The Children's Health Fund
Health Transportation Shortage Index (HTSI): A New Measure of Accessibility

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Commonly Used Abbreviations

ACO=Accountable Care Organization

ACS = American Community Survey

ACSC = Ambulatory Care Sensitive Condition

ACA = Affordable Care Act

APHA= American Public Health Association

CHC = Community Health Center

CHIP = Children's Health Insurance Program, formerly known as the State Children's Health Insurance Program

CHF = Children's Health Fund

ED = Emergency Department

FMAP = Federal Medical Assistance Percentage

FQHC = Federally Qualified Health Center

GIS = Geographic Information Systems

HPSA = Health Professional Shortage Area

HRSA = Health Resources and Services Administration

MUA = Medically Underserved Area

NEMT = Non-emergency medical transportation

NTD = National Transit Database

PUDF = Public Use Data File

SCHIP = State Children's Health Insurance Program, now known as CHIP

UA = Urban Area

UC = Urban Cluster

WTAI= Weighted Transportation Accessibility Index

ZCTA = ZIP Code Tabulation Area

Table of Contents

I. Executive Summary

Most discussions of children's access to health care services generally focus on economic barriers and health insurance status, in particular. There are, however, additional non-economic barriers including the distribution and supply of health professionals and the availability of transportation to get to health care visits. The Children's Health Fund (CHF)/Marist Institute survey (2006) found that 4% of children in the U.S. (more than 3 million) miss at least one health care appointment each year due to a lack of transportation irrespective of their insurance status. One-third of these missed appointments result in later use of emergency department services. Most affected by inadequate transportation are rural communities, which also have the highest rates of federally designated primary care health professional shortage area (HPSA) counties and of child poverty. There is no federal designation similar to HPSA to identify or track transportation-disadvantaged communities. A HPSA designation can facilitate additional health care resources (National Health Service Core, federally qualified health centers, enhanced reimbursement rates) to the community. A transportation disadvantaged designation might be used similarly to improve resources to enhance transportation access to child health care services. This report describes the efforts involved in creating a new measure of children's health care accessibility – The Children's Health Fund Health Transportation Shortage Index (HTSI).

As an ongoing project over the past two years, the original goal was to develop a complete and robust measure of children's accessibility to transportation and primary health services at this point in time. Data challenges in terms of availability, quality and completeness reduced the scope of the work to three metropolitan areas in Texas:

- Dallas County – Dallas, TX
- Harris County – Houston, TX
- Travis County – Austin, TX

We chose these three areas largely based on the realities of the data available to us. While disappointingly narrow in scope, the continued focus on Texas and these three metropolitan areas had a number of serendipitous effects. Most notably, we gained great insight into the quality and availability of many potential data sources. As our familiarity with the data grew, we can now better estimate to what capacities the HTSI can be refined and recreated in areas beyond Texas. In particular, this report details the intricacies, assumptions and sources of the data available going forward to create a more nationally recognized measure that can be deployed to improve access and most importantly, children's health and well-being.

Notable Findings:

- **Confidence in the Health Transportation Shortage Index methodology** – The creation of the HTSI was a key accomplishment. The HTSI is a relatively simplistic measure that can easily and quickly determine the extent to which transportation barriers are prevalent in by ZIP Code tabulation area (ZCTA). In developing the HTSI, we were able to establish the primary covariates of transportation barriers by modeling those against the rate of children's avoidable ED utilization.

- **Weighted Transportation Accessibility Index** (WTAI) – In our pursuit of the HTSI, we developed a sub-measure to gain further understanding of the interaction of public transportation and private vehicle ownership in a single measure. In addition, the WTAI was developed to coincide and complement national efforts to replace the outdated and methodologically flawed health professional shortage area (HPSA) and medically underserved area (MUA) designation. Where outcomes measures may be unavailable (i.e. hospital discharge data), this sub-measure can shed light on transportation barriers in a community as a whole.

- **Better understanding of the role transportation plays in health access.** Our analysis found a number of strong transportation-related relationships with children's emergency department (ED) use for avoidable health care conditions, also known as ambulatory care sensitive conditions (ACSCs). Among the strongest relationships were the ratio of vehicles to the population of driving age, distance to the nearest community health center or federally qualified health center, the severity of the HPSA score and the percentage of non-white children by ZIP Code.

II. Transportation Barriers and the Need for a New Measure of Child Health Accessibility

The Public Health Act of 1970 and the Mental Health Amendments of 1992 authorized the U. S. Department of Health and Human Services to designate Health Professional Shortage Areas (HPSAs). Today, the Shortage Designation Branch of the U. S. Health Services and Resources Administration (HRSA) administrates the program and is responsible for all designations. The HPSA designation is important to underserved areas as it provides a host of programs and resources to boost access to care by either bringing or encouraging health professionals to provide care in a specific geographic location or facility. For example:

- More than 37 federal programs depend on the shortage designation to determine eligibility or funding preference. These include National Health Service Corps, the Loan Repayment Program for Health Professionals, and Conrad-30/J1 visa waiver program;
- Many health care facilities depend on the benefits of shortage designation to provide access to care for their already underserved communities; and
- The designation provides incentives for physicians and other health care professionals to practice in underserved areas.

Despite the fact that there are programs to increase the supply of health professionals, there are few programs to ensure disadvantaged children have adequate transportation access to those services. Although transportation continues to be an increasingly cited barrier to care, as a nation we continue to have a poor understanding and few good policy solutions to increase transportation accessibility to primary health care services. Access to appropriate primary care will continue to be at the forefront of policy discussions as some 30 million previously uninsured Americans will likely gain health coverage through the passage of the Affordable Care Act (ACA) of 2010. We must ensure that investments made as a nation in providing health coverage are fully realized by reducing dependence on expensive and inefficient treatments through a coordinated medical home model. For those with transportation barriers, the value of the medical home in reducing disease burdens and ineffective care can never be realized. It is within this context that we attempt to define and quantify the relationship and impact transportation plays on children through developing the Children's Health Fund (CHF) – Health Transportation Shortage Index or HTSI.

Transportation Barriers to Health care Services – An Update of the Literature

In our review of the more current literature, we continue to find more instances where transportation is increasingly cited as a barrier to health and other social services (this is addition to the literature review reported in the Year 1 Report) (Borders, 2009). There appears to be a growing recognition among researchers and policy makers that many communities and subpopulations are suffering from transportation barriers as evidenced by the increase in research directed toward this key access barrier. For example, over half of all federally qualified community health centers (FQHCs) offer enabling services, such as transportation. Enabling services are particularly important for populations served by FQHCs who tend to have more barriers to access than the general population (Wells, Punekar, & Vasey, 2009). A recent study of low-income asthmatic children in Phoenix found transportation to be among the most frequently cited barrier to health care. Families without personal transportation reported difficulties with long commutes when utilizing public transportation for health and dental care appointments. They cited further barriers with picking up prescriptions from their local pharmacy. Despite the availability of non-emergency medical transportation (NEMT) services in Phoenix to Medicaid and SCHIP eligible children, less than 20% of qualifying parents utilized those services (Grineski, 2008). Other subgroups are disproportionately affected by transportation barriers, such as Native Americans. In Minnesota, Native American's reported transportation barriers at twice the rate of whites when accessing health care services (Call et al., 2006).

Non-Emergency Medical Transportation

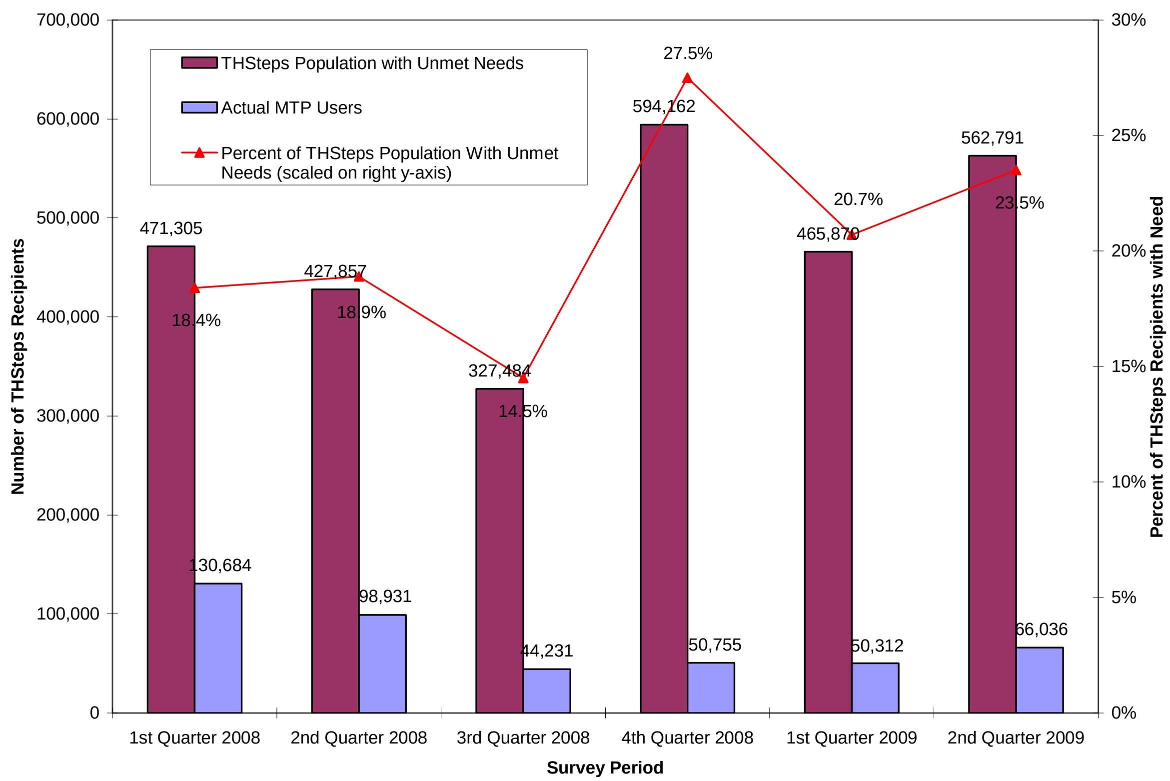
Recent budgetary constraints and policy shifts at the national level have incentivized states operating fee-for-service NEMT services through their Medicaid and Children's Health Insurance (CHIP) programs to move to capitated models through brokerage programs as part of the Deficit Reduction Act of 2005 (Pub. L. 109-171). Section 6083 of the Act amended section 1902(a) of the Social Security Act that permits states to implement a capitated brokerage program without a obtaining a section 1915(b) waiver from the Centers for Medicare and Medicaid Services (CMS). States have typically sought 1915(b) waivers in such instances to restrict freedom of choice of providers, selectively contract with brokers, and operate their programs differently in different areas of their respective states.

