs (10,101 ACSCs cases, 2,344 pneumonia cases, and 1,940 asthma cases) were used for final analysis.

A Pearson's correlation coefficient analysis was performed to examine the relationships between ACSCs/pneumonia and socioeconomic variables. Asthma was excluded because of the clustered spatial residual pattern which is explained section 4.2.3. Since low SES is consistently related to poor health outcomes (Eisner et al., 2011), correlation coefficient (r) of 0.2 or above was chosen to be the threshold, so as to include more socioeconomic variables. Selected exploratory variables that have high correlation coefficient of 0.2 or above were then used as input of exploratory regression which provides all possible combinations of exploratory variables.

The chosen combination of exploratory variables was then used in Ordinary Least Square (OLS) regression analysis and Geographically Weighted Regression (GWR). OLS is a global linear regression to estimate the dependent variable in terms of explanatory variables. It helps to find the best combination of explanatory variables for the dependent variable. There are six statistical checks we should examine in looking at the OLS result: 1) Check model performance. Adjusted r^2 tells how much the explanatory variables explain the dependent variable. 2) Check each explanatory variable in the model. The variable is statistically significant if there is an asterisk (*) next to it. Coefficient and its sign for each explanatory variable reflects the strength and type of relationship between each of explanatory variables and the dependent variable. The Variable Inflation Factor (VIF) of each explanatory variable should also be observed. VIF is the factor that indicates the presence of redundant variables in the model. If the VIF is above 7.5, variables should be removed one at a time until there is no redundancy; 3) Check the model significance. If Koenker statistics is not significant, Joint F-Statistics should be consulted. If the Koenker statistics is significant, Joint Wald Statistics should be consulted to determine the significance of the model; 4) Check the stationarity. If the Koenker statistics is significant, there is a nonstationary relationship in the model. When this is the case, robust probabilities should be used to access the statistical significance of explanatory variables; 5) Check if the model is biased. If the Jarque – Bera statistics is significant that means the residuals are not normally distributed and that the model is biased; 6) Check residual spatial autocorrelation. A spatial autocorrelation should be conducted to make sure the residuals are not clustered. Statistically significant clustering of residuals indicates that the key variable is missing and the OLS results cannot be trusted when the model is misspecified (ArcMap, 2016).

After finding an appropriate model, GWR, a local regression model was performed to improve OLS. A statistically significant Koenker statistics means that there may be non-stationarity in the model. GWR should be performed to improve OLS and model spatial variations of each exploratory variable. Residuals from the resulting model were examined by using Spatial Autocorrelation tool in ArcGIS which measures spatial autocorrelation based on feature locations and attribute values using the Global Moran's I statistic (ArcGIS Pro, 2017) to make sure the chosen model is reliable. Spatial autocorrelation is a spatial statistics tool that uses Global Moran's I statistics to measures spatial autocorrelation according to feature locations and values simultaneously. It evaluates whether the pattern of a selected feature is clustered, random or dispersed. The report returns Moran's I index, expected index, variance, z-score and p-value (ArcMap, 2016). For this tool, the null hypothesis is that the feature being analyzed is randomly distributed throughout the study area. A significant z-score and p-value with a positive Moran's I index indicates that the pattern of a selected feature is clustered while a negative Moran's I index indicates a tendency towards dispersion. When a p-value is not significant, the null hypothesis cannot be rejected which means that the features are independent. A random distribution of residuals from OLS indicates an unbiased and reliable model. OLS, GWR and Global Moran's I statistic were also performed in ArcGIS 10.4.1.

3.3 AIR POLLUTION AND THE HOSPITALIZATION

Hospitalization data was aggregated by month based on the data availability. Monthly average air pollutant data was calculated from September 1,2007 to August 31, 2012. Pearson's correlation was then calculated to determine if there is any relationship between air pollution and child hospitalization for pneumonia and asthma. $PM_{2.5}$ and PM_{10} have negative relationship with pneumonia and asthma hospitalization. Monthly differences of $PM_{2.5}$ and PM_{10} were calculated to catch any missing information and further determine if there is an association between the number of hospitalizations and the increased amount of $PM_{2.5}$ and PM_{10}.

3.4 CHANGE IN TEMPERATURE AND HOSPITALIZATION

As mentioned in section 3.1.5, there were two categories of temperature data: monthly average and minimum and maximum temperature for each month. Temperature change was calculated in two ways (from month to month and within each month) to determine whether there is consistent significant effect of temperature change on children hospitalization,

(1) Monthly temperature change from month to month: the difference of average temperature of current month and the average temperature of previous month

(2) Temperature change within a month: the difference of maximum and minimum temperature of each month

Pearson's correlation was then calculated to see if pneumonia and asthma hospitalizations are associated with temperature change from month to month and temperature change within each month.

3.5 NEIGHBORHOOD AND LIVING ENVIRONMENT

A human subject questionnaire "Asthma Survey for Adult Parent/Guardian of Children in Nueces County Texas" both online and in person was used to collect data about children's neighborhood and living environment. Variables that describe participants' neighborhood and living environment such as participants' length of residency in Nueces County, race, family income, education level, neighborhood air quality, smoking status, pet in the house or not, use of gas to cook at home and asthma management class participation were examined. Variables that specifically relate to children and asthmatic children such as outdoor activity time, diet, health insurance, age when the child was diagnosed as asthmatic and the gender of the asthmatic child were examined as well.

A Pearson's correlation was calculated to determine if there are relationships between asthma and factors such as age, outdoor play time, diet, race, income, education, smoking status, indoor pets, and neighborhood safety.

CHAPTER IV: RESULTS AND DISCUSSION

4.1. ACSCs, PNEUMONIA AND ASTHMA DISTRIBUTION

4.1.1 General Distribution

There is a total of 10,101 cases of ACSCs between 2007 and 2009, among which the number of asthma cases is 1,940 and pneumonia is 2,344. Pneumonia and asthma account for 42.4% of all ACSCs hospitalizations in the Texas Coastal Bend Area (Table 4.1). Among all the children in the study area, south Duval, north Kenedy, west Nueces, southwest Goliad and a very small area of north Bee counties have the largest percent of ACSCs (Figure 4.1). Northern Brooks, southern Jim Wells and Kleberg, northern and central San Patricio, and south Live Oak counties have the second largest of ACSCs percentage. The dispersion expands to northern Jim Wells, southwest and northeast Refugio County, and northern part of the study area (McMullen, Karnes and Goliad) which have the fewest percent of ACSCs.

South Duval, and a small part of San Patricio County have the largest pneumonia percentage while northern Jim Wells, southwest and northeast Refugio, and the northern part of the study area (McMullen, Live Oak, Karnes, most of Goliad) has the lowest percentage (Figure 4.2). Result shows that asthma has a small percentage which ranges from 0% - 3.47% (Figure 4.3). Asthma is most concentrated in Nueces and San Patricio counties while the counties that are adjacent to Nueces and San Patricio have the second largest percentage of asthma, including Live Oak, Bee and central Refugio counties (Figure 4.3). The north part of the study area (McMullen, Karnes and Goliad) again has the smallest percentage of asthma.

Table 4.1. Number of Asthma and Pneumonia Cases among All Ambulatory Care Sensitive Conditions (ACSCs) Children and Total Number of ACSCs in the Study Area

TotalACSCs	10,101
Conditions	**Number (percent)**
Asthma	1,940 (19.2%)
Pneumonia	2,344 (23.2%)
Total	4,284 (42.4%)

*Note: other ACSCs conditions are not shown here.

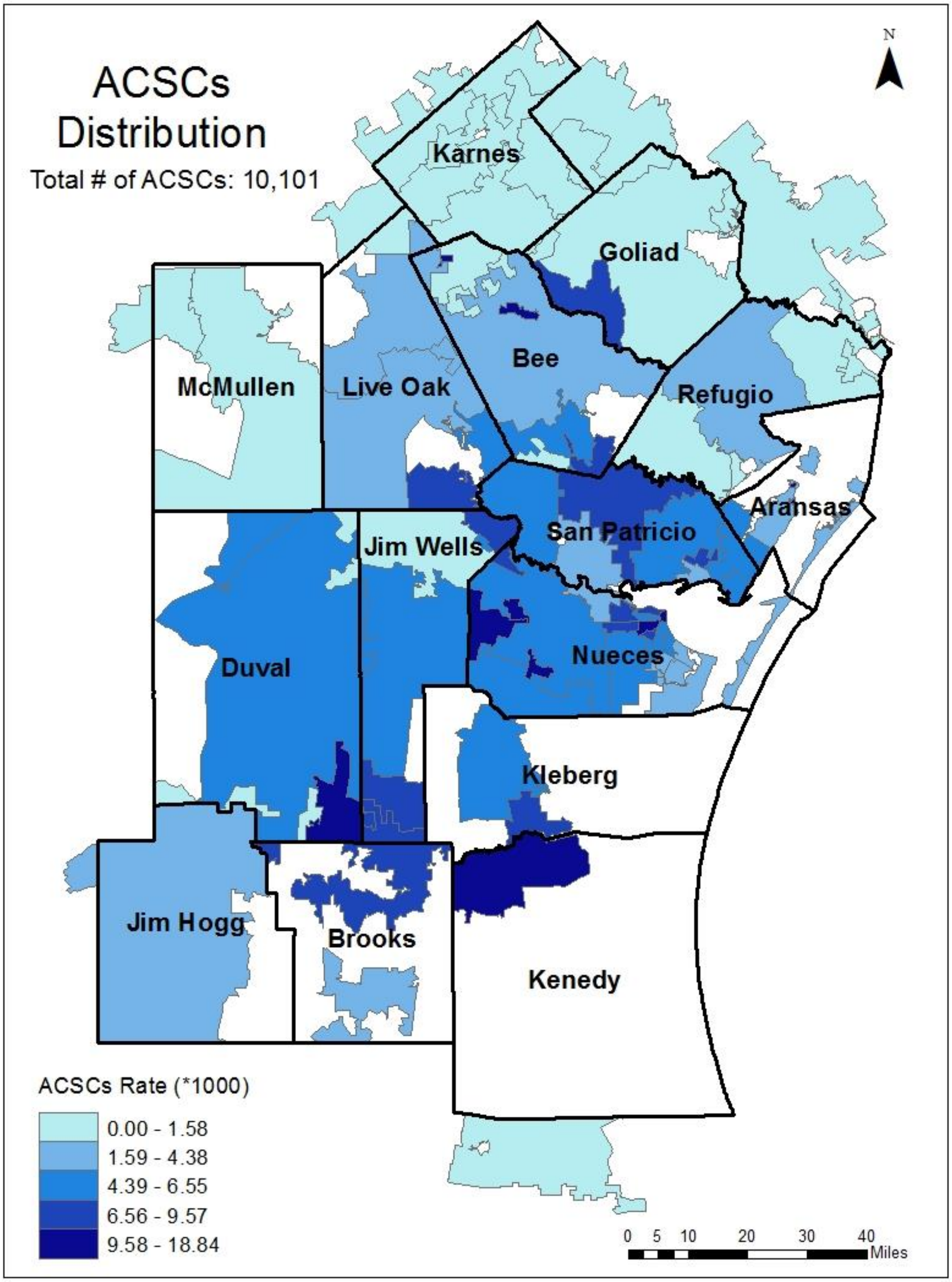


Figure 4.1. Distribution of Ambulatory Care Sensitive Conditions (ACSCs) Rate Among All Children in Texas Coastal Bend Area

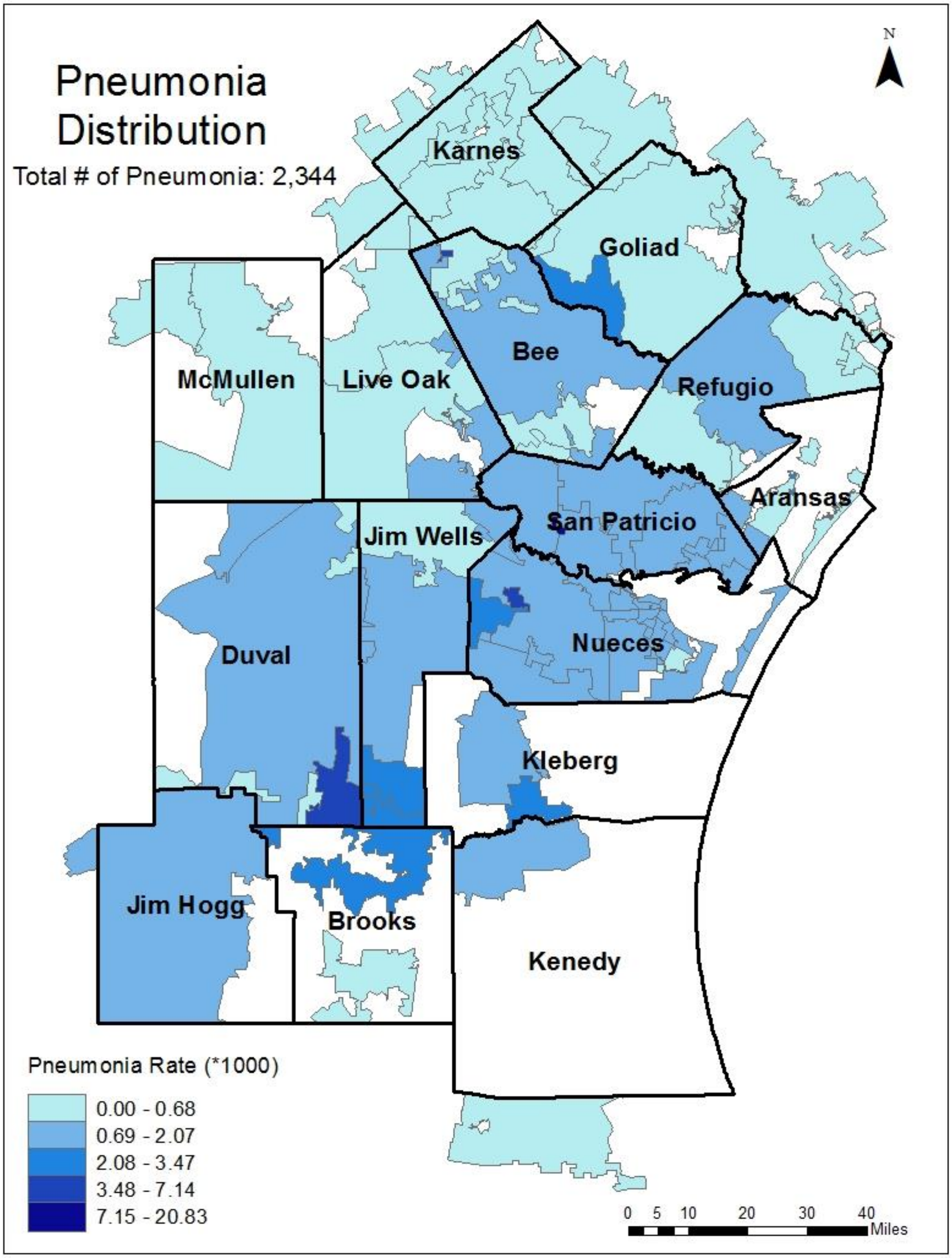


Figure 4.2. Distribution of Pneumonia Rate Among All Children in Texas Coastal Bend Area

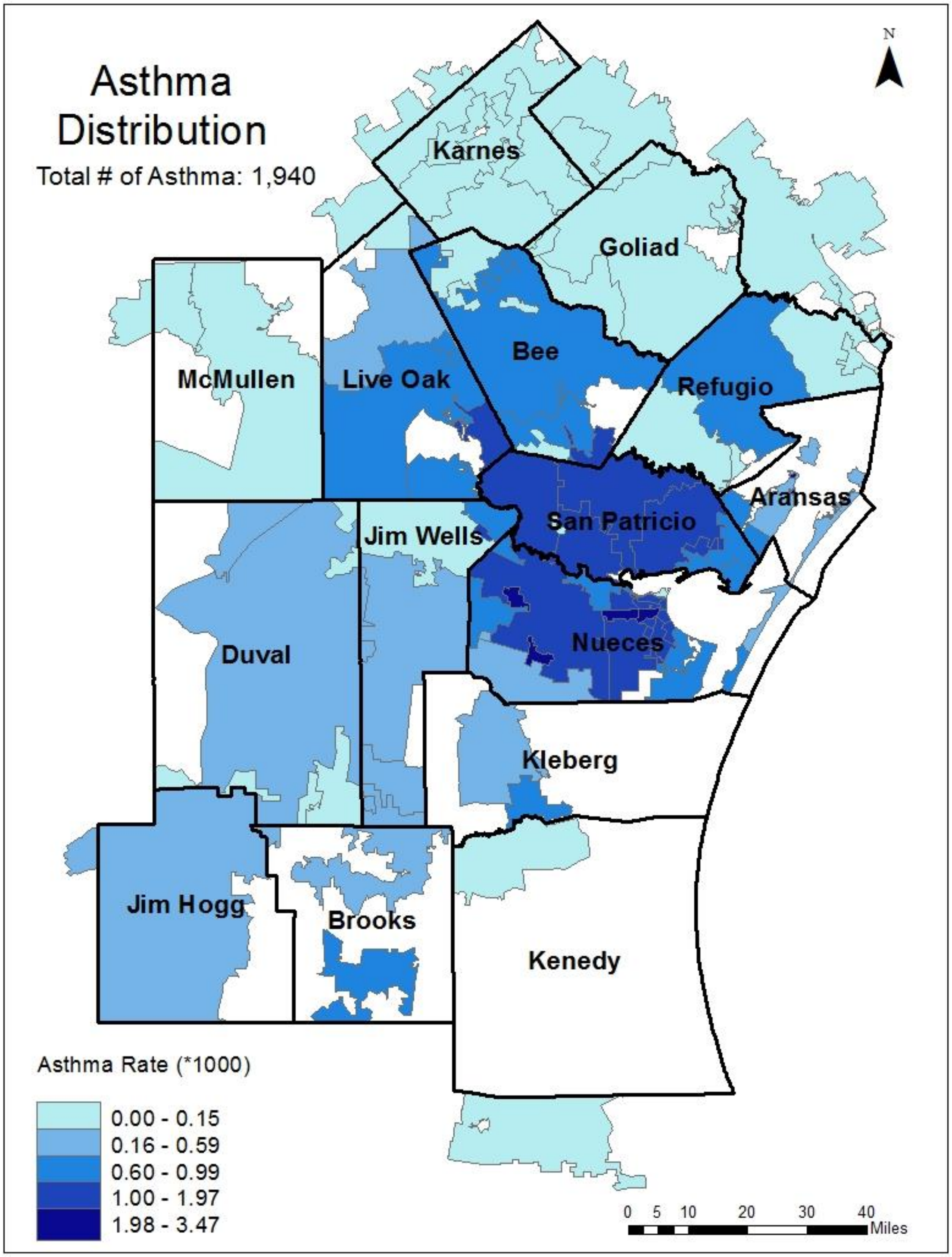


Figure 4.3. Distribution of Asthma Rate among All Children in Texas Coastal Bend Area

4.1.2 Hotspot Analysis

ACSCs and pneumonia have very similar hotspots in the study area from Hotspot Analysis. They both have concentration in Nueces and San Patricio and small areas in the neighboring counties but the concentration is not intense. For ACSCs, the relatively more intense concentration is located in a small part of west Kleberg, southwest and southeast Nueces, and a very small part of Aransas county. Most of Nueces and San Patricio, southwest Live Oak, southern Bee and small area of Aransas county do not have as intense clustering (Figure 4.4). Pneumonia also has relatively more intense concentration in southwest and southeast Nueces county. The neighboring counties such as majority of Nueces and San Patricio, a small area of northeast Jim Wells, southern Live Oak and southern Bee county do not have as intense clustering (Figure 4.5). As for cold spots, there is no cold spot for ACSCs but there is a pneumonia cold spot in Goliad County.

Asthma is quite different from ACSCs and pneumonia. It has intense hot spots in Nueces and San Patricio counties and the intense concentration expands to surrounding counties such as part of Kleberg, the northeast tip of Jim Wells, southeast Live Oak, southern Bee, the southwest of Refugio and large parts of Aransas. Northern Jim Wells also has hot spots of asthma but not as intense as those counties mentioned above. As for cold spots, the intense clusters are all of Karnes and Goliad, expanding to northeast Bee and the tip of northern Live Oak county. Most of northern Live Oak, Bee, Duval, Jim Hogg and Brooks county do not have as intense a cold spot (Figure 4.6).

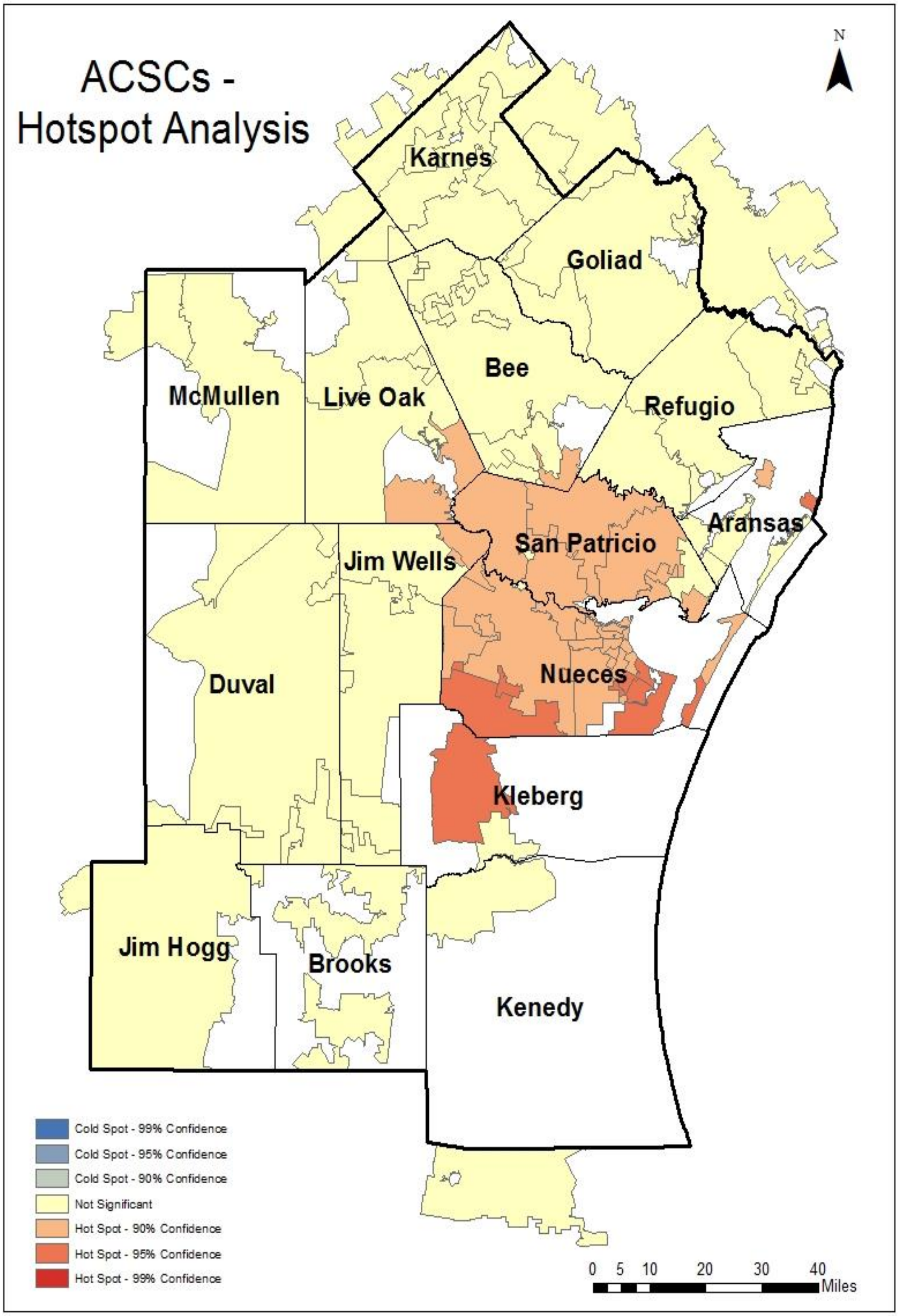


Figure 4.4. Ambulatory Care Sensitive Conditions (ACSCs) Hot Spots and Cold Spots

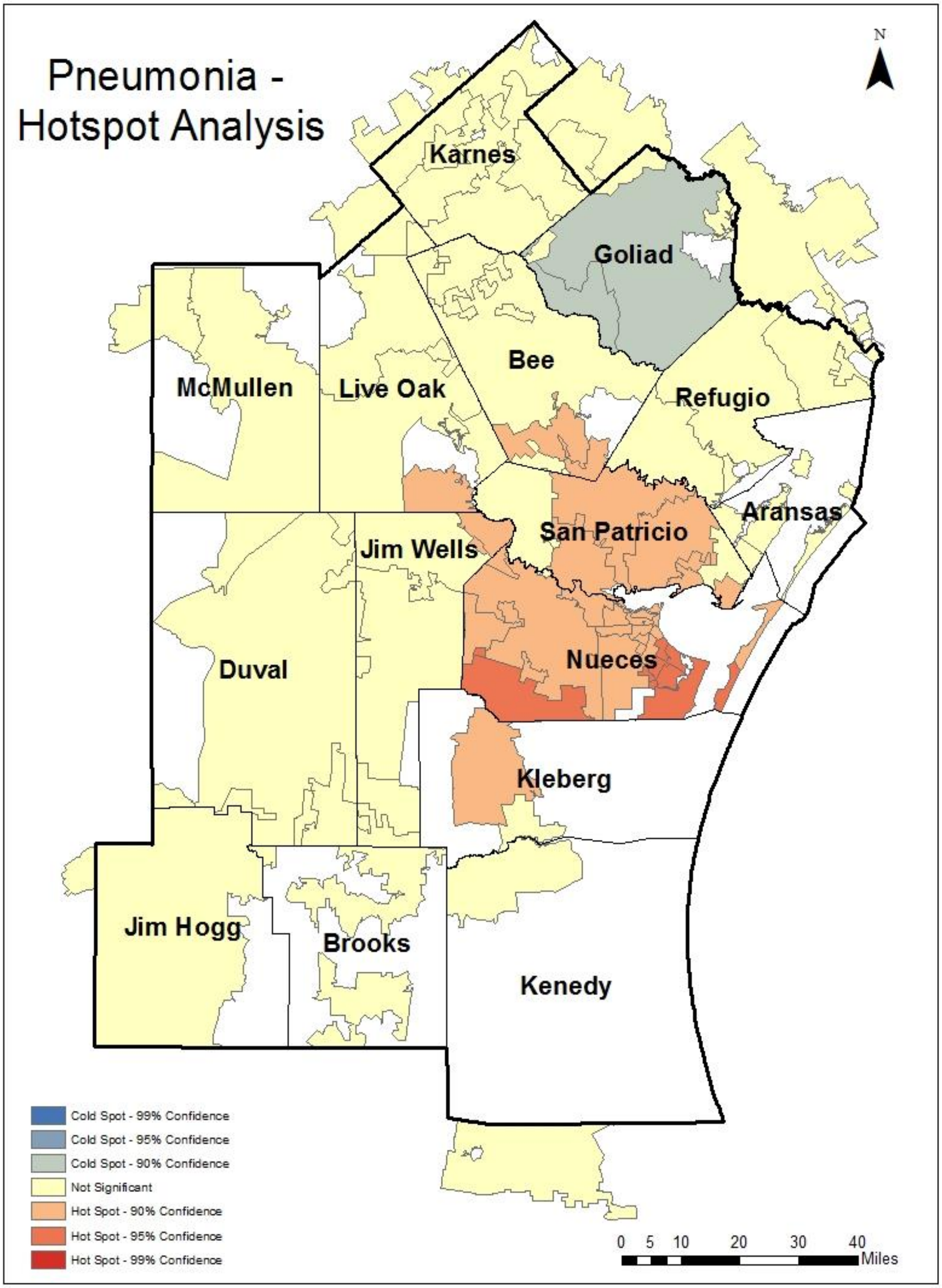


Figure 4.5. Pneumonia Hot Spots and Cold Spots

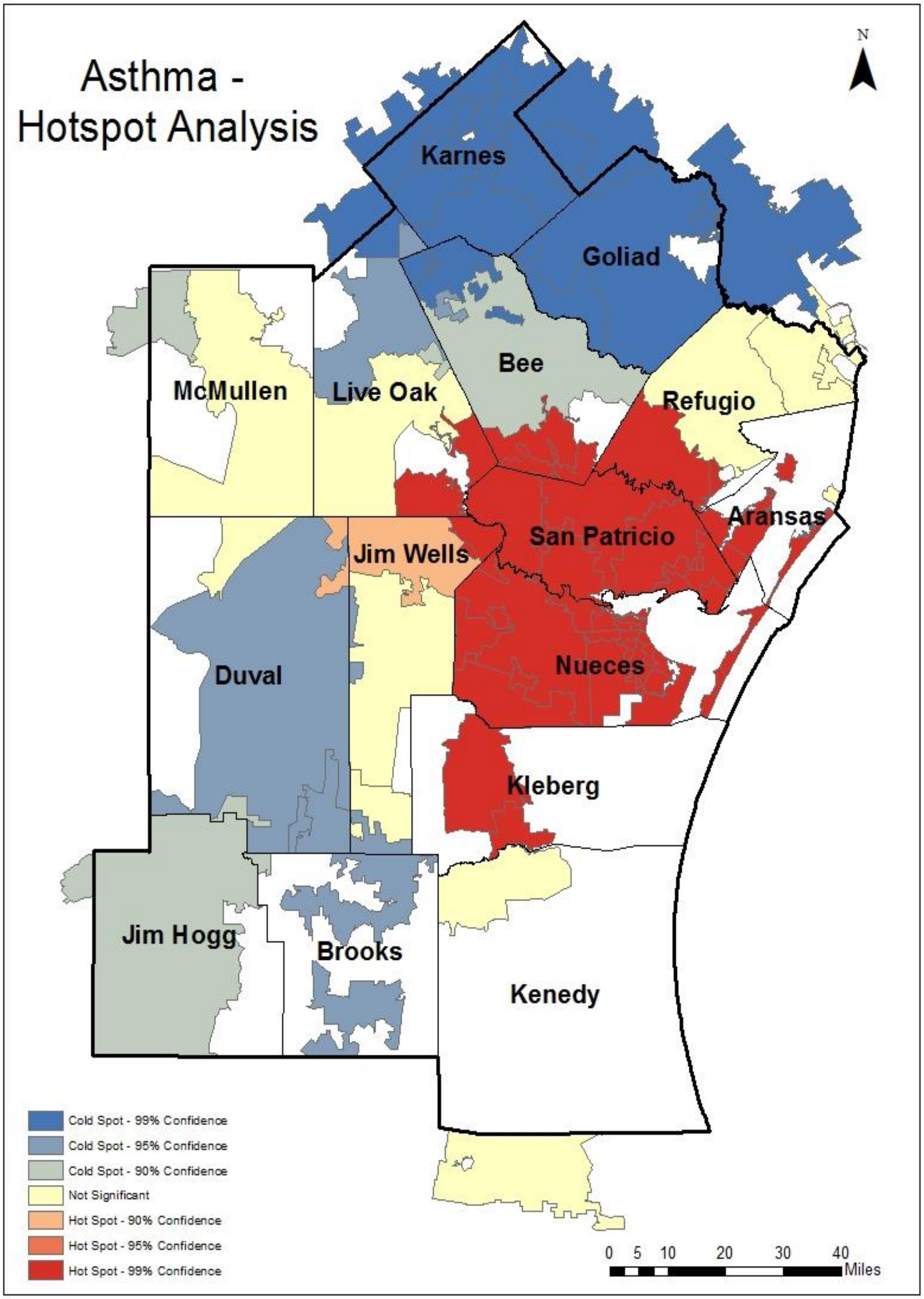


Figure 4.6. Asthma Hot Spots and Cold Spots

4.1.3 Anselin Local Moran's I (Cluster and Outlier Analysis)

The result from Anselin Local Moran's I shows that there is neither cluster nor outlier of ACSCs (Figure 4.7). The situation for pneumonia is the same except a very small area has high pneumonia prevalence next to low pneumonia prevalence in northwest Bee County (Figure 4.8). The case for asthmatic children is quite different. Clusters are in most of Nueces, and San Patricio counties and the cluster expands to a small region in southern Bee county. Two northern counties Karnes and Goliad have the most dispersion (Figure 4.9). As of outliers, southwest Refugio County has exceptionally low asthma prevalence next to high prevalence neighborhoods.