Perhaps the most compelling reason for states to move from traditional fee-for-service NEMT programs to a capitated brokerage model is the change in Federal Medical Assistance Percentages (FMAP). Prior to the Deficit Reduction Act of 2005, states could claim expenditures for NEMT services in one of two ways: as an administrative expense or as medical assistance. Administrative expenses receive a FMAP rate of 50%. The FMAP rate for medical assistance is calculated on the average per capita income in each state and the nation as a whole. The formula is designed to provide states that have lower per capita income compared to the U.S. with a greater share of financial assistance. The statute contains both minimum and maximum percentages so no state will have to pay for more than 50% of the cost and the federal government will not pay for more than 83% of the cost. In FY 2011, Texas' FMAP rate was 60.56%. As part of the American Recovery and Reinvestment Act (ARRA) of 2009, the federal government provided an increased FMAP rate for states for 27 months to help offset higher Medicaid costs in a weak economy, giving Texas a FMAP rate of 72.39%. In effect, the Deficit Reduction Act permits states to move NEMT services from an administrative expense to a medical assistance service through the utilization of a transportation brokerage model that permits states to be compliant with the direct vendor payment requirement of the Act. As a result, many states have moved or continue to expand capitated brokerage models to deliver NEMT services to their Medicaid populations. Although there is scant literature on the effectiveness of capitated brokerage models in delivering NEMT services, a 2009 article found that although capitated brokerage models in Kentucky and Georgia increased NEMT expenditures for asthmatic children, the incremental costs of increased NEMT utilization was lower than the costs associated with increased medical costs (J. Kim, Norton, & Stearns, 2009).

Transportation and Health care Accessibility in Texas

Texas continues to be an appropriate state to examine children's transportation barriers to health care services. In 1993, the case of *Linda Frew, et al. v Michael McKinney et al.* (McKinney was the Commissioner of the Texas Health and Human Services Commission at the time) was filed alleging that the Texas Medicaid program was failing to ensure access to check-ups as well as to medically needed follow-up care. In 1994, the court certified the case as class action. The "class" therefore became composed of all children enrolled in the Texas Medicaid program. The case raised a number of issues related to children's access to health services, including preventive care access, specialty care, transportation, dentistry, and medical case management. Some 17 years later, the State of Texas remains under a Corrective Action Order to improve services and access to care. In particular, NEMT services remain an area of concern by the court and the plaintiffs'. A recent evaluation of the Texas NEMT program found that children on Medicaid continue to have unmet transportation needs. An 18 month study found that approximately a quarter or about 475,000 children receiving Medicaid services had unmet transportation needs each quarter (see Figure 2). Another 30% or 600,000 of all children on Medicaid missed routine health and dental appointments because of transportation barriers (Borders, Chaudhuri, & Dyer, 2010). A 2006 study in Houston further corroborates the existence of transportation barriers in Texas. In their study, investigators analyzed the impact of transportation problems on a family's ability to keep a health care appointment. The authors found that as household size increased, the likelihood of the child to miss his or her appointment also increased. Among children that missed an appointment, their family was less likely to own a car as compared to families that did own a car (Yang, Zarr, Kass-Hout, & Kourosh, 2006).

Figure 1: Estimated Percent and Number of Medicaid-Covered Children with Unmet Transportation Needs in Texas



Source: Evaluation of the Texas Medical Transportation Program: Final Report, 2010

Despite the ongoing problems related to NEMT, Texas policy makers have recognized that transportation barriers exist in Texas for some time. When designing the State Children's Health Insurance Program (SCHP), now simply known as CHIP, benefits package in Texas, NEMT benefits were originally considered as part of the benefits package as a critical component to access. Unfortunately, after cost and other considerations by state officials, NEMT services were dropped from the final benefits package. This is not uncommon as most states implementing a separate state model (as compared to a Medicaid expansion), did not include NEMT services in their CHIP programs (Borders, Blakely, Ponder, & Raphael, 2011).

III. The Conceptual Model

The conceptual model was developed with the intention as a guide to develop baseline measures of transportation and health accessibility. The conceptual model reflects a wide range of key health factors associated with children's health outcomes based on the Healthy People 2020 model of the determinants of health and the associated outcomes.

Transportation and Health care Accessibility

Even the most cursory literature review of the terms "accessibility" and "transportation" reveals a similarly long list of definitions, concepts, constructs and models when compared to the terms "accessibility" and "health care". Although researchers have long been interested in capturing health care accessibility in terms of transportation, recent advances in geographic information systems (GIS) technology have advanced the study in recent years (Martin, Wrigley, Barnett, & Roderick, 2002). In their 2002 paper, Martin et al. go on to summarize recent strategies in measuring health care accessibility in terms in analyzing the integration of private and public transportation measures, as well as the challenges that remain. In particular, they analyze how the field has evolved over recent years while noting the strengths and weaknesses of current modeling. For example, population density and "crow fly" or straight line distances are often less than adequate proxies for modeling health outcomes. Despite their shortcomings, the availability of detailed transportation measures continues to present challenges in modeling health outcomes, resulting in the continued need and use of proxy variables such as these.

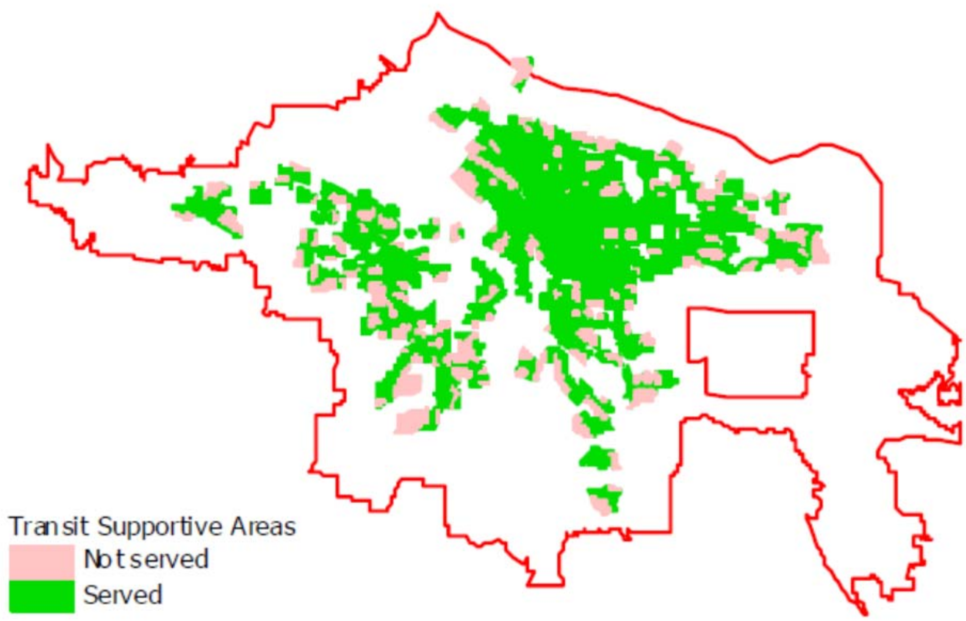
There are a number of means to measure the availability of transportation, reflecting different perspectives relating to the users of transportation, travel modes, land use, and performance indicators. Performance measures can further be segregated into subcategories, such as satisfaction, travel time, costs and reliability (Meyer & Schuman, 2002). With respect to accessibility, most transportation planners and researchers maintain it is the ultimate goal. Their assumption is based on the premise that improving mobility has net benefits to society. Yet similar to health care, accessibility is difficult to evaluate because it is impacted by a number of exogenous factors (Littman, 2003). For example, health care access can be affected by the location, quality and availability of the provider, the availability of health insurance and of course, transportation barriers. As such, it is the desire to better understand how the intersection of transportation and health care accessibility impact children's health.

One of the most challenging aspects of the project in Year 2 was developing more appropriate and sensitive measures of transportation accessibility, especially with respect to the availability of public transportation. Typically, public transportation researchers evaluate system accessibility through several factors (Transit Cooperative Research Program, 2003):

- *Spatial availability:* Where is service provided, and can one get to it?
- *Temporal availability:* When is service provided?
- *Information availability:* Does the customer know how to use the service?
- *Capacity availability:* Is passenger space available for the desired trip?

While each of these factors related to transit accessibility, we narrowed our definition primarily to spatial domains shaped by reviewing three separate transit accessibility measures. Although developed before the wide spread utilization of Geographic Information Systems (GIS), the Local Index of Transit Availability (LITA) (Rood, 1998) measures the intensity of the transit network within a given area using transit and census data. The LITA measures such things as the comfort and convenience of the transit service by accounting for vehicle type and capacity. The LITA is utilized primarily by property developers to judge where development projects requiring public transportation services are most likely to benefit from those services. The Time of Day Tool (ToDT) (Polzin, Pendyala, & Navari, 2002) measures temporal availability of transit against estimated travel demand on an hourly basis. Although potentially intriguing for the project, the complexity of the data required calculating the ToDT quickly rendered it unsuitable for a project of this scale. The Transit Capacity and Quality of Service Manual (TCQSM) (Transit Cooperative Research Program, 2003) was the model from which we based our transportation accessibility measures. The TCQSM incorporates GIS methodologies to calculate service coverage based on a .25 mile radius from each transit stop. The measure also includes Census data on household and job density to identify areas that public transportation could theoretically support, but that are not currently served by public transportation systems – what they deem as transit supportive areas as detailed in the figure below.

Figure 2: Transit-Supportive Areas: Served and Not Served



Source: Transit Cooperative Research Program, 2003

Factors Associated with Transportation and Health care Accessibility

The Agency for Healthcare Research and Quality (AHRQ) defines health disparities as the differences or gaps in care experienced by one population compared with another population. Although typically thought of in terms of race or ethnicity, health disparities exist across many dimensions to include such things as sex, socioeconomic status and geographic location. Each of these dimensions contributes to the overall health of the individual. Although the U.S. spends ($7,720) more than twice the per capita average on health care expenditures ($3,101) among all 34 Organization for Economic Co-operation and Development countries (OECD, 2011), health disparities have been evident for years in the U.S. Many children simply do not receive the care they often need while others receive substandard care (Agency for Healthcare Research and Quality, 2009).

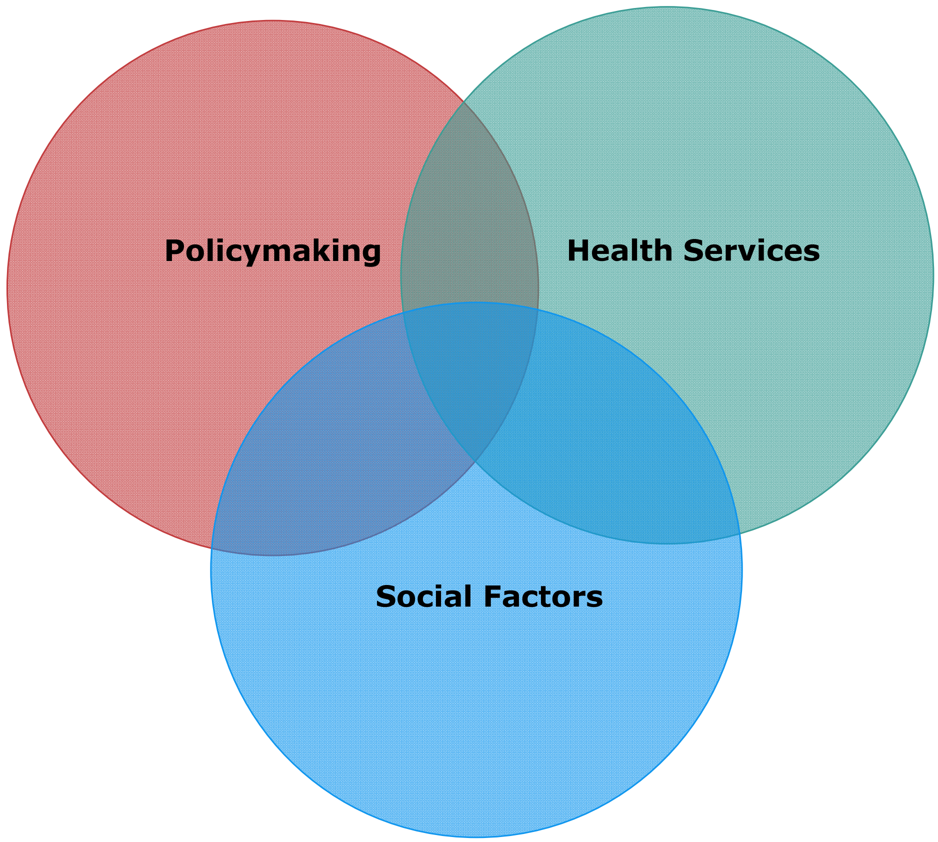
Eliminating health disparities is a major national policy objective. The U.S. Health and Human Services has led the charge to reduce health disparities and improve the health of all Americans through the Healthy People initiative, a science-based, 10-year benchmarking and monitoring program. Health disparities are often exacerbated by a range of personal, social, economic, and environmental factors that influence health status, known as the determinants of health. These factors are often interrelated and reach beyond merely the delivery of health care services, recognizing that a more holistic approach to improving population health must include areas such as education, housing, the environment and transportation. The Healthy People 2020 framework segregates health determinants into one of five broad categories (U.S. Health and Human Services, 2010):

- Policymaking;
- Social factors;
- Health services;
- Individual behavior; and
- Biology and genetics.

Using the Healthy People 2020 determinants of health framework as a guide, we considered a multitude of potential factors and variables for consideration in our measure across each of the five domains. After further applying the lessons learned from the Year 1 project, it became clear that many of the variables or factors that appeared important to analyzing transportation and health accessibility would not necessarily fall neatly within one of the five aforementioned domains. Further, data related to at least two of the domains; individual behavior and genetics were ill suited for this analysis. For example, we know little about the individual behaviors of parents and their children at the level desired for this analysis. In addition, biological and genetic factors were also similarly absent.

Given data availability, we arrived at adopting three of the five Healthy People 2020 determinants of health domains: policymaking, health services and social factors (see Figure 3). The conceptual model is designed to demonstrate the interconnectedness and non-exclusivity of each the three domains. For example, lack of affordable and accessible transportation in many areas could be considered both a policymaking problem as well as social factor. Between 1950 and until recently, the U.S. developed a modern highway system, driven largely by President Eisenhower's appreciation of the German Autobahn during his time as Supreme Commander of the Allied forces during World War II (Puentes, 2008). While the Eisenhower Interstate System officially ushered in America's fascination with the automobile, it did so at the detriment of other forms of transportation. Privately provided passenger rail service in the U.S. all but vanished after World War II leaving behind Amtrak, a government owned corporation. While the post-war highway building boom eased work and recreation-related travel, it did so primarily only for those with access to an automobile (Gutfreund, 2004). Today, those without access to an automobile or those with limited access to an automobile due to difficulties with operating expenses such gasoline, insurance and maintenance are likely to come from low-income households (Surface Transportation Policy Project, 2003b; Waller, 2005)

Figure 3: Conceptual Model: Determinants Impacting Children's Accessibility of Transportation and Primary Health care Services



Outcomes Associated with Transportation and Health care Accessibility

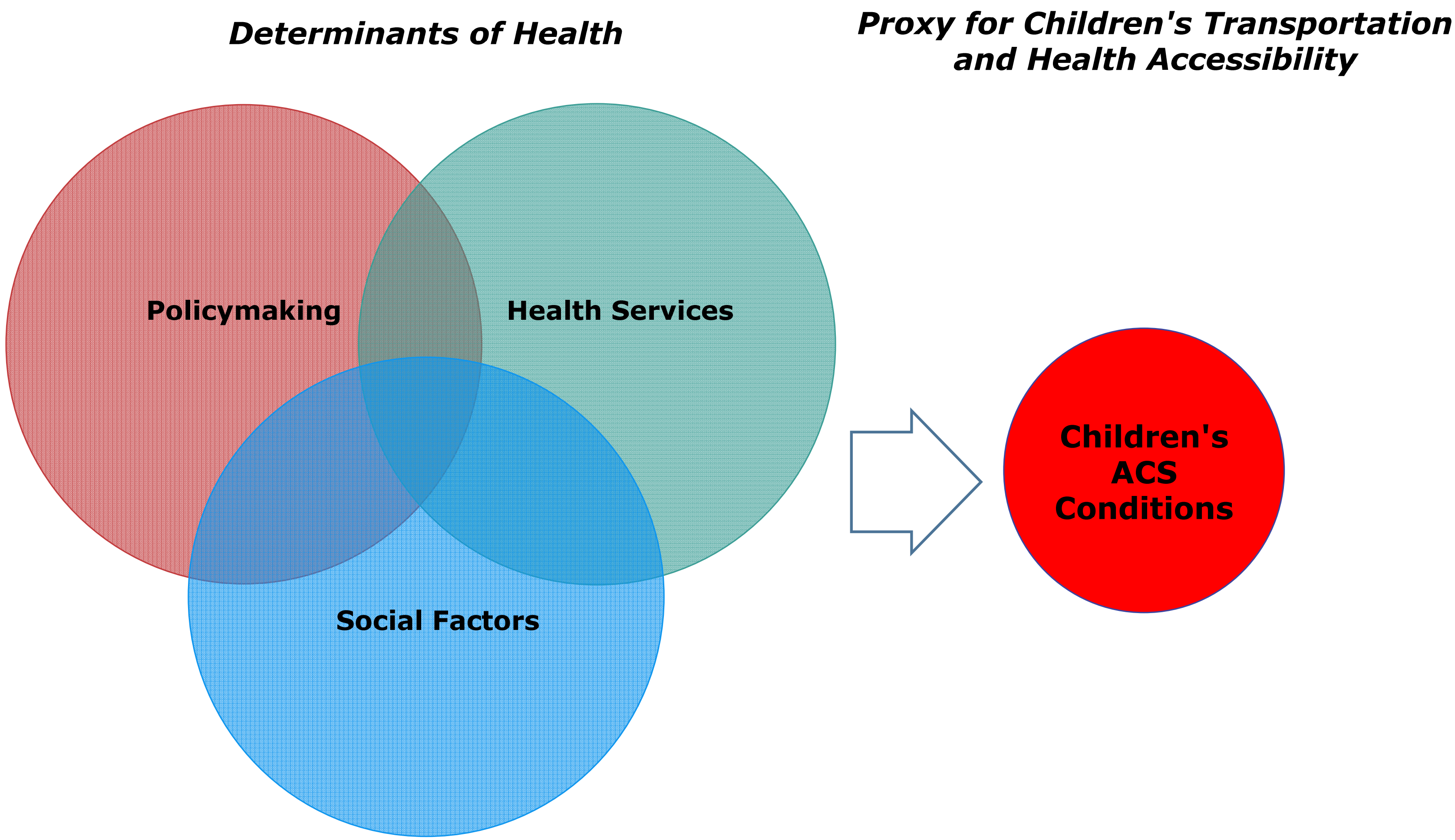
While the determinants of health (i.e. income, ethnicity, provider availability) are related to accessing health care services, they do not measure access. There are many dimensions to measuring access to health care services. Definitions of health care access can be defined in many ways, but generally fall into one of two camps. Many researchers examine the extent to which people are actually utilizing health care services. This is often accomplished through surveys using self-reported measures of utilization or by examining health care data. Others focus on more probabilistic forms of access, such as examining the presence of health coverage. Health coverage is an important accessibility variable within the U.S. health care system for the simple reason some type of payment mechanism is typically viewed as a requisite for entry to the health system outside of emergency situations. In addition, consistent health insurance coverage is also highly associated with the receipt of appropriate preventive care with those having no or inadequate health care coverage often report lower rates of primary care access and higher rates of more expensive and less effective emergency care (DeVoe, Fryer, Phillips, & Green, 2003). By examining utilization and or the presence of health care coverage, researchers employ such approaches to measure access disparities. Disparities in utilization often point to problems or access barriers to care while those without health insurance or inadequate coverage are also at-risk for suffering access barriers, though they are more difficult to quantify.