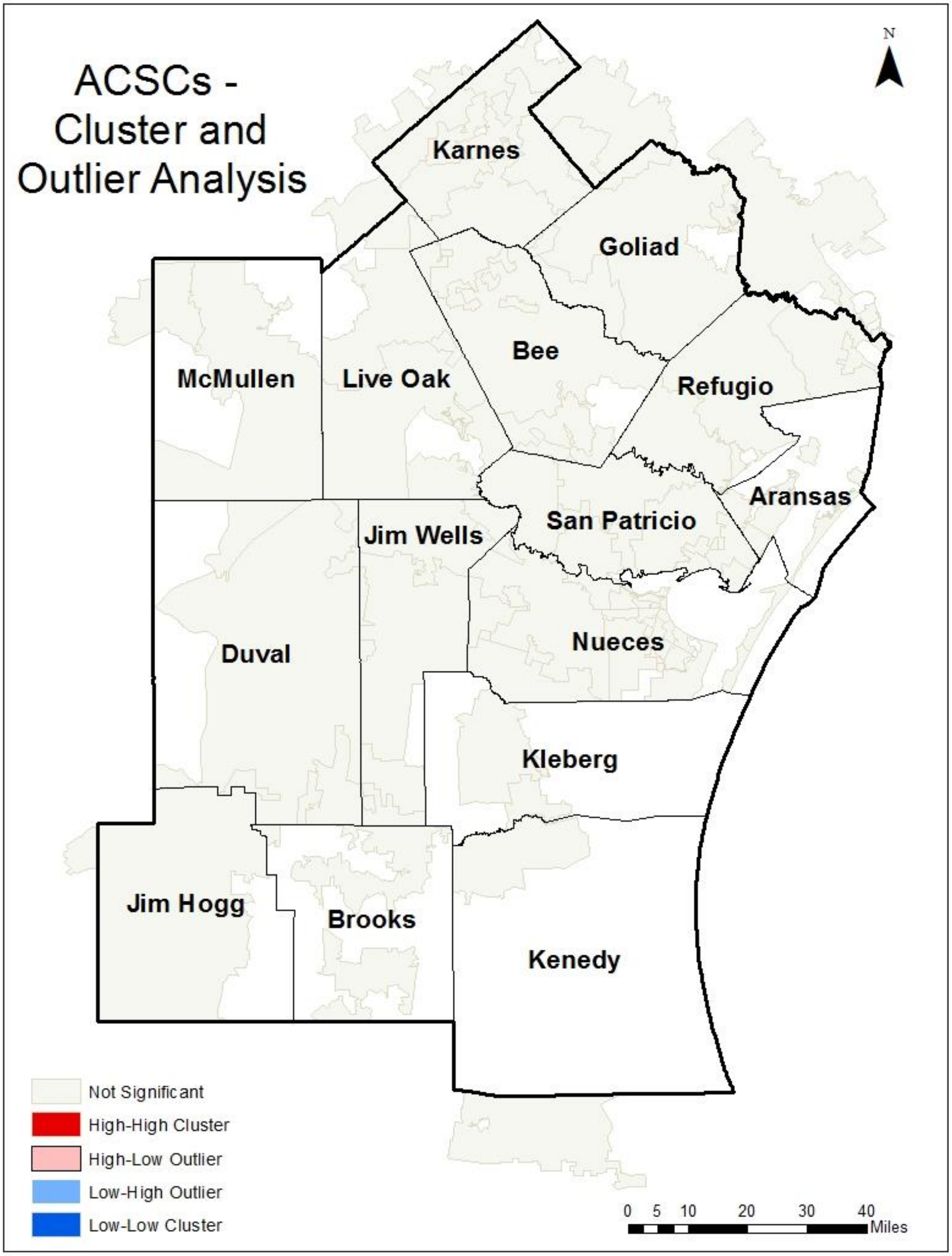


Figure 4.7. Ambulatory Care Sensitive Conditions (ACSCs) Cluster and Outlier

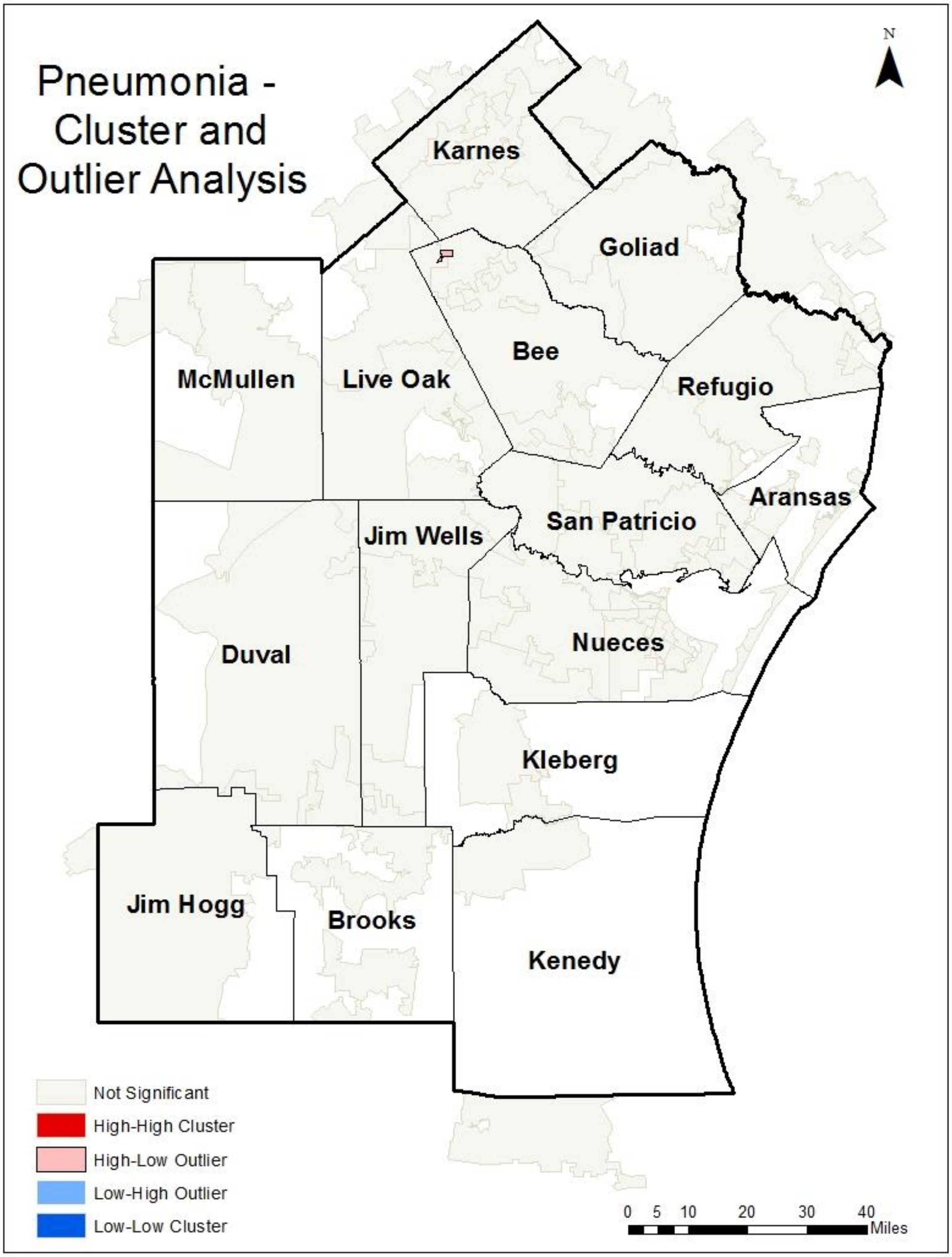


Figure 4.8. Pneumonia Cluster and Outlier

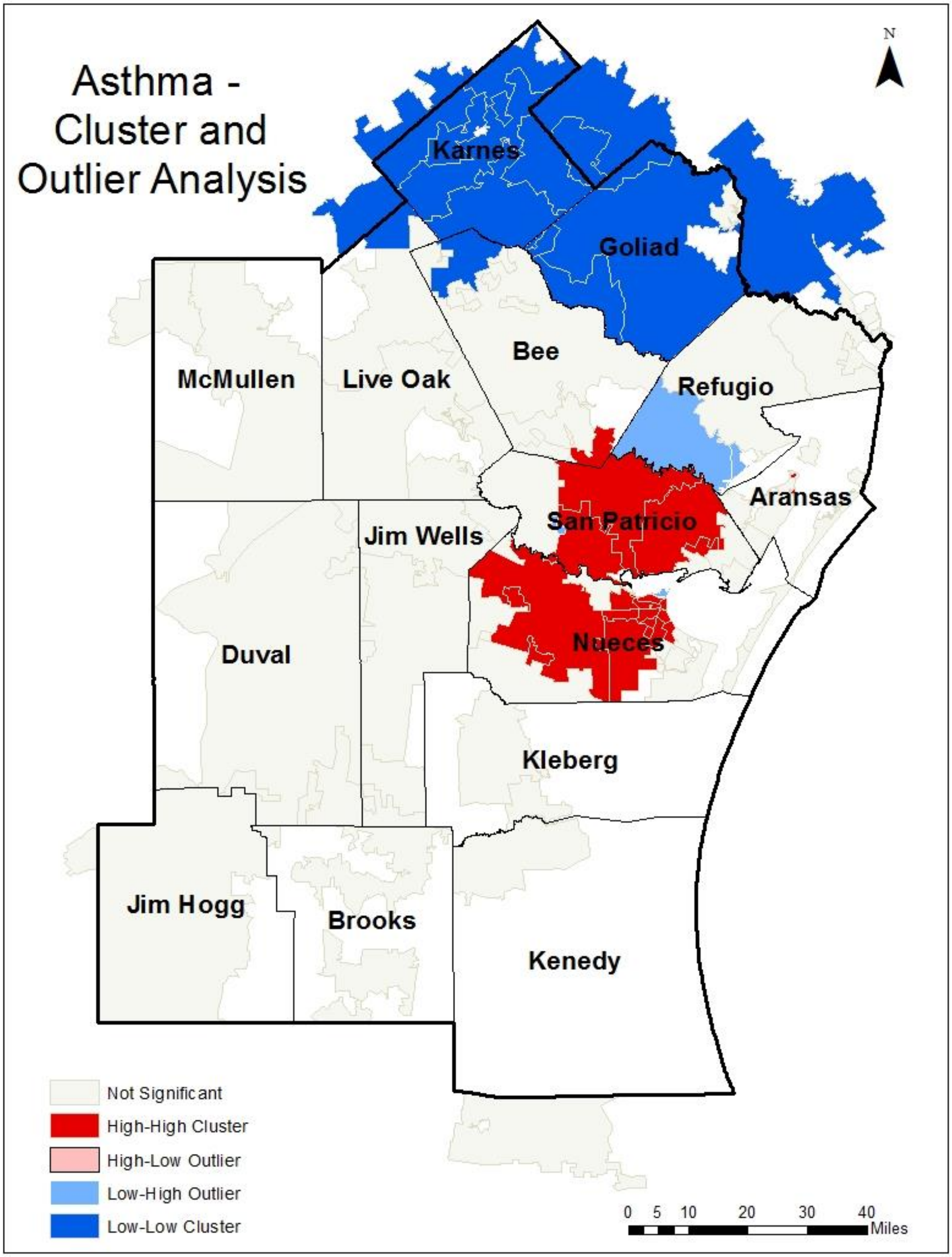


Figure 4.9. Asthma Cluster and Outlier

4.2. ASSOCIATIONS BETWEEN SOCIOECONOMIC STATUS AND ACSCs, PNEUMONIA AND ASTHMA

4.2.1 Selected Socioeconomic Variables and Exploratory Models

Eleven socioeconomic variables that have correlation coefficient of 0.2 or above were chosen (Table 4.2) as inputs for exploratory regression because they represent key variables that are potentially significant in explaining the number of ACSCs, pneumonia and asthma. Table 4.3 shows top 5 combinations of exploratory variables from exploratory regression. The model with the lowest corrected Akaike Information Criterion (AICc) and highest adjusted r^2 was chosen. It is the first combination: *insurHIS + noWifeHIS + noSSI,* and it's used for further OLS and GWR regression analysis.