In Year 1 of the project, we devoted significant time and effort in analyzing how to measure the extent to which children are impacted by transportation and health accessibility barriers. We arrived at analyzing children's rates of emergency department (ED) utilization. The appropriateness of ED utilization is often analyzed by looking at a subset of the admissions, called ambulatory care sensitive conditions (ACSCs). ACSCs are groups of diagnoses that are related to health care accessibility, especially in the realm of primary care services. Researchers have argued that certain conditions like asthma and diabetes are ACSC—that is, hospitalization is largely preventable by timely and appropriate primary and preventive health care. Thus, high rates of hospitalization for these conditions serve as indicators of a need for better or appropriate primary care.

While transportation barriers surely impact many forms of health care services, such as those with disabilities or in need of specialty care, the goal of this project was to focus singularly on transportation's impact on primary care. Timely and appropriate primary care is critically important, especially for children. Among children receiving preventive care, they were generally found to receive comprehensive and coordinated care, antecedents for appropriate development and good outcomes. Children that have a usual source of care, also commonly known as the "medical home", are also more likely to have reduced avoidable hospitalizations and ED visits (Carrier, 2009). A study of Medicaid-eligible children in Georgia, California and Michigan found that among children that receiving all age-appropriate well-child care, avoidable hospitalizations were reduced between 30 and 48% (Hakim & Bye, 2001).

Given the desire to understand how the confluence of health determinants related to transportation and health care accessibility impact children's health and well-being, we arrived at a full conceptual model (see Figure 4). This conceptual model provided the basis of the approach to the work whereby the rate of children's ACSCs is used as the proxy for accessibility. The full conceptual model is designed to demonstrate the approach to isolate the logical relationships of transportation, health services and social factors on access to children's primary care services.

Figure 4: Complete Conceptual Model: Determinants Impacting Children's Accessibility of Transportation and Primary Health care Services



Modeling Transportation and Health care Accessibility

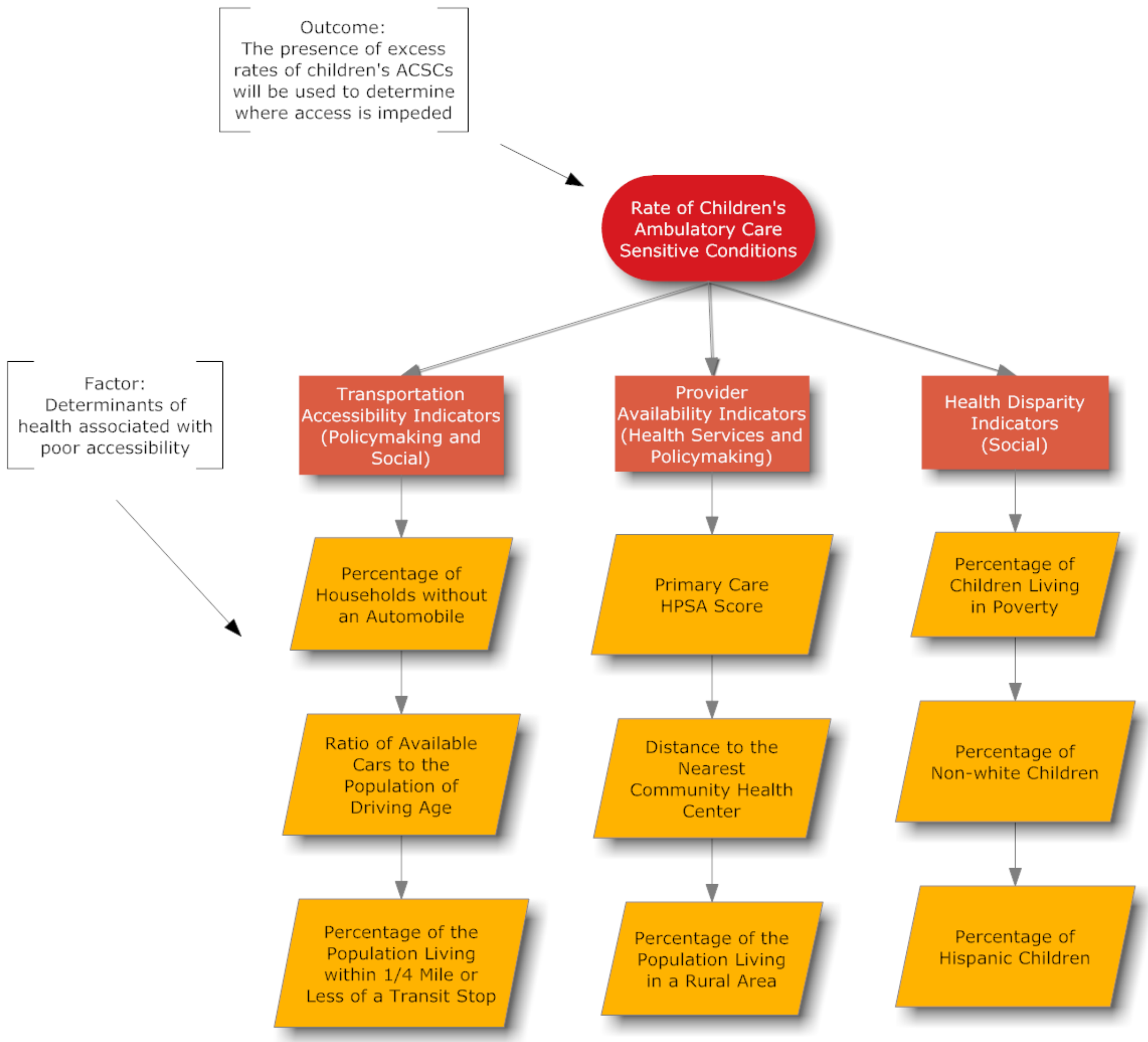
After developing our theoretical approach and constructs to measuring transportation and primary health care accessibility, we identified a number of potential factors for the model. This process resulted in the culling of an initially large group of variables or factors into a smaller, more manageable set of factors. Perhaps most importantly, the data reduction step resulted in a more predictive set of factors that resulted in building out the theoretical model into an operational model. The data reduction procedure resulted in the variables being placed into one of two theoretical constructs:

1. Outcomes – children's rate of ACSCs, and
2. Factors – traits associated with ACSCs.

As discussed earlier, primary care and the well-child examinations that accompany those services are widely viewed as the cornerstone of children's health and wellness. The goal of appropriate and timely primary care is to identify children with actual or potential health problems and to screen, diagnose, and treat these problems before they become permanent, lifelong disabilities. Thus, the strategy of employing ACSCs as a proxy measure is based on the idea that examining these sentinel health events gives us clues about children's inability to access preventive services in a timely manner. The ACSC measure is the principle outcome variable in HTSI.

In Year 1 of the study, we examined and considered a multitude of factors associated with poor access to children's primary care services. After careful scrutiny of those variables, data availability and quality of those measures, we pared the list considerably. The final result was a model with nine (9) key factors that fall into the three broad determinants of health domains: policymaking, health services and social factors. Among the nine specific factors chosen for the final analysis, it is clear that the factors do not always fit neatly within the three broad determinants of health domains. Thus, we developed additional subcategories under the three determinants of health related to the specificity of the project.

Figure 5: Conceptual Model for Identifying Children's Transportation and Health care Disadvantaged Communities



IV. General Approach and Key Assumptions

Given the enormous amount of data that went into the project as well as lacking individual-level data on each child suffering poor health outcomes, finding proximal indicators to understand the extent to which transportation is affecting their access to health care services required a number of assumptions about the general approach to the project, data availability and the analysis. Each of the key assumptions of the project is detailed within this section.

Guiding Principles

While the conceptual model served as a framework from which to approach the issue of children's transportation and health accessibility to primary health care services, there were a number of other goals that also influenced the project. With an eye on applying the results from this research to shape national policy on children's transportation and primary health care accessibility, the goal of the Year 2 research was to build upon the lessons learned from the Year 1 analysis to produce a robust measure. The Year 1 efforts were largely focused on a detailed examination of the scope of the overall issue of transportation accessibility with respect to children's primary health care services. This analysis included a careful theoretical review of health care access constructs, current literature on transportation as it relates to health care barriers, and the potential data sources available to construct a measure of children's transportation and health care accessibility. The analysis of the data included the appropriateness and quality of potential co-variants of an overall measure. To align the research efforts with the overall policy goals of the project, we developed several guiding principles from which to adhere. These guiding principles were adopted from an ongoing effort to more accurately designate Medically Underserved Areas (MUAs) and Health Professional Shortage Areas (HPSAs) through an evidence-based approach. While the guiding principles acted as constraints on the MUA/HPSA model as well as the work completed within this report, these guidelines helped assure broad application and acceptance of the efforts to develop more robust and effective measures of health shortages (Ricketts, Goldsmith, Holmes, & Randolph, 2007). It is our hope that adhering to a similar set of guidelines will produce similar results:

1. *Simplicity:* The measure should be understandable and usable among a broad audience and wide-range of users (policymakers, clinicians, advocates) seeking to determine if their community suffers from transportation and health accessibility barriers. In developing a model, the measure should be parsimonious, limiting the number of factors comprising the model. In addition, it should be based on readily available data so that a score could be computed for most any area.
2. *Broad Based, Regularly and Consistently Measured:* All data utilized in the measure should be measured with regular frequency to demonstrate trends over time. They should also be representative of large segments of the population, yet sensitive enough to register appropriate change. Consistency in the measurement is also important so that any variation in values is representative of true variation and not random error.
3. *Science-Based:* While there is a plethora of literature linking transportation as a significant barrier to health care, there is limited literature quantifying the impact. The scientific evidence should be grounded in research which demonstrates a strong relationship between transportation barriers and children's health care outcomes through a robust and verifiable statistical relationship.
4. *Community-focused:* Vulnerable children and their families often live within local communities that are the explicit targets of policy initiatives. Comparing children's health outcomes across communities within a larger geographic area, such as a city or county, can reveal inequalities that are more sensitive to levels of need. Greater geographic precision often brings greater sensitivity with respect to the measures of interest, offering indications where limited resources should be targeted. Counties and cities are the sum of smaller, often disparate "communities" of people sharing a particular characteristic in common. To more closely approximate community

analysis, data must be available to support analysis suitable for assignment for geographies smaller than the county level.

5. *Replicability and Comparability:* In the effort to drive national discussions and interest in improving children's accessibility to primary health care services, replication of the measure across all 50 states is the ultimate goal. Within state comparisons are less useful because of the desire to influence policy at a broad level. In addition, focusing on potential measurement replication and comparability from the outset will provide baseline measures from which to build upon should further analysis and refinement of the measures be required. Furthermore, should policy interventions be deemed appropriate, a replicable measure can provide guidance about where policy interventions are likely to have the greatest impact and establish baseline measures from which to evaluate any intervention.

In developing the HTSI, we evaluated the leading efforts across the country to learn from the success of respected researchers in the field and to replicate methodologically sound approaches when appropriate. While the approach we have taken cannot be fully attributed to a single source or model, three models were most influential in developing the approach and analysis within this report:

- HRSA's and The Cecil G. Sheps Center for Health Services Research at The University of North Carolina at Chapel Hill's *Designating Places & Populations as Medically Underserved: A Proposal for a New Approach* (http://bhpr.hrsa.gov/shortage/proposedrule/designatingplaces.html) (Ricketts, et al., 2007);
- The United Kingdom's *English Indices of Deprivation* (http://www.communities.gov.uk/publications/corporate/statistics/indices2010) (Bradshaw et al., 2009), and;
- The University of Wisconsin Population Health Institute's *County Health Rankings* (http://www.countyhealthrankings.org).

Geographical Unit of Analysis

In our efforts to examine transportation and primary care service accessibility at a "community" level, ZIP Code Tabulation Areas (ZCTAs) were chosen as the unit of geographic analysis. ZCTAs are a statistical geographic entity produced by the U.S. Census Bureau for tabulating summary statistics, first developed for the 2000 Census. ZCTAs are generalized area representations of U.S. Postal Service (USPS) ZIP Code service areas. They represent the most frequently occurring five-digit ZIP Code found in a given area. Simply put, each ZCTA is built by aggregating 2010 Census blocks, whose addresses use a given ZIP code. Each resulting ZCTA is then assigned the most frequently occurring ZIP code as its ZCTA code (U.S. Census Bureau, 2011b).

ZCTAs are not without their problems or critics because for the simple reason that they were created not to analyze health disparities, but to increase the efficiency of the U.S. Postal System. The term ZIP Code is an acronym for Zone Improvement Plan and presents challenges to researchers because ZIP Codes are highly dynamic, changing periodically to meet operational needs. In addition, they do not adhere to the same standards more associated when performing demographic and spatial analyses on more well defined features, such as those developed by the U.S. Census (i.e. Census tracts or blocks), adding error to the results if not corrected (Grubesic & Matisziw, 2006). Furthermore, there is no relationship between ZIP Codes and U.S. Census geography. ZIP codes can cross all geographies, such as states, counties, tracts, etc. (U.S. Census Bureau, 2010) introducing the greater potential for measurement error.

While ZCTAs are not the preferred geography for spatial analysis, we selected this unit of analysis because it was the best available option. This was chosen primarily because of the tradeoffs between the desire to assess accessibility problems at more localized levels of geography and privacy concerns complicated by differing interpretations of the Health Insurance Portability and Accountability Act of 1996 (HIPPA) among database owners. For example, while all of the work within this report is specific to the State of Texas, other state hospital associations and/or public health departments maintain hospital discharge datasets. Key, however, is that not all states even gather these data consistently nor make them publicly available. Further, some states such as Illinois that do make data publicly available often do so by limiting identifying data to the county level, masking the very accessibility problems at localized levels we are seeking to address. The trend does seem to be moving toward greater openness and many states permit researchers to make applications for protected data (i.e. those that would have geographic identifiers). The Texas Department of State Health Services does make available a Public Use Data File (PUDF) that contains ZIP Code identifiers for each record that was the basis of this analysis and the primary reason for selecting ZCTAs as the unit of analysis. Although originally targeted for analysis by this project due to the well-documented health disparities among children, the State of Mississippi has only recently begun wide-scale collection of similar data and at this time. We continue to be in negotiations with officials from the Mississippi State Department of Health and Mississippi Hospital Association to obtain a similar dataset. In addition, a request to the Michigan Hospital Association (MHA) to obtain a similar dataset in Michigan that was recently approved by MHA, although we had not received the data at the time of this report.

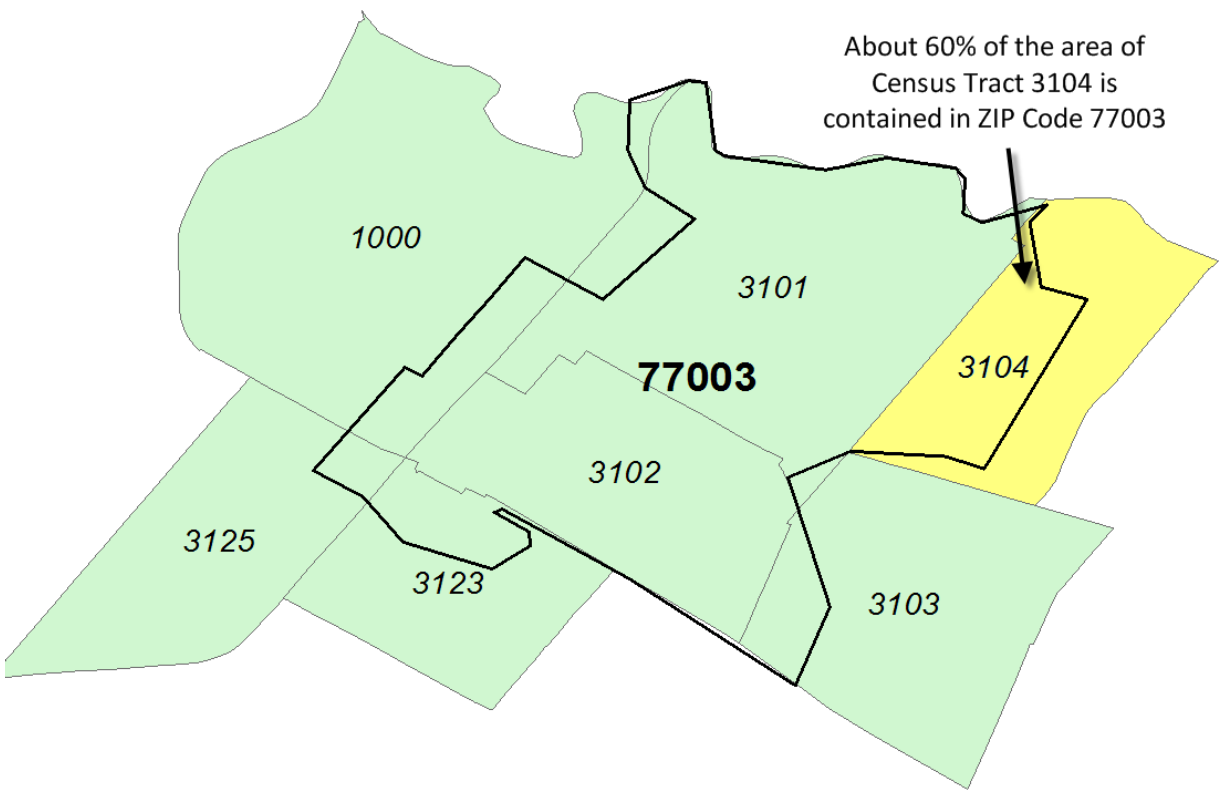
American Community Survey

Data from the American Community Survey (ACS) were instrumental in developing the socioeconomic factors for the analysis. ACS is a nationwide survey designed to provide communities a fresh look at how they are changing and is a critical element in the Census Bureau's decennial census program. The ACS collects information such as age, race, income, commute time to work, home value, veteran status, and other important data. In 2010, the Census Bureau released the first 5-year estimates for small areas, such as Census tracts.

The U.S. Census Bureau determined that given the rapid U.S. demographic change, detailed data collection as part of the decennial census was no longer acceptable for producing the type of information required by the Federal government, states, municipalities and many other users of that information. In 2010, every residence received a short form of just 10 questions. The more detailed socioeconomic information previously collected through the long-form decennial census based on statistically valid sampling procedures was scrapped in favor of the American Community Survey (ACS). The ACS was fully implemented in January of 2005 and collects detailed population and housing data every month. The data are tabulated on a yearly basis providing more timely information for critical economic planning by governments and the private sector. In the current information-based economy, federal, state, tribal, and local decision makers, as well as private business and nongovernmental organizations, need current, reliable, and comparable socioeconomic data to chart the future (U.S. Census Bureau, 2008).

The smallest geographic area made available for these data were at the Census block group level. While data were available at the Census block group, we found ACS data at the Census tract level, however, to be the most complete for our purposes. Data at the ZCTA were not available at the time of this analysis although the U.S. Census Bureau will be releasing estimates at this level in the future. Socioeconomic data were available at the ZCTA from the 2000 Census, but we determined the data to be outdated and not representative of a state experiencing rapid demographic change such as Texas. We therefore were faced with the challenge of obtaining the most recent socioeconomic data within our chosen geographical unit of analysis, the ZCTA. Because Census tracts are not direct subsets of ZIP Codes, using the Geographic Information System (GIS) software ArcMap and Geographic Correspondence Engine created by John Blodgett at Office of Social and Economic Data Analysis at the University of Missouri, we developed estimates for the socioeconomic factors at the ZCTA area. The Geographic Correspondence Engine permits the examination of the relationships between different geographies (Blodgett, 2010). Using 2000 Census tract geography, we used the Geographic Correspondence Engine to estimate the proportion of each Census tract to assign to each ZCTA. The ZCTA 77003 is a ZIP Code within Houston, TX (see Figure 6). Seven Census tracts are fully or partially contained within ZCTA 77003 by estimating the amount of area each of the seven Census tracts shown below are contained within ZCTA 77003 based on the polygon's weighted center. The weighted center of the polygon is a function of the geography of the polygon and the population density. Thus, the calculations do not assume that the population is evenly distributed across each Census tract. For example, the weighted centroid estimate obtained from the Geographic Correspondence Engine estimated that 60% of the population of Census tract 3104 was contained within ZCTA 77003.