Table 4.2. Exploratory Variables (x_i) and Their Correlations to Dependent Variables (y_i)

log(xi) / yi	total HIS	male HIS	female HIS	FW	insurHIS	married BP	noWife AP	married BP_HIS	noWife AP_HIS	SSI	noSSI
ACSCs	0.3	0.23	0.31	0.37	0.35	0.3	0.33	0.35	0.42	0.37	-0.38
Pneumonia	0.33	0.31	0.27	0.51	0.38	0.23	0.46	0.28	0.51	0.27	-0.25

*totalHIS: total Hispanic children population
*maleHIS: male Hispanic children population
*femaleHIS: female Hispanic children population
*FW: children living with father who has a job
*insurHIS: insured Hispanic children
*marriedBP: married couple family with related children income below poverty level
*noWifeAP: male householder with no wife present income above poverty level
* marriedBP_HIS: Hispanic married couple family with related children income below poverty
* noWifeAP_HIS: Hispanic family male householder with no wife present income above poverty
*SSI: household with Supplemental Security Income (SSI), cash public assistance income, or Food Stamps/SNAP
*noSSI: household without Supplemental Security Income (SSI), cash public assistance income, or Food Stamps/SNAP

Table 4.3. Top Five Exploratory Models from Exploratory Regression Results

OID	Field1	RunID	AdjR2	AICc	JB	K_BP	MaxVIF	SA	NumVars	X1	X2	X3
50	0	51	0.337846	803.153662	0.091602	0.732643	1.129618	0.027235	3	ACSC09$.LOG_INSURHIS	ACSC09$.LOG_NOWIFEAP_HIS	ACSC09$.LOG_NOSSI
49	0	50	0.326144	804.625157	0.078696	0.849228	1.142657	0.040401	3	ACSC09$.LOG_INSURHIS	ACSC09$.LOG_NOWIFEAP_HIS	ACSC09$.LOG_SSI
46	0	47	0.316227	805.852291	0.000645	0.093103	1.013417	-1.797693e+308	3	ACSC09$.LOG_INSURHIS	ACSC09$.LOG_MARRIEDBP	ACSC09$.LOG_NOWIFEAP_HIS
35	0	36	0.305694	805.916979	0.075991	0.820802	1.000032	0.000258	2	ACSC09$.LOG_NOWIFEAP_HIS	ACSC09$.LOG_NOSSI	
48	0	49	0.313644	806.169097	0.035281	0.722942	1.12896	-1.797693e+308	3	ACSC09$.LOG_INSURHIS	ACSC09$.LOG_NOWIFEAP	ACSC09$.LOG_NOSSI

4.2.2 Regression Analysis Results for ACSCs

As mentioned in the Methodology chapter two regression methods were used in this study, OLS and GWR. Table 4.4 shows the results from OLS regression for ACSCs and its explanatory variables. The Variance Inflation Factor (VIF) values are all less than 7.5 which means there is no multilinearity problem with the model. The r^2 is 0.34 which means the model explains about 34% of the variability, AICc is 803. Jarque-Bera statics is not significant, suggesting that the residuals are normally distributed and the model can be trusted. This is also confirmed by the bell shape or normal curve from Figure 4.11 and the randomly distributed scatterplot from Figure 4.12. Spatial autocorrelation report (Figure 4.13) also confirms that the residuals are randomly distributed with a z-score of 1.32 and p-value of 0.19. Koenker statistic is not significant. Three variables that are most significant to the discharge rate of children treated for ACSCs in Texas Coastal Bend area: (1) insurHIS: Hispanic children with health insurance coverage, (2) noWifeAP_HIS: families with a father householder who is Hispanic with no wife present income above poverty level and (3) noSSI: the income in the past 12 months is at or above poverty level and children living in household with no Supplemental Security Income (SSI), cash public assistance income, or Food Stamps/SNAP.

Table 4.4. Ambulatory Care Sensitive Conditions (ACSCs): Summary of Ordinary Least Square (OLS) Results

Summary of OLS Results - Model Variables

Variable	Coefficient [a]	StdError	t-Statistic	Probability [b]	Robust_SE	Robust_t	Robust_Pr [b]	VIF [c]
Intercept	57.952057	19.856389	2.918560	0.004566*	28.018005	2.068386	0.041832*	--------
1.CSV.INSURH	131.157591	59.052514	2.221033	0.029172*	75.214483	1.743781	0.085043	1.129618
1.CSV.NWIFEA	815.094558	182.931225	4.455743	0.000029*	221.683034	3.676847	0.000431*	1.009749
1.CSV.NOSSI	-197.530901	59.039878	-3.345720	0.001257*	79.347151	-2.489452	0.014863*	1.120322

OLS Diagnostics

Input Features:	zcta	Dependent Variable:	1.CSV.R_ACSC_07_09
Number of Observations:	84	Akaike's Information Criterion (AICc) [d]:	803.153662
Multiple R-Squared [d]:	0.361779	Adjusted R-Squared [d]:	0.337846
Joint F-Statistic [e]:	15.116131	Prob(>F), (3,80) degrees of freedom:	0.000000*
Joint Wald Statistic [e]:	38.516303	Prob(>chi-squared), (3) degrees of freedom:	0.000000*
Koenker (BP) Statistic [f]:	1.285233	Prob(>chi-squared), (3) degrees of freedom:	0.732643
Jarque-Bera Statistic [g]:	4.780615	Prob(>chi-squared), (2) degrees of freedom:	0.091602

Notes on Interpretation

* An asterisk next to a number indicates a statistically significant p-value (p < 0.01).

[a] Coefficient: Represents the strength and type of relationship between each explanatory variable and the dependent variable.

[b] Probability and Robust Probability (Robust_Pr): Asterisk (*) indicates a coefficient is statistically significant (p < 0.01); if the Koenker (BP) Statistic [f] is statistically significant, use the Robust Probability column (Robust_Pr) to determine coefficient significance.

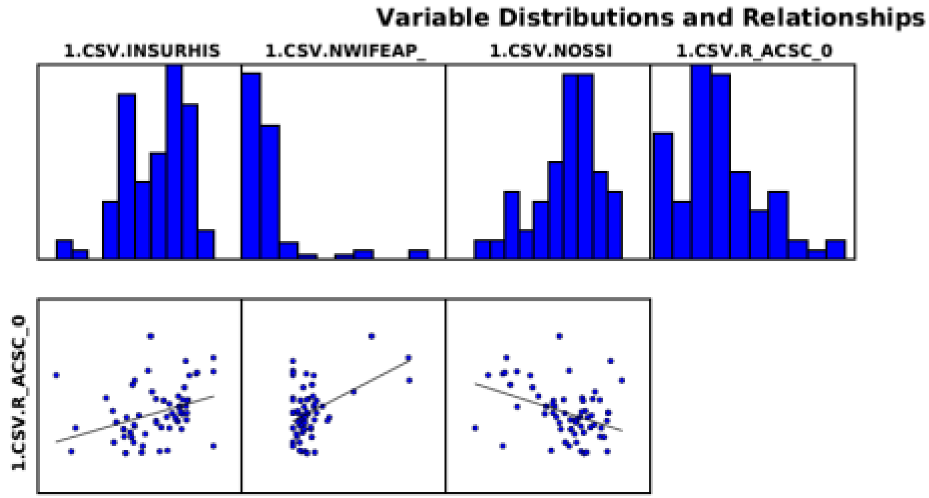
[c] Variance Inflation Factor (VIF): Large Variance Inflation Factor (VIF) values (> 7.5) indicate redundancy among explanatory variables.

[d] R-Squared and Akaike's Information Criterion (AICc): Measures of model fit/performance.

[e] Joint F and Wald Statistics: Asterisk (*) indicates overall model significance (p < 0.01); if the Koenker (BP) Statistic [f] is statistically significant, use the Wald Statistic to determine overall model significance.

[f] Koenker (BP) Statistic: When this test is statistically significant (p < 0.01), the relationships modeled are not consistent (either due to non-stationarity or heteroskedasticity). You should rely on the Robust Probabilities (Robust_Pr) to determine coefficient significance and on the Wald Statistic to determine overall model significance.

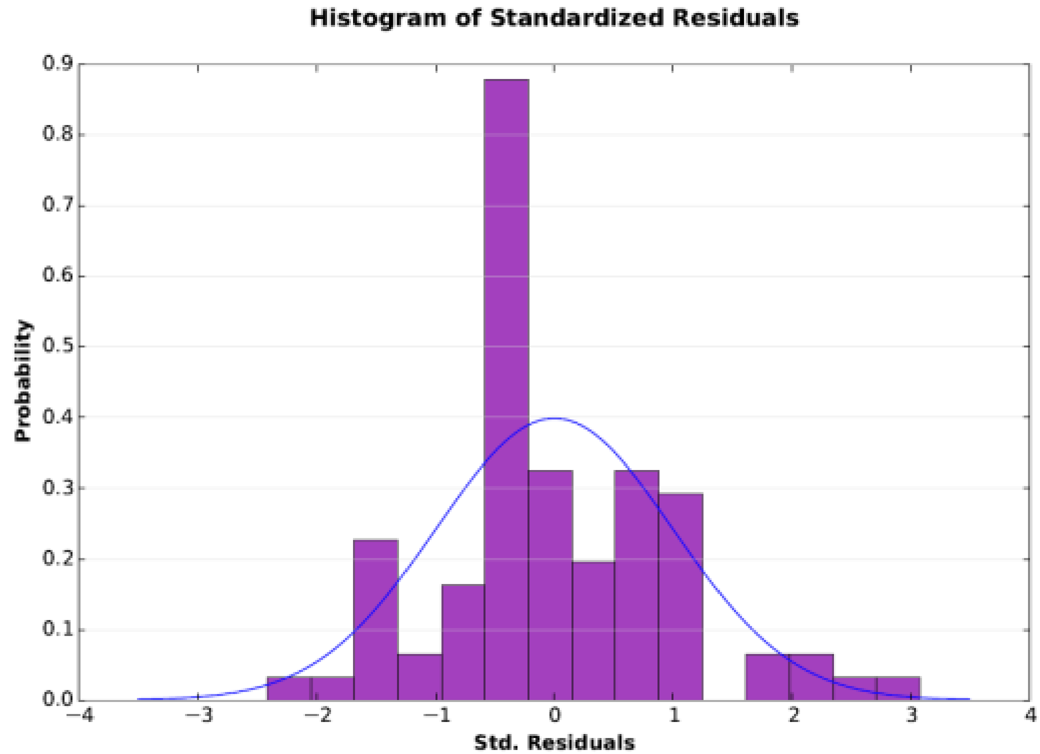
[g] Jarque-Bera Statistic: When this test is statistically significant (p < 0.01) model predictions are biased (the residuals are not normally distributed).



The above graphs are Histograms and Scatterplots for each explanatory variable and the dependent variable. The histograms show how each variable is distributed. OLS does not require variables to be normally distributed. However, if you are having trouble finding a properly-specified model, you can try transforming strongly skewed variables to see if you get a better result.

Each scatterplot depicts the relationship between an explanatory variable and the dependent variable. Strong relationships appear as diagonals and the direction of the slant indicates if the relationship is positive or negative. Try transforming your variables if you detect any non-linear relationships. For more information see the Regression Analysis Basics documentation.

Figure 4.10. Ambulatory Care Sensitive Conditions (ACSCs): Variable Distributions and Relationships



Ideally the histogram of your residuals would match the normal curve, indicated above in blue. If the histogram looks very different from the normal curve, you may have a biased model. If this bias is significant it will also be represented by a statistically significant Jarque-Bera p-value (*).

Figure 4.11. Ambulatory Care Sensitive Conditions (ACSCs): Histogram of Standardized Residuals

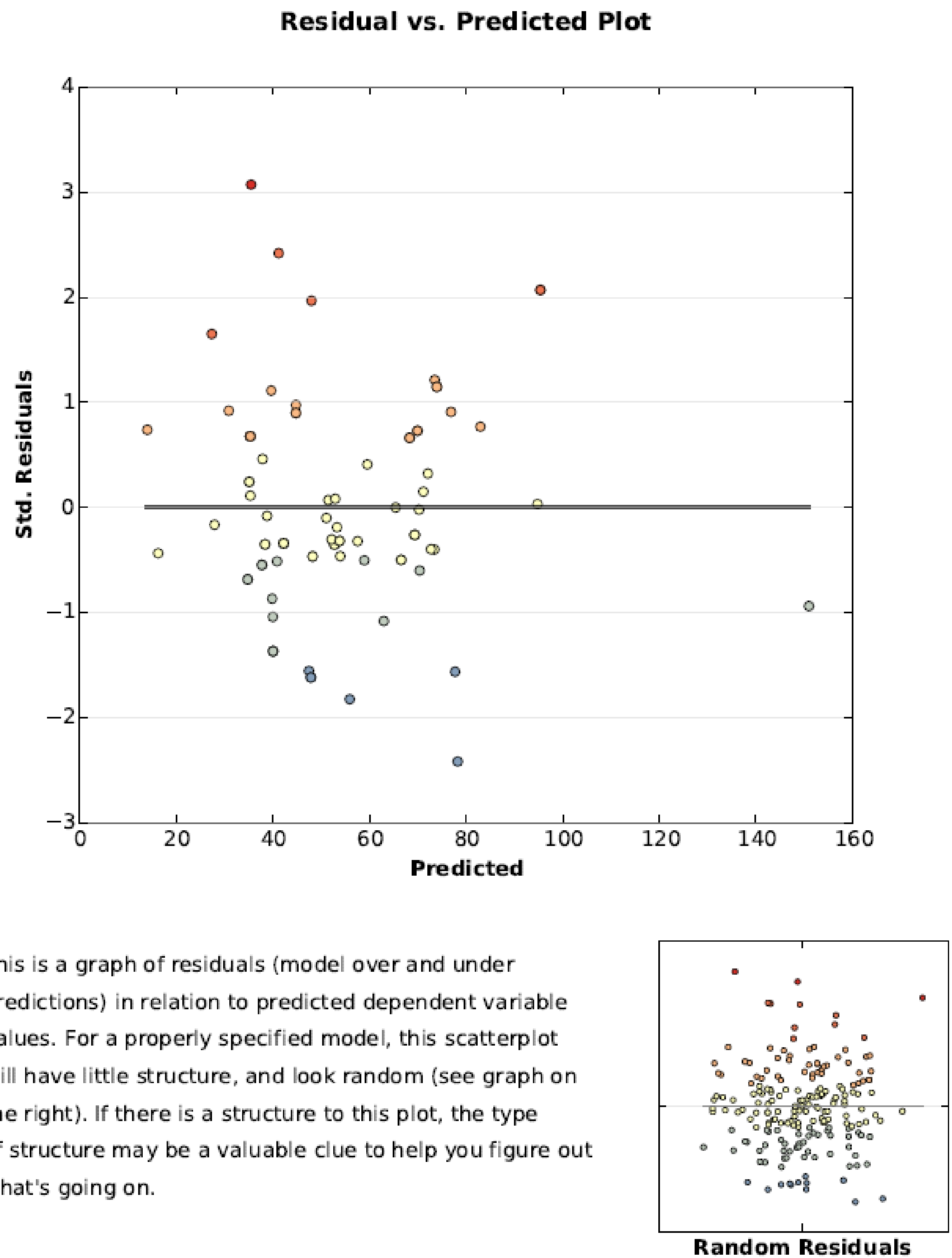
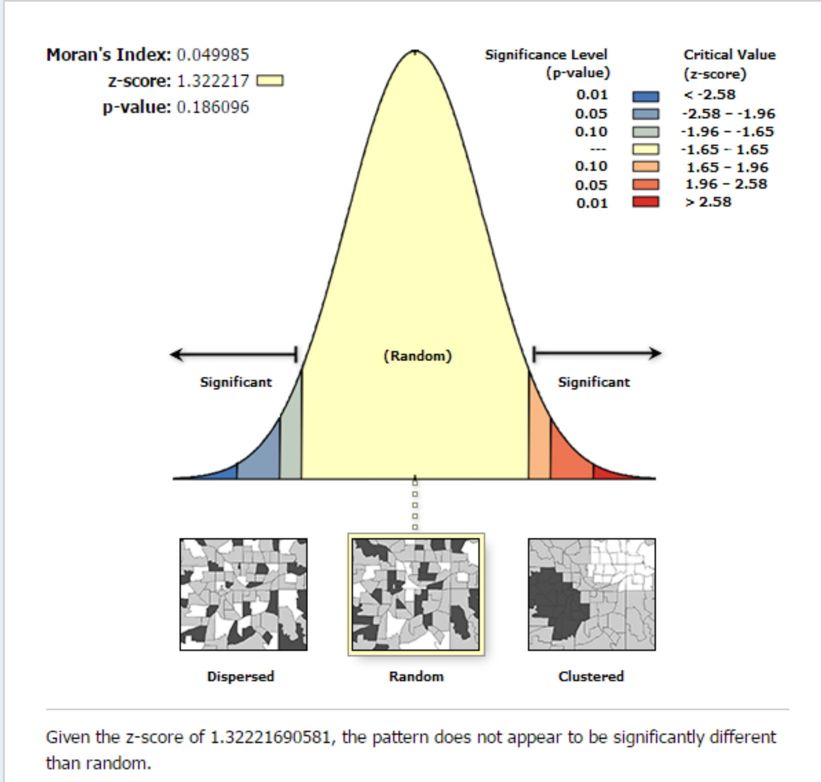


Figure 4.12. Ambulatory Care Sensitive Conditions (ACSCs): Residual vs. Predicted Scatterplot

Spatial Autocorrelation Report



Global Moran's I Summary

Moran's Index:	0.049985
Expected Index:	-0.012048
Variance:	0.002201
z-score:	1.322217
p-value:	0.186096

Dataset Information

Input Feature Class:	acsc_ols_1
Input Field:	RESIDUAL
Conceptualization:	INVERSE_DISTANCE
Distance Method:	EUCLIDEAN
Row Standardization:	False
Distance Threshold:	36042.8405 Meters
Weights Matrix File:	None
Selection Set:	False

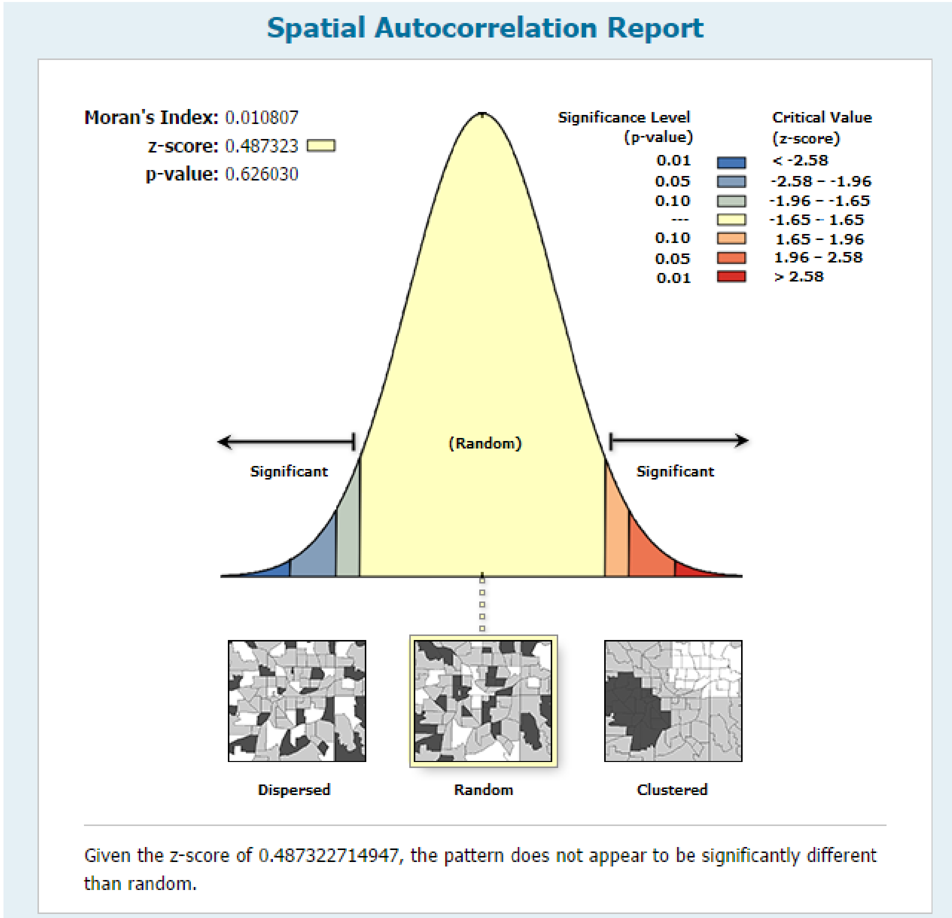
Figurer 4.13. Ordinary Least Square (OLS) Spatial Autocorrelation Report for Ambulatory Care Sensitive Conditions (ACSCs) Residuals

Variables insurHIS and noWifeAP_HIS have a positive coefficient sign which can be interpreted as “insured Hispanic children and children from Hispanic single father family which is above poverty level seek help from hospitals more often”. Another significant variable noSSI has a negative coefficient sign which means that children who receive SSI, food stamps and SNAP are more likely to receive health care from the hospital.

GWR result shows that adjusted r^2 is 0.57 which is higher than OLS (0.34) and the AICc (788) is smaller than OLS (803) (Table 4.5). Based on these two factors, GWR improves OLS result which means allowing the relationships to vary over space improves the model. The pattern of residuals is spatially random (Figure 4.14). GWR helps to visualize the spatial relationships between chosen variables and model the spatial variation of those variables. Figure 4.15 shows four maps, including one map for standardized residual and three others (one for each variable) of the local coefficient estimates. In the standardized residual map, the red areas mean high rates of ACSCs. Red areas have positive numbers which means the model underpredicted the ACSCs rate. The blue areas show low rates of ACSCs. Blue areas have negative numbers which means the model overpredicted the ACSCs rate. As of the maps of local coefficient estimates for each variable, the red areas show where the coefficients are large which means the exploratory variable is a strong predictor. The blue areas show the coefficients are small which means the exploratory variable is a weak predictor. The variations in the coefficient estimates for all three variables reveal that the influence of these variables in the model varies considerably over the study area (the coefficients range is large) (Figure 4.15). Variable insurHIS has a northeast to southwest trend except Refugio County whose coefficients are in a middle range. Otherwise, the coefficients range from 61.92 in the northeast area to 498.52 in the southwest area. Variable noWifeAP_HIS has a strong southwest to northeast trend with the coefficients range from 337.2 in the southwest area to 1538.66 in the northeast area. Variable noSSI shows an opposite direction to that of variable noWifeAP_HIS, has a strong northeast to southwest direction of the influence with coefficients range from -409.67 to 33.78 respectively.

Table 4.5. Ambulatory Case Sensitive Conditions (ACSCs): Geographically Weighted Regression (GWR) Model

VARNAME	VARIABLE
Bandwidth	65369.32028
ResidualSquares	41064.80417
EffectiveNumber	14.58895513
Sigma	24.32319307
AICc	787.7423721
R2	0.573546273
R2Adjusted	0.490057247



Global Moran's I Summary

Moran's Index:	0.010807
Expected Index:	-0.012048
Variance:	0.002199
z-score:	0.487323
p-value:	0.626030

Figure 4.14. Geographically Weighted Regression (GWR) Spatial Autocorrelation Report for Ambulatory Case Sensitive Conditions (ACSCs) Residuals

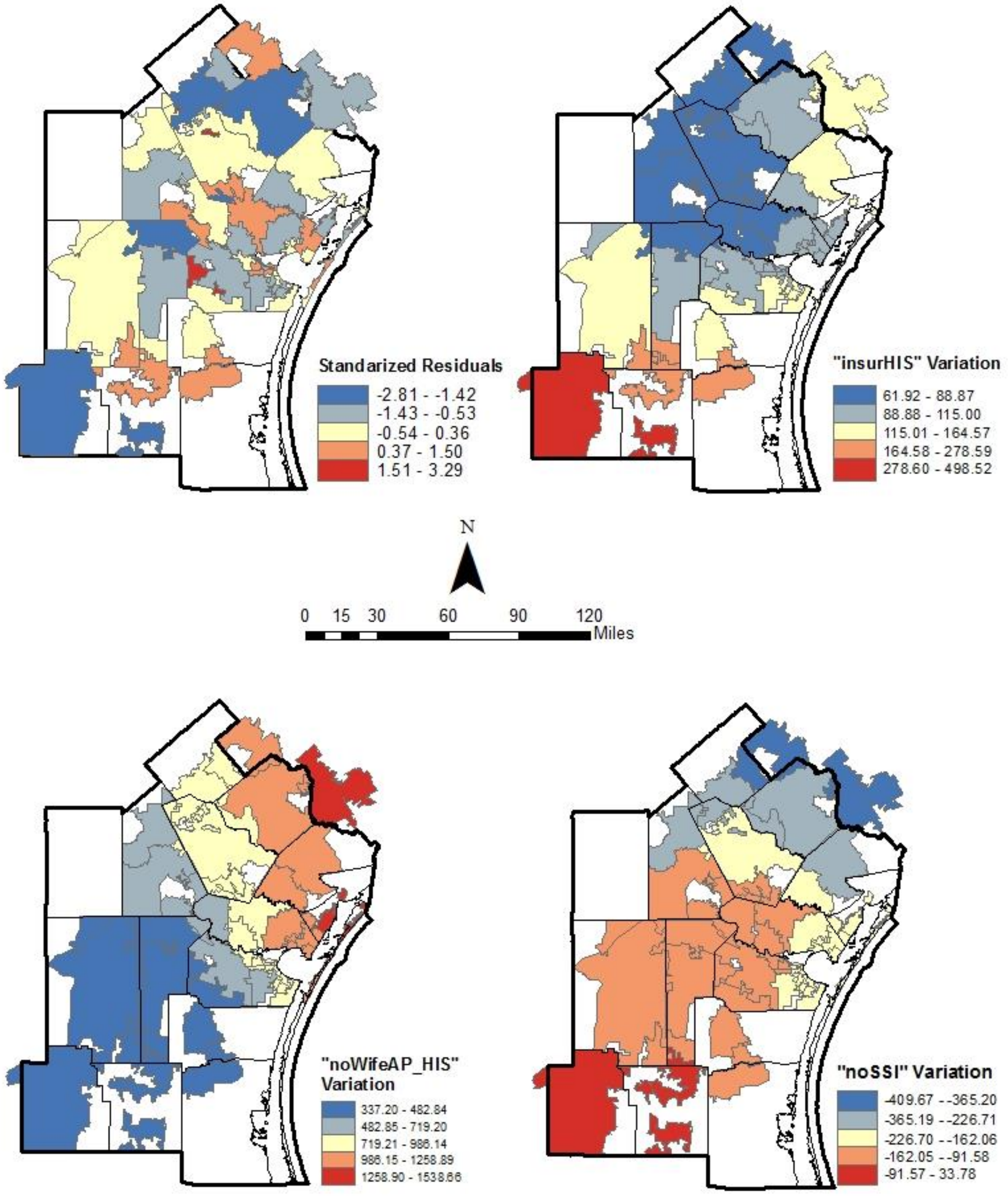


Figure 4.15. Geographically Weighted Regression (GWR) model for Ambulatory Case Sensitive Conditions (ACSCs): standardized residuals and coefficients for the variables.

4.2.3 Regression Analysis Results for Pneumonia

The result from OLS for pneumonia and its explanatory variables is shown in Table 4.6. The VIF values are all less than 7.5 which means multicollinearity is not a problem. The model has a r^2 of 0.38 and AICc of 616. This model explains approximately 38% of the variability. Jarque-Bera statics is significant, suggesting that the residuals are not normally distributed and the model cannot be trusted. We can tell there are outliers very easily from histogram and scatterplot (Figure 4.17 & 4.18). However, the spatial autocorrelation report (Figure 4.19) shows that the residuals are randomly distributed with a z-score of 0.88 and p-value of 0.38. A GWR should be performed to improve the model. Koenker statistic is not significant. Compared with the ACSCs results (Table 4.4), two variables: (1) insurHIS: "Hispanic children with health insurance coverage" and (2) noWifeAP_HIS: "families with a father householder who is Hispanic with no wife present income above poverty level" are significant but not the third variable noSSI ("income in the past 12 months is at or above poverty level and children living in household with no Supplemental Security Income (SSI), cash public assistance income, or Food Stamps/SNAP"). Both of the significant variables have positive signs which can be interpreted the same as for ACSCs from section 4.2.1 that children who are covered by health insurance are more likely to receive pneumonia care from hospitals and that children from a single father family are less likely to receive routine health care and have poor access to health care (HSR, 2017) and that they will visit hospital when the preventable conditions get out of hand.

Table 4.6. Pneumonia: Summary of Ordinary Least Square (OLS) Results

Summary of OLS Results - Model Variables

Variable	Coefficient [a]	StdError	t-Statistic	Probability [b]	Robust_SE	Robust_t	Robust_Pr [b]	VIF [c]
Intercept	3.257058	6.524494	0.499205	0.619010	4.551091	0.715665	0.476278	--------
1.CSV.INSURH	59.723242	19.403719	3.077928	0.002858*	23.133852	2.581638	0.011654*	1.129618
1.CSV.NWIFEA	338.838315	60.108299	5.637130	0.000000*	49.568146	6.835808	0.000000*	1.009749
1.CSV.NOSSI	-34.973767	19.399567	-1.802812	0.075187	20.339598	-1.719492	0.089397	1.120322

OLS Diagnostics

Input Features:	zcta	Dependent Variable:	1.CSV.R_PNEUMONIA_07_09
Number of Observations:	84	Akaike's Information Criterion (AICc) [d]:	616.175987
Multiple R-Squared [d]:	0.401838	Adjusted R-Squared [d]:	0.379406
Joint F-Statistic [e]:	17.914308	Prob(>F), (3,80) degrees of freedom:	0.000000*
Joint Wald Statistic [e]:	132.061071	Prob(>chi-squared), (3) degrees of freedom:	0.000000*
Koenker (BP) Statistic [f]:	6.880116	Prob(>chi-squared), (3) degrees of freedom:	0.075819
Jarque-Bera Statistic [g]:	869.655613	Prob(>chi-squared), (2) degrees of freedom:	0.000000*

Notes on Interpretation

* An asterisk next to a number indicates a statistically significant p-value ($p < 0.01$).

[a] Coefficient: Represents the strength and type of relationship between each explanatory variable and the dependent variable.

[b] Probability and Robust Probability (Robust_Pr): Asterisk (*) indicates a coefficient is statistically significant ($p < 0.01$); if the Koenker (BP) Statistic [f] is statistically significant, use the Robust Probability column (Robust_Pr) to determine coefficient significance.

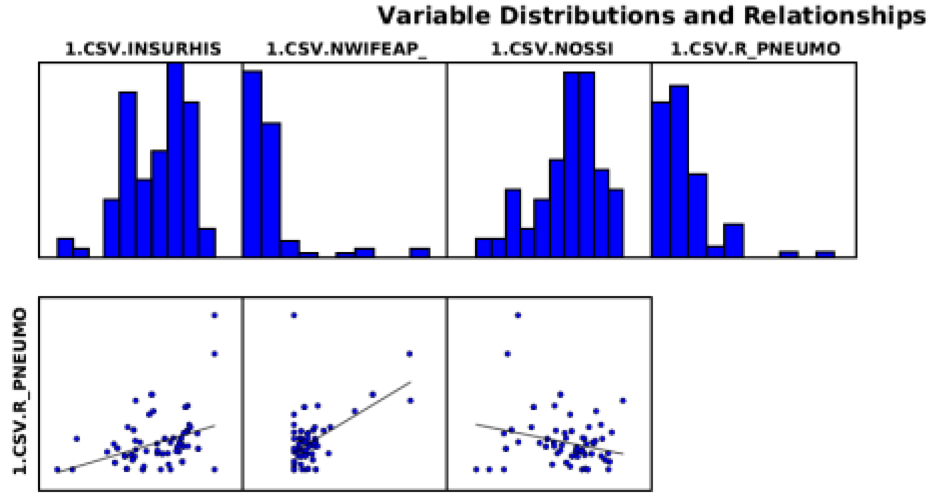
[c] Variance Inflation Factor (VIF): Large Variance Inflation Factor (VIF) values (> 7.5) indicate redundancy among explanatory variables.

[d] R-Squared and Akaike's Information Criterion (AICc): Measures of model fit/performance.

[e] Joint F and Wald Statistics: Asterisk (*) indicates overall model significance ($p < 0.01$); if the Koenker (BP) Statistic [f] is statistically significant, use the Wald Statistic to determine overall model significance.