Figure 6: Sample Census Tract Apportioning to ZIP Code Tabulation Areas



The apportioned value of the Census tract area within the boundaries of the corresponding ZCTA serves as the weight. The weight is then then multiplied by the by the ACS 5-Year estimate value of each socioeconomic variable. The product of each calculation is then summed for each socioeconomic variable of interest across each Census tract to develop the final ZCTA estimates. The table below depicts an example of how the estimates for children's poverty level were calculated for ZCTA 77003.

Table 1: Sample Calculation for Developing Estimates from the American Community Survey at the ZIP Code Tabulation Area

Census Tract	Number of Children Living Below Poverty (From 5 Year ACS Est.)		Proportion of Census Tract Apportioned to the ZCTA 77003		Estimated Number of Children Living in Poverty Apportioned to ZCTA 77033
1000	72	X	0.9%	=	0.65
3101	745	X	98.0%	=	730.1
3102	190	X	100%	=	190.0
3103	567	X	4.8%	=	27.2
3104	370	X	60.0%	=	222.0
3123	204	X	11.2%	=	22.9
3125	149	X	0.8%	=	1.2
Total					**1,194.0**

Variable Standardization

We standardized each measure at the ZCTA level in order to facilitate accurate and easy comparisons in the desire to create a single overall measure of health and transportation barriers or the HTSI. Because some measures are in a number of different scales (i.e. some are percentages, some are rates or some are distances), standardizing each of these measures transforms them into the same metric. This gives each individual indicator a mean (average) value of 0 and a standard deviation (measure of spread) of 1. In statistics, we call this a z-score.

The z-score developed for each Census tract is relative to balance of the remainder of the study area for the particular metric. A positive z-score indicates a value for the ZCTA that is higher than the average as compared to the rest of the study area while a negative z-score indicates a value for the ZCTA that is lower than the average of study area. It is important to note that the results as reported within the following maps do not represent statistically significant differences and should not be construed as such. The z-score simply provides a relative assessment of each ZCTA as a single unit of analysis, compared to the overall average from which it is being measured against.

Data Limitations - Ambulatory Care Sensitive Condition

While the ultimate goal of the project was and remains to develop a the HTSI for the entire country, our efforts to extend the analysis even to the entire State of Texas were throttled due to two unanticipated data challenges related to the hospital discharge dataset and public transportation data. Although we were cognizant of several limitations associated with the Texas Department of State Health Services Hospital Discharge dataset, we underestimated the degree to which the limitations would stymie the research. Recall that the key outcome variable, the rate of children's ACSCs by ZCTA, was derived from this PUDF. Without this key outcome variable, it was impossible to determine precisely where children were truly suffering from accessibility problems.

The State of Texas exempts a number of facilities from reporting to the hospital discharge dataset (Texas Department of State Health Services, 2008):

> "Exempt facilities include those located in a county with a population less than 35,000, or those located in a county with a population more than 35,000 and with fewer than 100 licensed hospital beds and not located in an area that is delineated as an urbanized area by the U.S. Bureau of the Census (Section 108.0025). Exempt hospitals also include hospitals that do not seek insurance payment or government reimbursement (Section 108.009)."

Furthermore, data are suppressed to protect patient confidentiality. In the PUDF, the following data elements were suppressed (Texas Department of State Health Services, 2008):

- The last two digits of the patient's ZIP code are suppressed if there are fewer than thirty patients included in the ZIP code.
- The entire ZIP code is suppressed if a hospital has fewer than fifty discharges in a quarter.
- The ZIP code is changed to '88888' for patients from states other than Texas and the adjacent states.
- The entire ZIP code and gender code are suppressed if the ICD-9-CM code indicates alcohol or drug use or an HIV diagnosis.
- The entire ZIP code and provider name are suppressed if a hospital has fewer than five discharges of a particular gender, including 'unknown'. The provider ID is changed to '999998'.
- The country code is suppressed if a hospital has fewer than five discharges from a particular country.
- Age is represented by 22 age group codes for the general patient population and 5 age group codes for the HIV and alcohol and drug use patient populations.

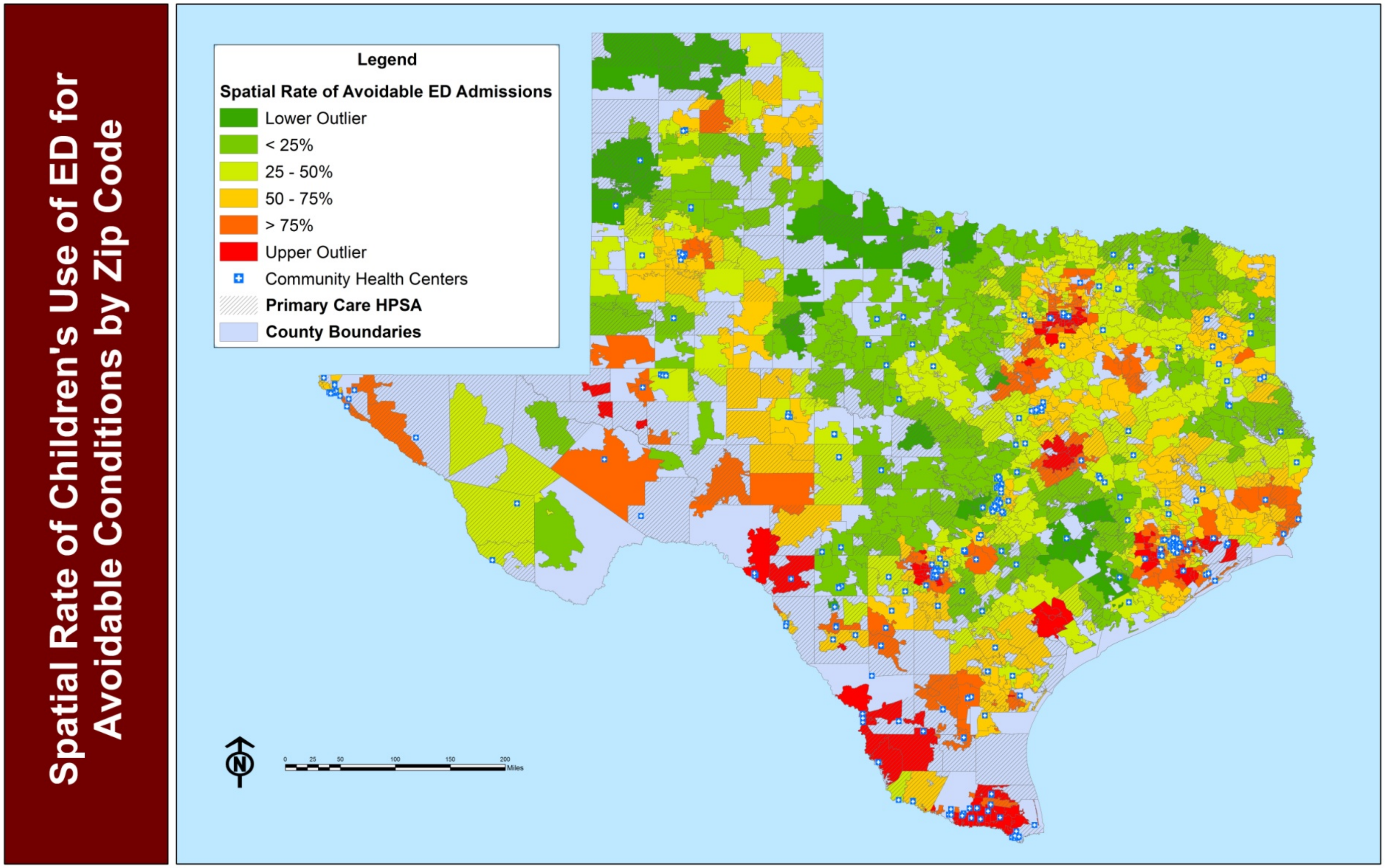
- Race is changed to 'Other' and ethnicity is suppressed if a hospital has fewer than ten discharges of a race.
- All facility type indicators are suppressed if a hospital has fewer than fifty discharges in a quarter and the provider ID is changed to '999999'.

As we began to analyze the hospital discharge data in detail, it became clear that there were extremely high rates of missing values in the rural areas of Texas. To estimate the impact of the underreporting, we examined all "short-term" and "Critical Access Hospitals" (CAH) operating in Texas through a HRSA database (Health Resources and Services Administration, 2011a). Although it is difficult to determine the exact number of hospitals that did not report into the database, there are 418 licensed hospitals in Texas designated as either CAH or short-term. Not all of the 418 hospitals were acute care hospitals that were likely to admit children suffering from ACSCs as the hospital name seemed to indicate it was a surgical center. These surgical centers typically had only a few beds. Simply eliminating obvious facilities that are excluded from reporting to the database, 79 were CAHs and another 178 facilities had fewer than 100 beds, suggesting that more than half of all hospitals in Texas were exempt from reporting. Low reporting among rural hospitals and data suppression to protect confidentiality severely impacted our ability to analyze the rural areas of Texas.

We attempted to estimate ACSC rates in the rural areas of Texas using data we were much more confident in from the state's largest urban areas. An Empirical Bayes (EB) was suggested by several colleagues as a possible technique (among others) to develop stable ACSC rates across the rural ZCTAs in the state. The EB approach is a smoothing technique whereby raw rates are "shrunk" towards the overall statewide mean or average. In essence, the EB technique uses a weighted average derived from the raw rate for each ZCTA and the state average, with weight being proportional to the underlying population at risk. Simply put, small (in terms of population) ZCTAs will tend to have their rates adjusted considerably while the rates for the larger ZCTAs barely change (Anselin, 2005). EB smoothing techniques have been used for other health studies to develop stable rates in areas with small populations. For example, this technique was applied to Sudden Infant Death Syndrome (SIDS) data in North Carolina and was credited with shrinking unstable estimates and stabilizing the variance thereby producing models with greater accuracy (Berke, 2004).

We ran the analysis numerous times using different weighting assumptions and dropping outliers to build at least a small, but representative set of rural ZCTAs from which we could infer to adequately represent the rate of children's ACSCs. After several adjustments and iterations of the model, we determined that the missing data in the more rural ZCTAs was too much to overcome to develop reliable estimates. An example of one of the EB smoothing models is displayed in Figure 7. Although there are no urban or rural designations delineated in Figure 7 – when measured against the overall average for the state, the urban areas of Texas were consistently above the mean while the majority of the rural areas of the state were consistently below the mean. While this outcome is possible, the preponderance of literature documenting problems with health care accessibility in rural areas seemed at odds with our derived estimates.

Figure 7: Empirical Bayes Smoothing of Children's Avoidable ED Admissions



Rural Public Transportation Data Limitations

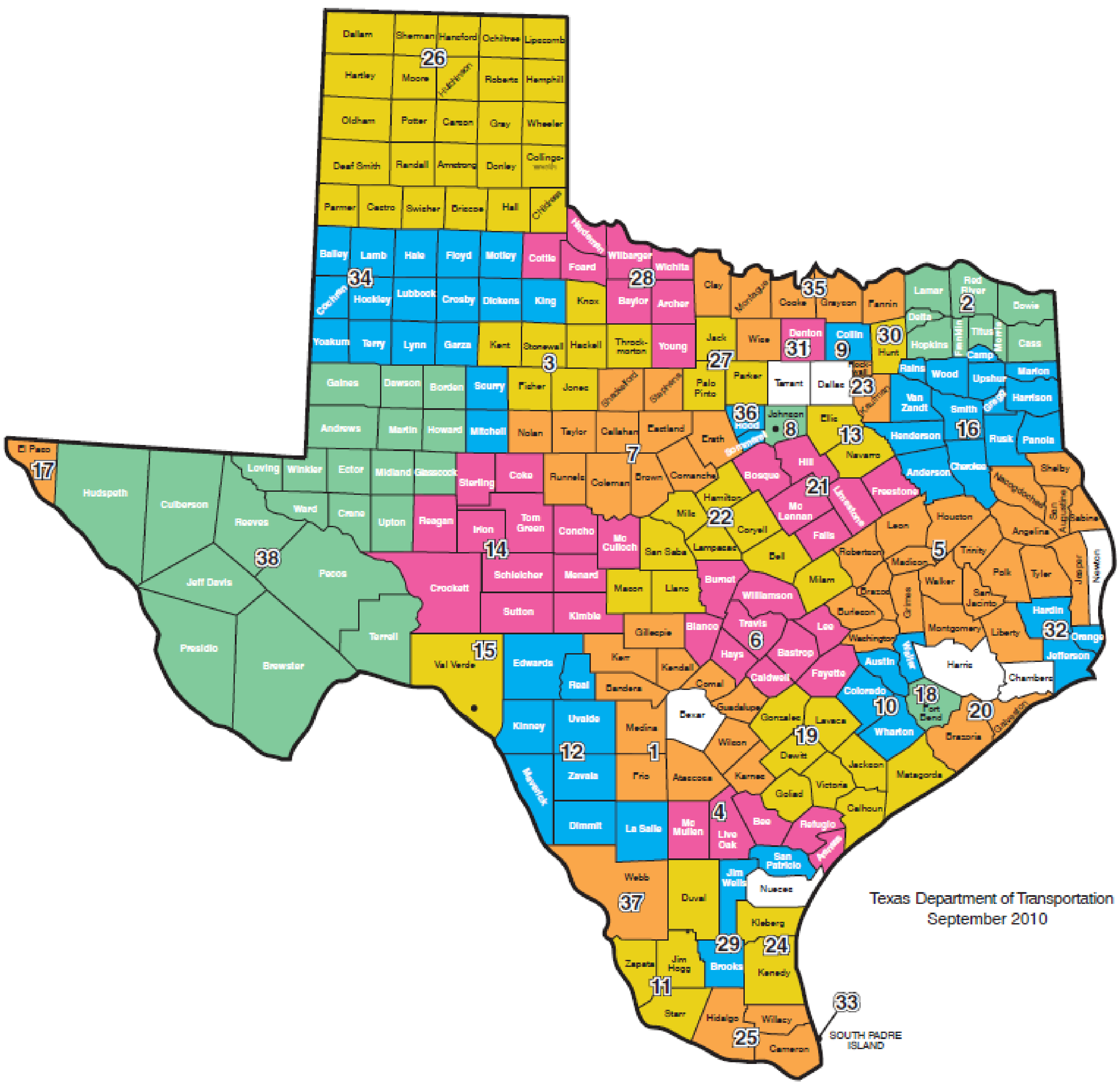
Historically, rural transit systems were implemented to respond to the mobility needs of the elderly. In 1999, some 319 non-profit agencies within the State of Texas provide transportation services primarily to the elderly and individuals with special needs in rural area (Turnbull, Dresser, & Higgins, 1999). Although virtually all rural transit systems in Texas do provide services to low-income populations, they are typically not "fixed route" bus systems with which most people associate with public transportation. While several of the transit accessibility measures discussed in Section II of the report were found to be potentially useful for urban transit models, they were much less useful for assessing rural transit for the simple reason that most rural transit systems do not offer conventional fixed-route, fixed-stop service that large urban transit systems do. Today, many are offering "flexible" services that are a sort of hybrid demand responsive type service; yet do not provide the kind of door-to-door services associated with taxis and para-transit. For example, rural transit systems offer services through route deviation where a small bus operates along a somewhat predefined route with a regular schedule, but can deviate from the route to accommodate off-rate passengers. Another flexible type of service is known as the zone route, where the bus accommodates service request within a defined area, but typically has fixed arrival and departure times for specific areas for each "zone" of the larger service area. The data for flexible routes and demand response services in rural areas are much less available than for the larger urban areas. In addition, the type of service offered does not lend itself to accessibility measures such as the Transit-Supportive Area analysis discussed earlier.

Data on public transportation systems are widely available through the National Transit Database (NTD) which is the Federal Transit Administration's (FTA's) primary national database for statistics on the transit industry. Federally funded public transportation systems operating in Urbanized Areas (UZAs) are required to report their data to the NTB. A UZA a statistical geographic consisting of a central core and adjacent densely settled territory that together contain at least 50,000 people, generally with an overall population density of at least 1,000 people per square mile (U.S. Census Bureau, 2003). The NTD maintains statistics on measures such as total expenditures, vehicle miles, revenue miles, service area square mileage, one-way trips, capital expenditures, etc. Data on rural public transportation providers are generally less available; however, we did receive a database of a similar set of metrics from the Texas Transportation Institute (TTI) at Texas A&M University. Federal support for rural public transportation programs comes largely from 5310 and 5311 program funding. The programs are named after the corresponding section of the United State Code that authorizes the program and funding. 5310 funding supports improvements to enhance accessibility and mobility for the elderly and for individuals with disabilities. 5311 funding specifically supports public transportation in rural areas, with population of less than 50,000. Although rural public transportation programs do have reporting requirements, they are less rigorous than those of larger urban public transportation programs.

As we began our analysis of small city and rural transit systems in Texas, we anticipated there to be large swaths of the state with no public transportation coverage whatsoever. Furthermore, we anticipated that we would be readily able to identify those areas as well. To our surprise, the entire state of Texas is theoretically covered by some form of public transportation (see Figure 7). Consider Rural Public Transportation System 38 that shares borders with portions of New Mexico and Mexico. West Texas Opportunities, Inc. is a non-profit organization dedicated to serving 17 counties. The program receives transportation funding through 5310 and 5311 program funding and is also a provider of Medicaid covered NEMT. Within the 17 county service area is Brewster County, the largest of Texas' 254 counties. Brewster County alone covers 6,193 square miles, which is bigger than Connecticut (5,544 square miles) or the combined area of Delaware (2,489 square miles) and Rhode Island (1,545 square miles).

Although there is little question that public transportation is available for those living in the 17 county area, the real question, especially with respect to the analytical and policy goals of this project are: To what degree is public transportation available and accessible in these rural areas? Unfortunately, this remains a critical, yet unanswered question.

Figure 8: Texas Rural Public Transportation Systems



Source: Texas Department of Transportation

V. Variable Definitions and Sources

The following section provides a detailed explanation of each variable that went into the development of the H. For each variable, we provide:

- Rationale for inclusion in the model;
- Detailed definition including the formula and variables;
- Data source; and
- A choropleth map of the analysis for Harris County, Texas as a visual representation of the analysis. Harris County is home to the City of Houston.

Transportation Accessibility Factors

Researchers are increasingly recognizing the importance of mobility on many fronts. The original Title XIX legislation that created the Medicaid program did not include language that required states to provide NEMT to and from routine medical appointments. Medicaid transportation programs exist today because of court decisions that ruled states must assure access to covered Medicaid services. Medicaid recipients are entitled to NEMT, and both the states and federal government must pay for those transportation services. Federal Medicaid regulations now assert that states must "ensure necessary transportation for recipients to and from providers" as codified in 42 C.F.R. § 431.53 (Community Transportation Association of America, 1997). Beyond health care accessibility, there is a strong connection between personal mobility and the reduction of poverty. Both left and right leaning policy organizations have concluded that greater mobility was associated with low-income populations escaping poverty (Blumenberg & Waller, July 2003; A. Kim, 2003).

Percentage of Households without an Automobile

RATIONALE: The private vehicle is the dominant form of transportation in the U.S. and is among the most widely owned assets held by U.S. households. With vehicle ownership, however, comes great expense. Transportation costs comprise a larger and larger proportion of the average American's household budget, comprising about 19% of household budgets (Surface Transportation Policy Project, 2003a). Transportation expenses also disproportionately impact low-income populations. Although the working poor, such as many of those who qualify for Medicaid and CHIP, spend less on transportation expenses than those in higher income brackets, transportation costs amount to a significantly higher proportion of their income. When examining poor households (those with incomes below $20,000) that primarily used a private automobile for transportation, transportation costs consumed between 21% and 27% of household income (Bureau of Transportation Statistics, 2003; Waller, 2005).