[f] Koenker (BP) Statistic: When this test is statistically significant ($p < 0.01$), the relationships modeled are not consistent (either due to non-stationarity or heteroskedasticity). You should rely on the Robust Probabilities (Robust_Pr) to determine coefficient significance and on the Wald Statistic to determine overall model significance.

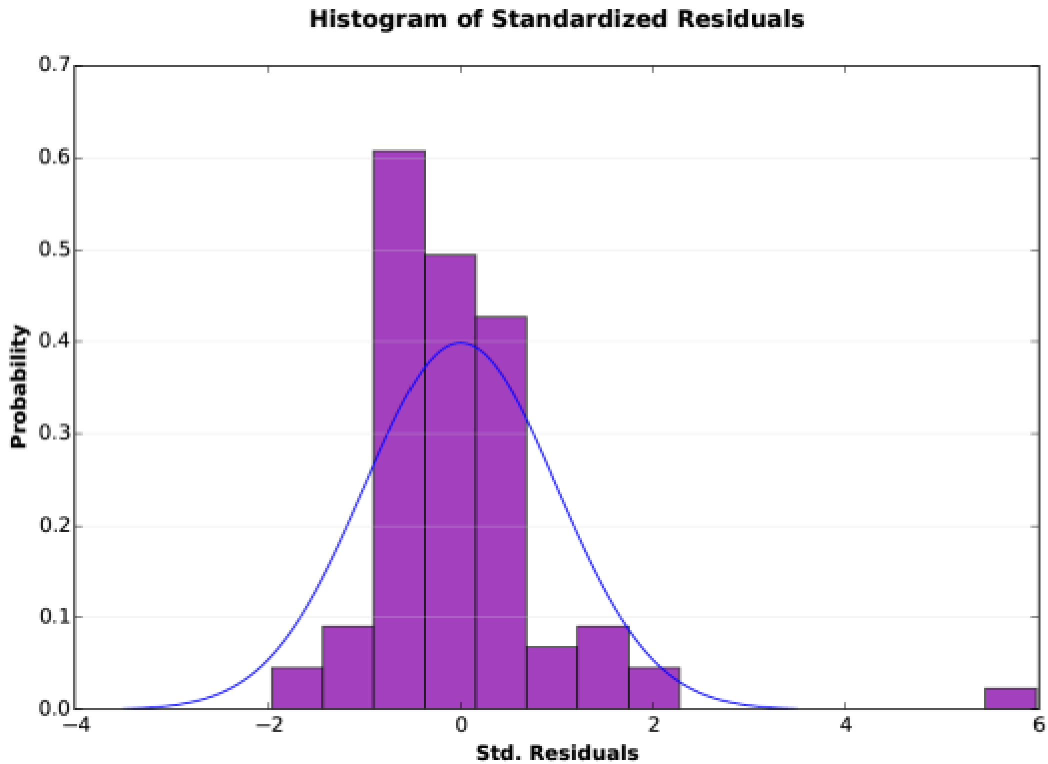
[g] Jarque-Bera Statistic: When this test is statistically significant ($p < 0.01$) model predictions are biased (the residuals are not normally distributed).



The above graphs are Histograms and Scatterplots for each explanatory variable and the dependent variable. The histograms show how each variable is distributed. OLS does not require variables to be normally distributed. However, if you are having trouble finding a properly-specified model, you can try transforming strongly skewed variables to see if you get a better result.

Each scatterplot depicts the relationship between an explanatory variable and the dependent variable. Strong relationships appear as diagonals and the direction of the slant indicates if the relationship is positive or negative. Try transforming your variables if you detect any non-linear relationships. For more information see the Regression Analysis Basics documentation.

Figure 4.16. Pneumonia: Variable Distributions and Relationships



Ideally the histogram of your residuals would match the normal curve, indicated above in blue. If the histogram looks very different from the normal curve, you may have a biased model. If this bias is significant it will also be represented by a statistically significant Jarque-Bera p-value (*).

Figure 4.17. Pneumonia: Histogram of Standardized Residuals

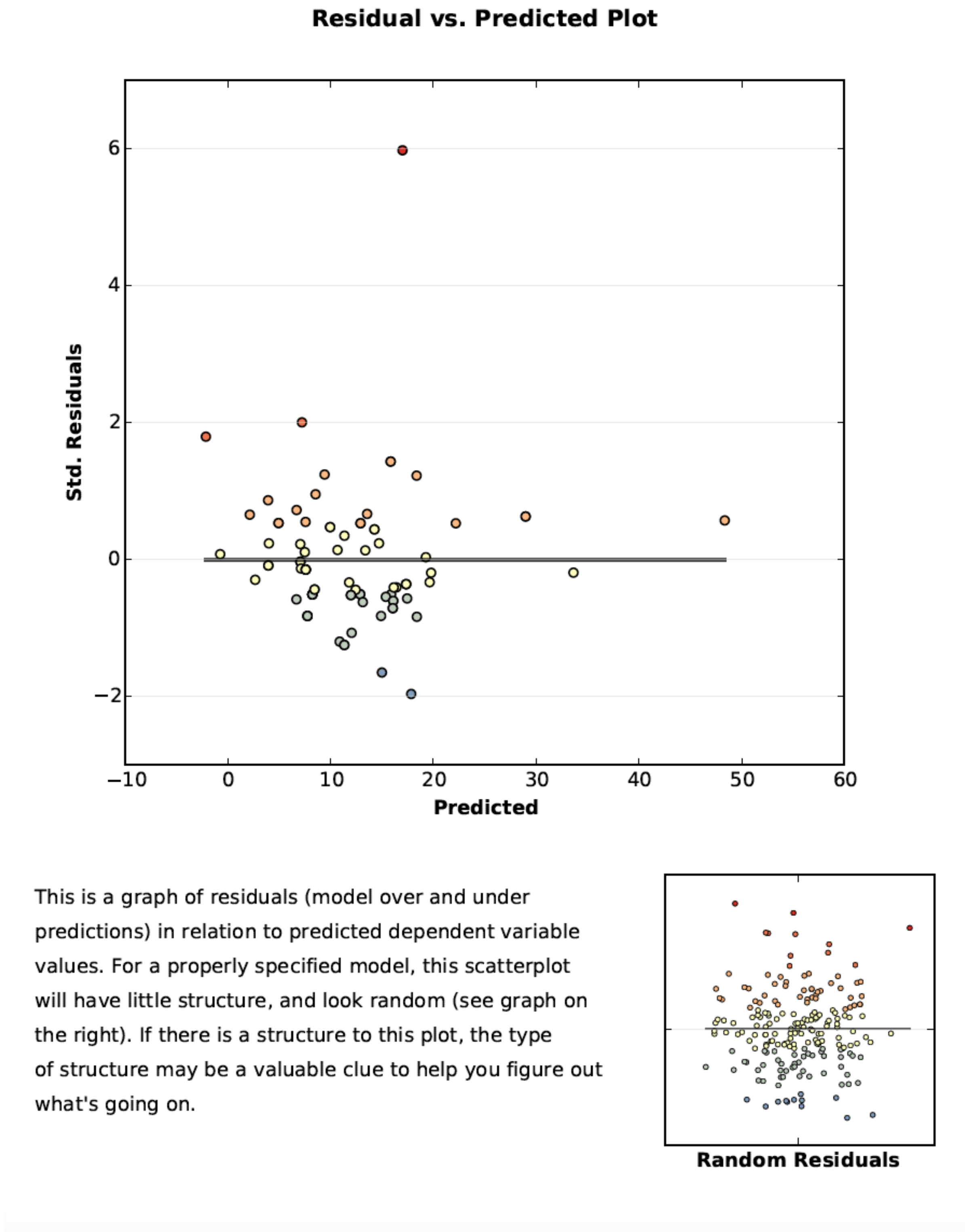


Figure 4.18. Pneumonia: Residual vs. Predicted Scatterplot

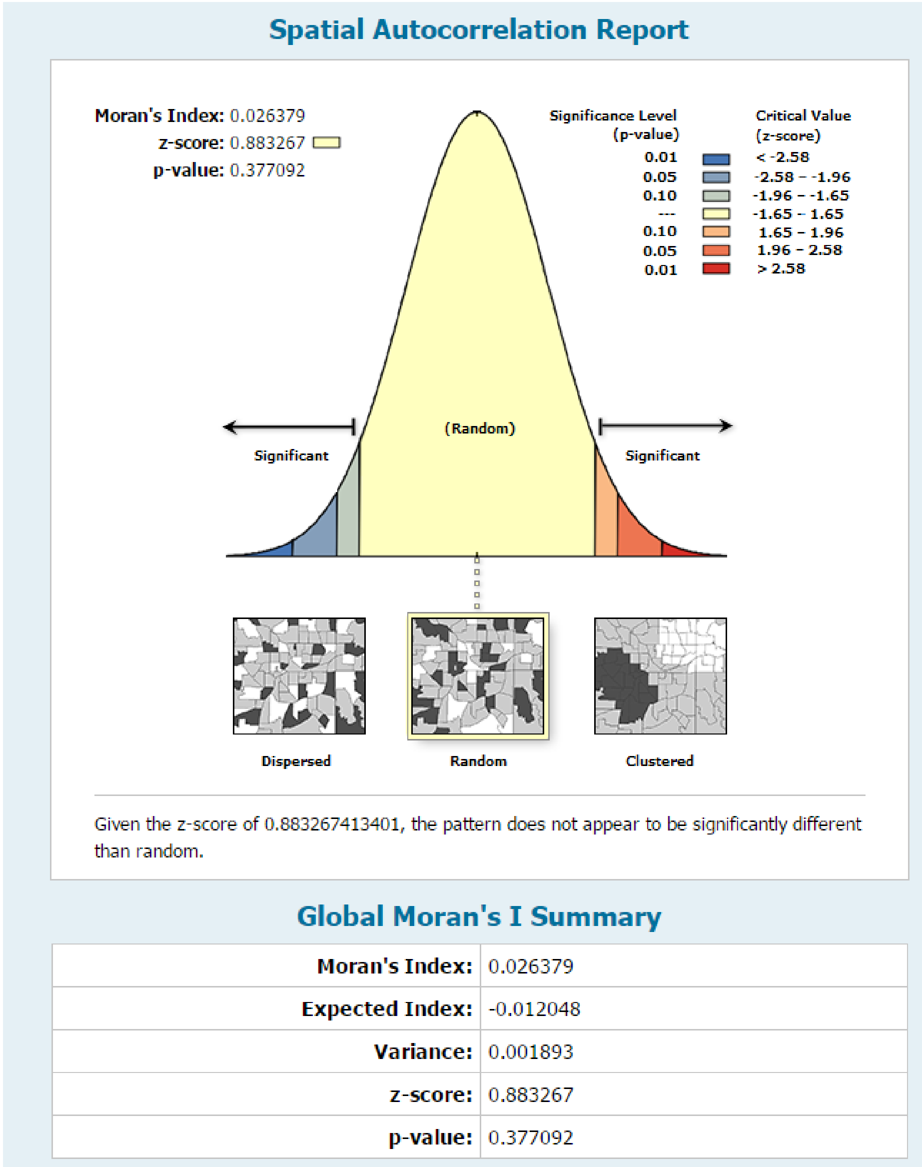


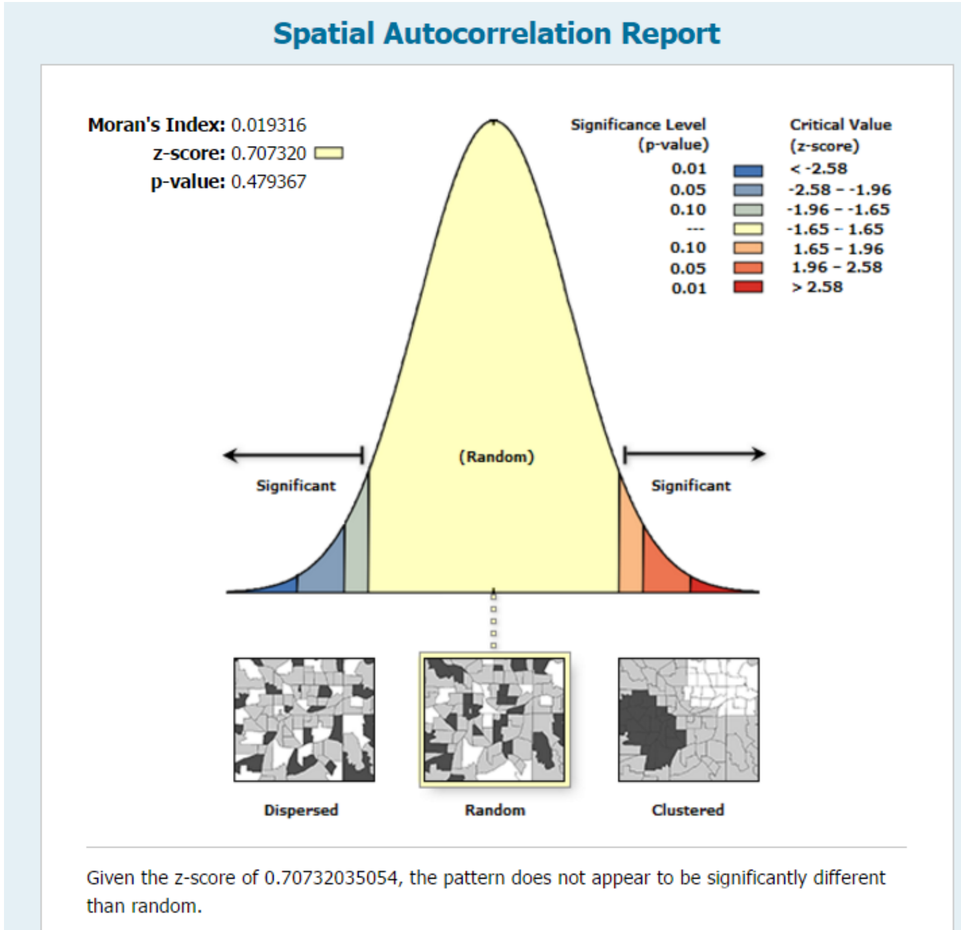
Figure 4.19. Ordinary Least Square (OLS) Spatial Autocorrelation Report for Pneumonia Residuals

Since the Jarque-Bera statistics is significant in the OLS model, it is necessary to perform a GWR to improve the model. The GWR result (Table 4.7) has an r^2 of 0.58 and AICc of 604 while those of OLS are 0.39 and 617 respectively. GWR has higher r^2 and lower AICc which confirms that it improves the OLS model in this case. Spatial pattern for residuals of pneumonia is random (Figure 4.20).

Figure 4.21 shows standardized residual map and three local coefficient estimates maps, one for each variable. From the standardized residual map, there are more overpredicted areas (blue areas) than underpredicted areas (red areas). Overall, the model does not vary as much as that of ACSCs (Figure 4.15). The higher influence of variable insurHIS is in the northwest and southern area. The lowest influence is in the east of the study area while the highest variation of variable noWifeAP_HIS is in the northeast and southwest areas and the lowest variation is in the center of the study area. Variable noSSI has a northeast to southwest direction of influence with the least influential area in the northwest and the most influential area in the southwest.

Table 4.7. Pneumonia: Geographically Weighted Regression (GWR) Model

VARNAME	VARIABLE
Bandwidth	65369.32028
ResidualSquares	4657.223209
EffectiveNumber	14.58895513
Sigma	8.191232168
AICc	604.8968827
R2	0.580159831
R2Adjusted	0.497965574



Global Moran's I Summary

Moran's Index:	0.019316
Expected Index:	-0.012048
Variance:	0.001966
z-score:	0.707320
p-value:	0.479367

Figure 4.20. Geographically Weighted Regression (GWR) Spatial Autocorrelation Report for Pneumonia Residuals

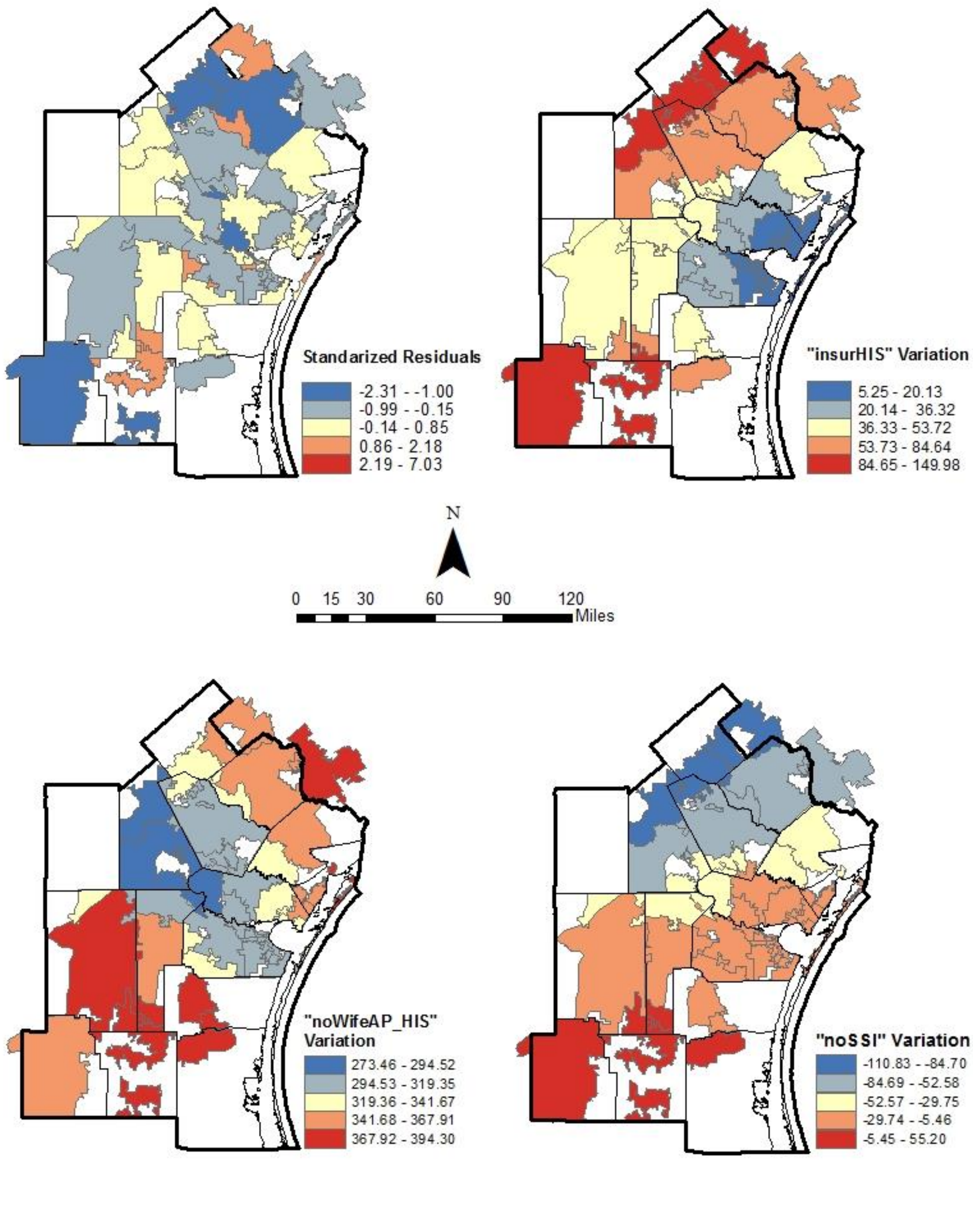


Figure 4.21. Geographically Weighted Regression (GWR) model for Pneumonia: standardized residuals and coefficients for the variables.

4.2.3 Regression Analysis Results for Asthma

Spatial autocorrelation report (Figure 4.22) shows that the residuals are clustered with a z-score of 11.44 and p-value of 0.0. Thus, the regression model for asthma cannot be trusted. Although more combinations of variables from exploratory models (Table 4.3) were used to find the best model for asthma, the residual patterns were consistently clustered. Therefore, asthma from the regression analysis was not discussed here. Asthma was then being analyzed and reported using a human subject questionnaire which is presented in section 4.6.

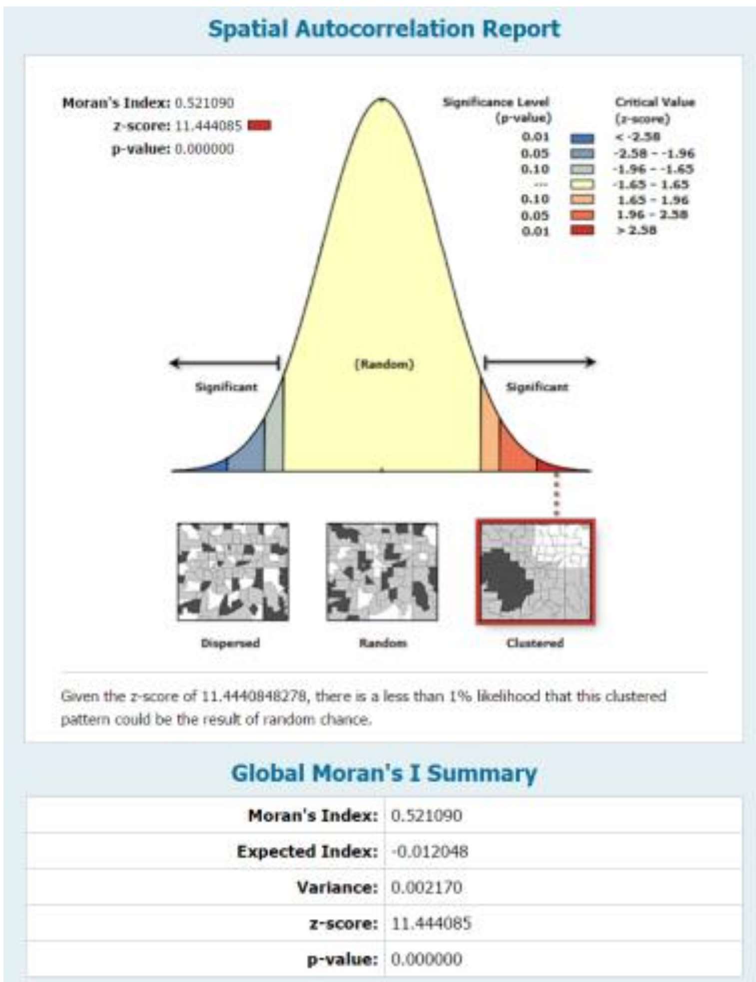


Figure 4.22. Ordinary Least Square (OLS) Spatial Autocorrelation Report for Asthma Residuals

4.3. ASSOCIATIONS BETWEEN AIR POLLUTION AND ACSCs, PNEUMONIA AND ASTHMA

Pearson's correlation result shows that SO_2 has the highest correlation with pneumonia and asthma. O_3 also has positive correlation with pneumonia and asthma but not as strong as SO_2 (Table 4.8). $PM_{2.5}$ and PM_{10} have negative correlation with both pneumonia and asthma. However, increase of $PM_{2.5}$ and PM_{10} concentration does increase the pneumonia and asthmatic discharges, although the relationship is relatively weak (Table 4.8).

Table 4.8. Correlation Between Air Pollutants (x_i) and Asthma/Pneumonia (y_i)

yi \ xi	O_3	SO_2	$PM_{2.5}$	PM_{10}	diff_$PM_{2.5}$	diff_PM_{10}
Asthma	0.188	0.495	-0.214	-0.06	0.113	0.097
Pneumonia	0.21	0.544	-0.295	-0.121	0.154	0.111

*diff_$PM_{2.5}$ is the difference of $PM_{2.5}$ from current month to previous month
*diff_PM_{10} is the difference of PM_{10} from current month to previous month

4.4. ASSOCIATIONS BETWEEN CHANGE IN TEMPERATURE AND ACSCs, PNEUMONIA AND ASTHMA

Both temperature change from month to month and within a month have positive association with pneumonia and asthma. Pneumonia is more significantly associated with changes in temperature. It has correlations of 0.43 and 0.36 with temperature change within a month and temperature change from month to month respectively while those of asthma are 0.15 and 0.18 respectively (Table 4.9).

Table 4.9. Correlation Between Monthly Temperature Change (x_i) and Asthma/Pneumonia (y_i)

yi \ xi	Temperature Change within a Month	Temperature Change from Month to Month
Asthma	0.148	0.176
Pneumonia	0.434	0.356

4.5. ASSOCIATIONS BETWEEN NEIGHBORHOOD AND LIVING ENVIRONMENT AND ASTHMA

Among the combined total of 317 participants, 69.1% (219) are currently living with children under 18 years old and of these, 46.6% are asthmatic children (Table 4.10). With a relatively small sample size, the fact that 46.6% of the children are asthmatic is a strikingly large number which confirms our hypothesis that asthma is a serious problem in the coastal bend area. Among all the participants, most have been living in Nueces County for more than 6 years (66.9%) which means the result is trustworthy due to a long period of time living in the same area with same neighborhood and living environment. The majority of the respondents are Hispanic (46.7%) and white (32.2%). 24.0% of them have family income over $100,000 in the past 12 months and those with college and graduate degree are 44.8% and 33.1% respectively.

Almost all the participants do not smoke in the house (93.4%). Sixty eight percent of the participants thinks the air quality is good in their neighborhood and 27.4% rate it fair. Overall, most of them feels safe and comfortable in their neighborhood (75.1%) and somewhat safe (23.3%). Most of them (79.8%) have never taken a class on how to manage asthma and among the asthmatic children, 69.6% of the parents or guardians have never taken an asthma management class.

Table 4.10. Descriptive Data for All Participants from Human Subject Questionnaire

Total Participants	317
Total Number of Children in The Survey	219
Total Number of Asthmatic Children in The Survey	102
Live in Nueces County	**Number (percent)**
<1 year	33 (10.4%)
1-3 years	44 (13.9%)
4-6 years	27 (8.5%)
more than 6 years	212 (66.9%)
Race	
American Indian or Alaskan Native	1 (0.3%)
Asian	9 (2.8%)
Black or African American	16 (5.0%)
Hispanic or Latino	148 (46.7%)
Native Hawaiian or Pacific Islander	1 (0.3%)
Non-Hispanic White	102 (32.2%)
Don't know	2 (0.6%)
Other	36 (11.3%)
Income	
less than $10,000	49 (15.5%)
10,000 - 29,999	36 (11.4%)
30,000 - 49,999	43 (13.6%)
50,000 - 69,000	48 (15.1%)
70,000 - 99,000	54 (17.0%)
more than $100,000	76 (24.0%)
Education	
primary/middle school	4 (1.3%)
high school/GED	57 (18.0%)
college	142 (44.8%)
graduate	105 (33.1%)
other	7 (2.2%)
Smoke	
Smoke free	296 (93.4%)
sometimes	12 (3.8%)
frequently	6 (1.9%)
Pet in the house	
yes	183 (57.7%)
no	133 (42.0%)
Air quality	
poor	12 (3.8%)
fair	87 (27.4%)
good	216 (68.1%)
Neighborhood	
safe and comfortable	238 (75.1%)
somewhat safe	74 (23.3%)
not safe and dangerous	4 (1.3%)
Asthma management class	
yes	63 (19.9%)
no	253 (79.8%)
Cook at home and use gas stove	
yes	95 (30.0%)
no	196 (61.8%)

*Note: the numbers will not add up to total since participants chose not to answer a certain question.

Among the asthmatic children (Table 4.11), 76.5% of them were diagnosed when they were younger than 5 years old and 20.6% between 5 and 10 years old. Among all the children in this survey, during the weekday, 58.9% of them spent more than 1 hour outdoor after school and

29.2% spent between half an hour to one hour outdoor. On the weekend, 51.1% spent between 1 and 3 hours outdoor while 38.8% spent more than 3 hours outdoor playing. Most of the children have health insurance (91.8%) and eat fresh fruit and vegetables (79.9%).

Table 4.11. Descriptive Data for All Children and Asthmatic Children from Human Subject Questionnaire

Total Number of Asthmatic Children in The Survey	102 (46.6%)	
Total Number of Children in The Survey	219	
Age	**Asthmatic children**	**All children**
<5 years	78 (76.5%)	
5-10 years	21 (20.6%)	
>10 years	3 (2.9%)	
Gender		
male	39 (38.2%)	
female	28 (27.5%)	
both	34 (33.3%)	
Asthma management class		
yes	31 (30.4%)	
no	71 (69.6%)	
Weekday outdoor activity		
>1 hr	59 (57.8%)	129 (58.9%)
0.5-1 hr	31 (30.4%)	64 (29.2%)
<0.5 hr	11 (10.8%)	25 (11.4%)
Weekend outdoor activity		
>3 hrs	41 (40.2%)	85 (38.8%)
1-3 hrs	50 (49.0%)	112 (51.1%)
<1 hr	10 (9.8%)	21 (9.6%)
Fruit and vegetable consumption		
yes	81 (79.4%)	175 (79.9%)
no	2 (2.0%)	3 (1.3%)
sometimes	19 (18.6%)	40 (18.3%)
Health insurance		
yes	95 (93.1%)	201 (91.8%)
no	7 (6.9%)	17 (7.8%)

*Note: the numbers will not add up to total since participants chose not to answer a certain question.

Results show that weekday and weekend outdoor activity have the strongest relationship with asthma (Table 4.12), 0.44 and 0.52 respectively. Other variables have some association with asthma but the association is not strong.

Table 4.12. Exploratory Variables (x_i) and Their Correlations to Dependent Variable Asthma (y_i) from Human Subject Questionnaire

xi \ yi	asthma
age: age when the child was diagnosed as asthmatic	-0.170300254
weekday: weekday time spent outdoor after school	0.445585015
weekend: weekend time spent outdoor	0.521624658
diet: if children consume fresh fruits and vegetables	-0.217358033
race: race of the participant	-0.077415808
income: total household income In the past 12 months	0.186276579
education: highest education in the family	0.145561008
smoke: smoking status in the house	-0.02269511
pets: are there pets in the house	-0.047776466
neighborhood: perception of neighborhood safety	-0.125079612
neigh-sat: are they satisfied with their neighborhood	-0.109567242

4.6. DISCUSSION

ACSCs, pneumonia and asthma all have high concentrations in Nueces and San Patricio counties. It is virtually certain that asthma is as highly, if not more highly, prevalent in Nueces and San Patricio counties as ACSCs and pneumonia. Recall from the study area map (Figure 1.1) that there is a row of refineries in between Nueces County and San Patricio County. Arguably the pollutions from refineries affects child ACSCs hospitalization. More research is needed in this study area to further identify the effect of pollution from refineries and to identify the relationships between children ACSCs hospitalization and refineries. The low rate of ACSCs, pneumonia and asthma distribution on the north side of the study area (Figure 4.1, 4.2 & 4.3) might be because the children from those counties seek hospital care from hospitals not represented in the data used here, such as those in Victoria for example.

This study confirms that children with health insurance are more likely to visit the hospital when their respiratory condition becomes acute (Pamuk et al., 1998). In our study, Hispanic children with health insurance and children in general who receive SSI, Food Stamps and SNAP visit hospitals more often. Children who are eligible to receive SSI are those from families with limited income, a disabled family member and / or a family member that is 65 years or older (SSA, 2017). Children from the families who are receiving Food Stamps and SNAP should have a current bank balance under $2,001 or under $3,001 for a group who share a household with a person age 60 and older or with a disability and annual income below a certain level depending on the number of members in the family (Benefits.gov, 2017). In another word, children who are eligible for these programs are poor. Poor children usually can only afford to live in poor neighborhoods which usually have more pollution than more affluent neighborhoods. As we know, pollution can lead to poor health (Diez Roux, 2001; Pickett and Pearl, 2001; Yen and Syme, 1999). In most of the states including Texas, SSI and Food Stamps applications are the same as a Medicaid application which means the same rule is applied when deciding if the applicants are eligible. So, children with SSI and Food Stamps very likely also have Medicaid as the application is the same and as a determination that a person is entitled to SSI automatically entitles that person to Medicaid. Since they are insured by government, they are entitled to receive hospital care when they are sick.

Children from a single father family are less likely to receive routine health care and have poor access to health care than those with a mother regardless of income (HSR, 2008). Our study, shows that Hispanic children from single father families visit hospitals more often which can be interpreted that children without the care of mother, get sick easier and fathers do not arrange routine health care for them so that they visit hospital when the preventable conditions get out of hand. All these circumstances lead to a potential explanation that these groups, especially Hispanic families, have not been educated in preventative care for their children with ACSCs and only seek care on an emergency basis when preventable conditions get out of hand.

Unlike other studies suggesting that $PM_{2.5}$ and PM_{10} are most likely to cause pneumonia and asthma exacerbation (Qian, Ritz and Wilhelm, 2009), our study does not reveal significant effect of $PM_{2.5}$ and PM_{10} on childhood pneumonia and asthma. However, our result agrees with other studies that SO_2, a ubiquitous oil refinery pollutant, is highly associated with pulmonary illness (Gasana et al., 2012).

Sharp daily temperature change increases both childhood pneumonia and asthma hospitalization (Guo et al., 2011; Kan et al., 2007; Lin et al., 2013; Xu et al., 2013). Our study shows that large monthly temperature change is also highly associated with pneumonia and asthma hospitalization in children, especially for childhood pneumonia. Parents and guardians should pay more attention to their children when temperature changes dramatically so that they are able to better adjust to this change and avoid pneumonia or asthma attack. Larger changes in temperature in a short period of time, such as over the course of a day, have a greater impact than the seasonal adjustment in temperature over a month. It is not high temperature or low temperature that makes pneumonia and asthma worse, but the large rapid change between them (Kan et al., 2007; Xu et al., 2013). This is because of the stress of adjusting to the change on the child's unprepared body (Xu et al., 2014). Sudden large temperature changes make the symptoms of pneumonia and asthma much worse but measuring temperature change by month was not sufficient to demonstrate the relationship between sudden large temperature changes and pneumonia or asthma. Daily statistics (if daily hospitalization discharge data is available) is a better choice to demonstrate the relationship.

Most of the asthmatic children were diagnosed as asthmatic when they were less than five years old, but asthma is hard to diagnose among young children as they are too young to express how they feel (NHLBI, 2014). Asthma is a more chronic illness among children because they have narrower airways compared to adults and they breathe more air per pound of body weight and spend more time outdoors than adults (Gasana et al., 2012). Our study also shows that time spent outdoor is highly associated with asthma (Table 4.12). The potential interpretation is that when children spend more time outdoor playing, they inhale more air thus more pollution.

CHAPTER VI: CONCLUSION AND FUTURE WORK

5.1. CONCLUSION

The first hypothesis is that ACSCs, pneumonia and asthma hotspots are around the refinery row was supported by the research. Air pollution has long been examined by many researchers in their studies, and proved to be extremely harmful to human health (Vieira et al., 2012; Gasana et al., 2012; Hwang et al.; Kang et al.; Peled et al.; Qian, Ritz, and Wilhelm, 2009; Urman et al., 2014). We found SO_2, a ubiquitous oil refinery pollutant, to have a seriously negative impact on the health of children with pneumonia, asthma and other ACSCs. This is probably caused by the proliferation of oil refineries near the center of our study area. However, more research needs to be done to draw a more confident conclusion.

Our second hypothesis is that children with low SES are more likely to have pneumonia, asthma or other ACSCs was supported by the research. ACSCs have been used as an index to evaluate the quality and quantity of primary care. Poor children are not able to have routine primary care (Halfon, Newacheck, and St. Peter, 1992). Routine checkups are likely in turn lower the instances of hospitalization for pneumonia, asthma and other ACSCs. Children with health insurance are more likely to visit the hospital when their respiratory condition becomes acute (Pamuk et al., 1998). Children living with single fathers are less likely to have health insurance, and have lower rate of routine care (HSR, 2008). These children have poor access to health care which make them more vulnerable to health-related problem (HSR, 2008). Two out of three significant variables found from the OLS and GWR results are related to “Hispanic family” and should catch the attention of insurance company actuaries: Hispanic families are more likely to seek treatments for ACSCs and pneumonia at the hospital (a practice significantly more expensive than long term preventative treatment), suggesting that perhaps Hispanic families do not seek preventative health care for children on a long-term basis.

The third hypothesis was also validated by the results. Sharp temperature change increases pneumonia and asthma hospitalization. Parents and guardians should pay extra attention to children and make sure they are well equipped and monitored during such changes. Climatologists anticipate a growing number of extreme temperature events in the future as climate change continues. Child care providers should be prepared to provide appropriate clothing in the event of extreme temperature change, drenching rain, hail storms, and heatwaves.

Neighborhood and living environment factors were not significant to childhood asthma according to the results from human subject questionnaire. Therefore, the fourth hypothesis was not proven. From the survey, fewer than 20% of the survey participants in Nueces County have ever taken a class on how to manage asthma. In the families that have children with asthma, only 30% of the parents/guardians have taken any asthma management classes. Related organizations, community service and perhaps even health insurance carriers should provide more opportunities for residents to attend pneumonia and asthma prevention and management classes like the CDC's outreach project in the lower Rio Grande Valley which proved that preventative asthma education can significantly reduce hospital visits and lower the cost of health care (CDC, 2017). Lower costs allow health care insurers to provide more health care to more children in need.

It is well known to public health workers that managed childhood preventative care reduces the incidences of acute respiratory conditions, which in turn drastically reduces the cost of medical care. As such, these findings suggest that policy makers at corresponding government departments, and possibly the insurance companies paying for these hospital services, would be wise to develop a preventative managed care plan for their insured clients with pneumonia, asthma and other ACSCs.

5.2. FUTURE WORK

Better data and professional researchers to assemble and analyze it, will help the coastal bend area to get a better picture of itself and help it to plan what it wants to be in the future and how to get there in the most cost effective and mutually beneficial manner. Academic research such as this is necessarily limited by cost and access to data. A larger number of participants in the human subject survey will increase the reliability of the research. With access to local school district, healthcare provider and insurance company data and permission to conduct survey research among parents, teachers and students, the number of participants will increase substantially and in turn increase the accuracy and reliability of the research.

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APPENDICES

APPENDIX A

CONSENT FORM

ASTHMA SURVEY FOR ADULT PARENT/GUARDIAN OF CHILDREN IN NUECE COUNTY TEXAS

This is A Part of Master Thesis

Introduction

The purpose of this form is to provide you information that may affect your decision as to whether or not to participate in this research study. If you decide to participate in this study, this form will also be used to record your consent.

You have been asked to participate in a research project studying asthma among children in Nueces County Texas. The purpose of this study is to find some of the causes of asthma. You were selected to be a possible participant because you are 18 years or older and the resident in Nueces County. This study will be conducted as part of a Texas A&M University – Corpus Christi master's research thesis requirement.

What will I be asked to do?

If you agree to participate in this study, you will be asked to describe the living condition and your neighborhood. This study will take about 10 – 15 minutes.

What are the risks involved in this study?

The risks associated in this study are minimal, and are not greater than risks ordinarily encountered in daily life.

What are the possible benefits of this study?

The possible benefits of participation are that together we can better understand the potential factors that cause or trigger the childhood asthma and help provide better health care of your children.

Do I have to participate?

No. Your participation is voluntary. You may decide not to participate or to withdraw at any time without your current or future relations with Texas A&M University-Corpus Christi being affected.

Who will know about my participation in this research study?

This study is confidential. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely and only Dr. Lucy Huang and her research assistant Na Lin will have access to the records.

Whom do I contact with questions about the research?

If you have questions regarding this study, you may contact Dr. Lucy Huang (email: lucy.huang@tamucc.edu; phone: 361-825-2646) or Na Lin: nlin@islander.tamucc.edu

Whom do I contact about my rights as a research participant?
This research study has been reviewed by the Research Compliance Office and/or the Institutional Review Board at Texas A&M University-Corpus Christi. For research-related problems or questions regarding your rights as a research participant, you can contact Caroline Lutz, Research Compliance Officer, at (361) 825-2497 or caroline.lutz@tamucc.edu

Signature
Please be sure you have read the above information, asked questions and received answers to your satisfaction. You will be given a copy of the consent form for your records. By signing this document, you consent to participate in this study. You also certify that you are 18 years of age or older by signing this form.

Signature of Participant:_________________________________ **Date:**______

Printed Name: ____

Signature of Person Obtaining Consent:______________________ **Date:**______

Printed Name: ____

APPENDIX B

Asthma Survey for Adult Parent/Guardian of Children in Nueces County Texas

Texas A&M University – Corpus Christi – Department of Computing Sciences

This survey questionnaire is designed for a Master's Thesis research on monitoring geographical, environmental and socio-economic factors that play important roles in triggering asthma in children under 18 years old in Nueces County Texas.

This survey will take about 10 – 15 minutes to complete. Your participation is completely voluntary and you may withdraw at any time. If you come to a question that you do not want to answer, please skip it. All information is confidential. Your responses will help us better understanding the role these factors play and come up with better solution to provide better health care for your children.

1. Do you have a child or children under 18 years old in your house?
   - ☐ Yes
   - ☐ No (go to question 9)

2. How many children do you have? ______________________

3. What is your relationship to the child / children?
   - ☐ Mother
   - ☐ Father
   - ☐ Grandparent
   - ☐ Others (please specify) ____

4. Have you ever been told by a doctor or other health professional that your child / children had asthma?
   - ☐ Yes
   - ☐ No (go to question 7)

5. If your answer to question 4 is yes, what was the age(s) of your child/children when you were told by the doctor that he / she had asthma? _________________________

6. What is the gender of the child / children that has/have asthma?
   - ☐ Male
   - ☐ Female
   - ☐ Both

7. During the weekday, how much time on average would you say your children play outdoors daily, after school?
   - ☐ More than 1 hour
   - ☐ Between half an hour and 1 hour

- ☐ Less than half an hour

8. During weekend, how much time on average would you say your children play outdoors daily?
   - ☐ More than 3 hour
   - ☐ Between 1 and 3 hours
   - ☐ Less than 1 hour

9. A large selection of fresh fruits and vegetables is available in my neighborhood.
   - ☐ Yes
   - ☐ No
   - ☐ Somewhat

10. The fresh fruits and vegetables in my neighborhood are of high quality.
    - ☐ Yes
    - ☐ No
    - ☐ Somewhat

11. Does your child / children consume fresh fruits and vegetables?
    - ☐ Yes
    - ☐ No
    - ☐ Sometimes
    - ☐ N/A

12. Since geography and environment are two of the major factors to analyze when studying asthma, please tell us your address so that we can analyze the data and make suggestions according the neighborhood you live in. Please note that this information is used to conduct this study only and is strictly confidential.

    Street Address____

    City____________________________________

    Zip Code________________________________

13. How long have you been living in Nueces County?
    - ☐ Less than 1 year
    - ☐ 1-3 years
    - ☐ 4-6 years
    - ☐ More than 6 years

14. What race or races do you consider yourself to be? Check all that apply.
    - ☐ American Indian or Alaskan Native
    - ☐ Asian

- ☐ Black or African American
- ☐ Hispanic or Latino
- ☐ Native Hawaiian or Pacific Islander
- ☐ Non-Hispanic White
- ☐ Don't know
- ☐ Other (please specify) ____

15. Which category best represents your TOTAL household income from all household members during the past 12 months?
    - ☐ Less than $10,000
    - ☐ 10,000 – 29,999
    - ☐ 30,000 – 49,999
    - ☐ 50,000 – 69,000
    - ☐ 70,000 – 99,000
    - ☐ More than $100,000

16. What is the highest education level in the family?
    - ☐ Primary / Middle School
    - ☐ High School / GED
    - ☐ College
    - ☐ Graduate
    - ☐ Other

17. Which of the following best describes your home situation?
    - ☐ My home is smoke free
    - ☐ People occasionally smoke in the house
    - ☐ People frequently smoke in the house

18. Do you usually cook at home?
    - ☐ Yes
    - ☐ No

19. Is gas used for cooking in your home?
    - ☐ Yes
    - ☐ No
    - ☐ Don't know

20. Do you use gas to heat your house?
    2.1 Yes
    2.1 No

21. Do you use gas to heat your hot water?
    - ☐ Yes
    - ☐ No

22. In the past 30 days, has anyone seen or smelled mold or a musty odor inside in your home? Do not include mold on food.
    - ☐ Yes
    - ☐ No
    - ☐ Don't know

23. Does your home have pets such as dogs, cats, hamsters, birds or other feathered or furry pets that spend time indoors?
    - ☐ Yes
    - ☐ No

24. Have you or any members in your family ever taken a course or class on how to manage asthma?
    - ☐ Yes
    - ☐ No

25. Do your children live with the parents or grandparents?
    - ☐ Parents
    - ☐ Grandparents
    - ☐ Parents and Grandparents together
    - ☐ N/A

26. Is there family violence in your home? (Your answer is completely confidential)
    - ☐ Yes
    - ☐ No

27. Do your children have health insurance?
    - ☐ Yes
    - ☐ No
    - ☐ N/A

28. Rate the air quality in your neighborhood from 1 to 5.
    - ☐ 1 (very poor)
    - ☐ 2 (poor)
    - ☐ 3 (fair)
    - ☐ 4 (good)
    - ☐ 5 (very good)

29. Which of the following statement is most descriptive of your neighborhood?
    - ☐ is safe and comfortable
    - ☐ is somewhat safe
    - ☐ is not safe
    - ☐ is dangerous
    - ☐ is very dangerous

30. About how many people do you recognize or know by sight in this neighborhood?
- None
- A few
- Many
- Most or all

31. This is a cohesive or unified neighborhood
- Strongly Agree
- Agree
- Unsure
- Disagree
- Strongly Disagree

32. People in this neighborhood generally get along with each other.
- Strongly Agree
- Agree
- Unsure
- Disagree
- Strongly Disagree

33. How many of your relatives or in-laws live in your neighborhood?
- 0 family
- 1-3 families
- 4-5 families
- More than 5 families

34. How many of your friends live in your neighborhood?
- 0
- 1-3
- 4-5
- More than 5

35. All things considered, would you say you are very satisfied, satisfied, dissatisfied or very dissatisfied with your neighborhood as a place to live?
- Very satisfied
- Satisfied
- Neutral – Not satisfied or dissatisfied
- Dissatisfied
- Very dissatisfied

This is the end of Survey. Thank you for your time!