Even though the number of vehicles per American household continues to rise (about two vehicles per household), there is great disparity among vehicle ownership rates among income groups. In 2009, low-income households earning less than $10,000 per year before taxes had less than one vehicle per household. In fact, only after household income is firmly above $50,000 annually does the typical household have two vehicles per household (Bureau of Labor Statistics, 2011).

FORMULA OR CALUCATION: Percent of Households (HH) without a Vehicle

$$= \frac{(\text{Owner Occupied HH without Vehicle} + \text{Rental Occupied HH without Vehicle})}{\text{Total Number of Occupied HH}}$$

SOURCE: American Community Survey 5 Year Estimates, Census Tract Level (Converted to ZIP Code Tabulation Area Level)

http://www.census.gov/acs

FREQUENCY DATA ARE UPDATED: Yearly.

Figure 9: Percentage of Households without a Vehicle by Metropolitan Area

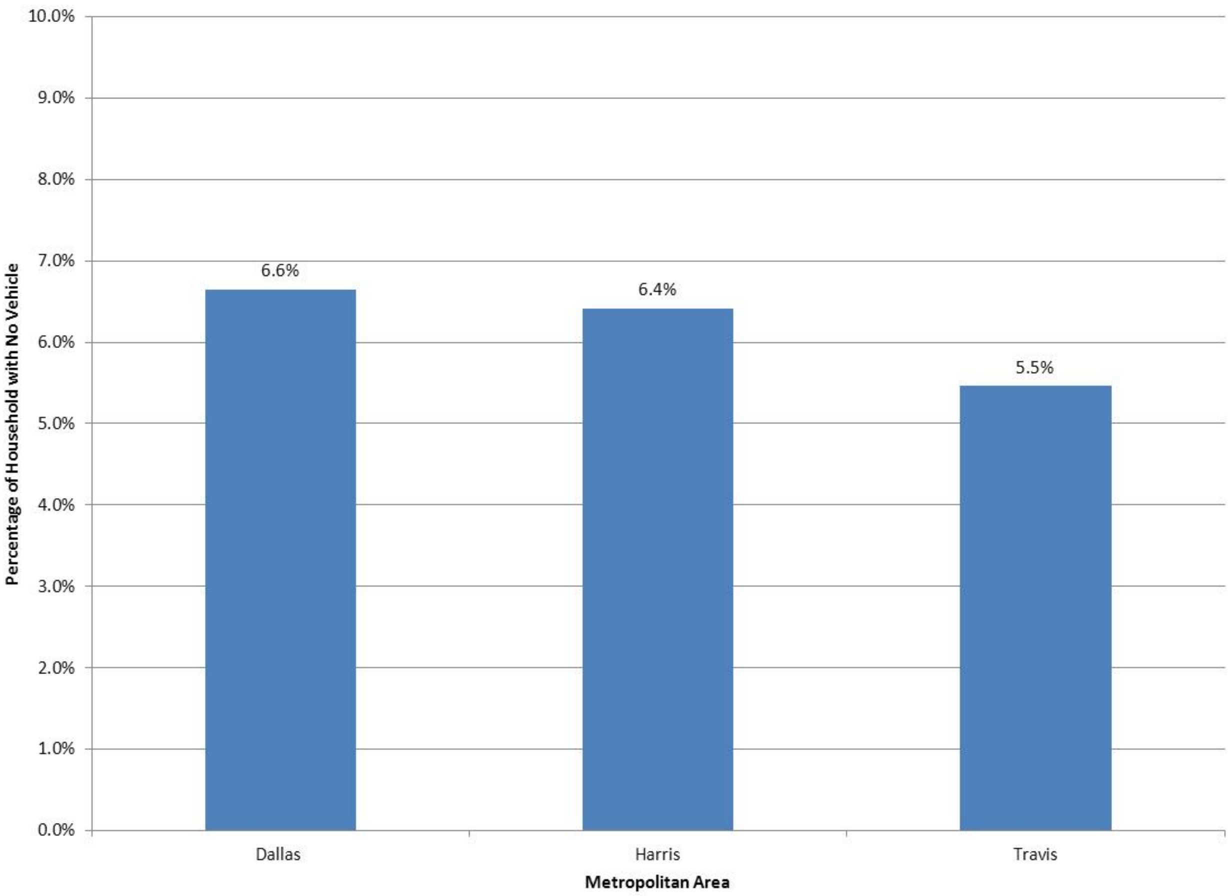
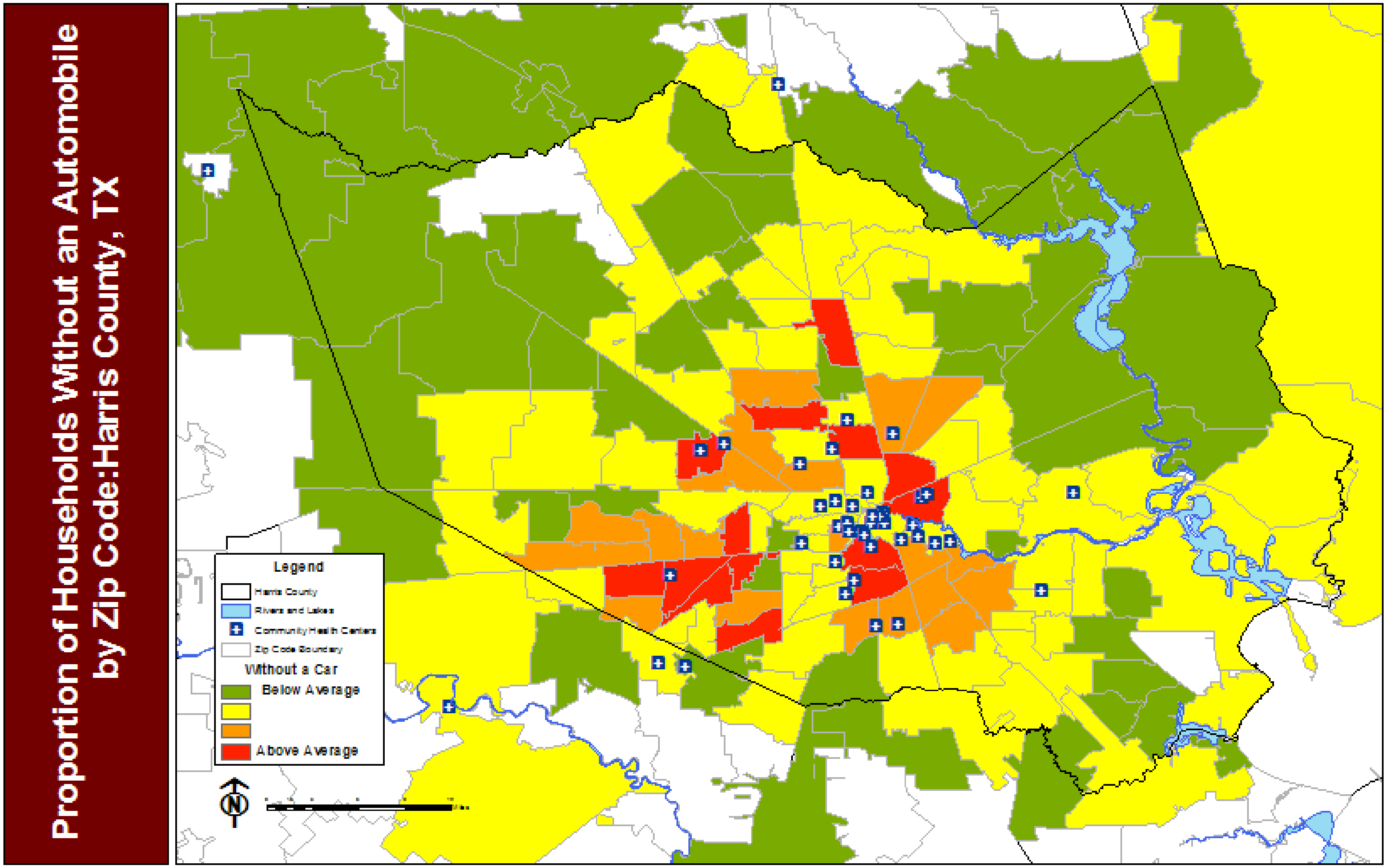


Figure 10: Percentage of Occupied Households without a Vehicle by ZCTA: Houston, TX



Rate of Private Vehicles per 1,000 Population of Driving Age

RATIONALE: As noted in the previous section, with car ownership also comes the heavy burden of operating and maintaining the vehicle. Furthermore, since very low-income households (less than $10,000) typically own less than one vehicle, the percentage of households without a vehicle provides an incomplete understanding of private vehicle accessibility. Yet in many rural areas or those without adequate public transportation access, vehicle ownership is often an important asset for many households, especially welfare recipients that are transitioning into the labor force as a result of work requirements from time-limited Temporary Assistance to Needy Families. Transportation problems among low-income populations appear to be especially problematic. A 2008 evaluation of the Medicaid NEMT program in Texas, found that 27% of nonusers of the program reported an inability to find transportation (Borders, Chaudhuri, & Dyer, 2008).

FORMULA OR CALUCATION: Rate of Vehicles per 1,000 Population of Driving Age

$$= \frac{\text{Aggregate Number of Available Vehicles}}{* \text{ Total Population age 18 and older}} \times 1{,}000$$

✸ Although the minimum driving age in Texas is 16, the age data were aggregated into group intervals. The group containing those ages 15 – 17 were reported in such a way that made disaggregating them impossible so they were excluded from the analysis.

SOURCE: American Community Survey 5 Year Estimates, Census Tract Level (Converted to ZIP Code Tabulation Area Level)

http://www.census.gov/acs

FREQUENCY DATA ARE UPDATED: Yearly.

Figure 11: Rate of Aggregate Vehicles per 1,000 Population of Driving Age (18 Years and Older) by Metropolitan Area

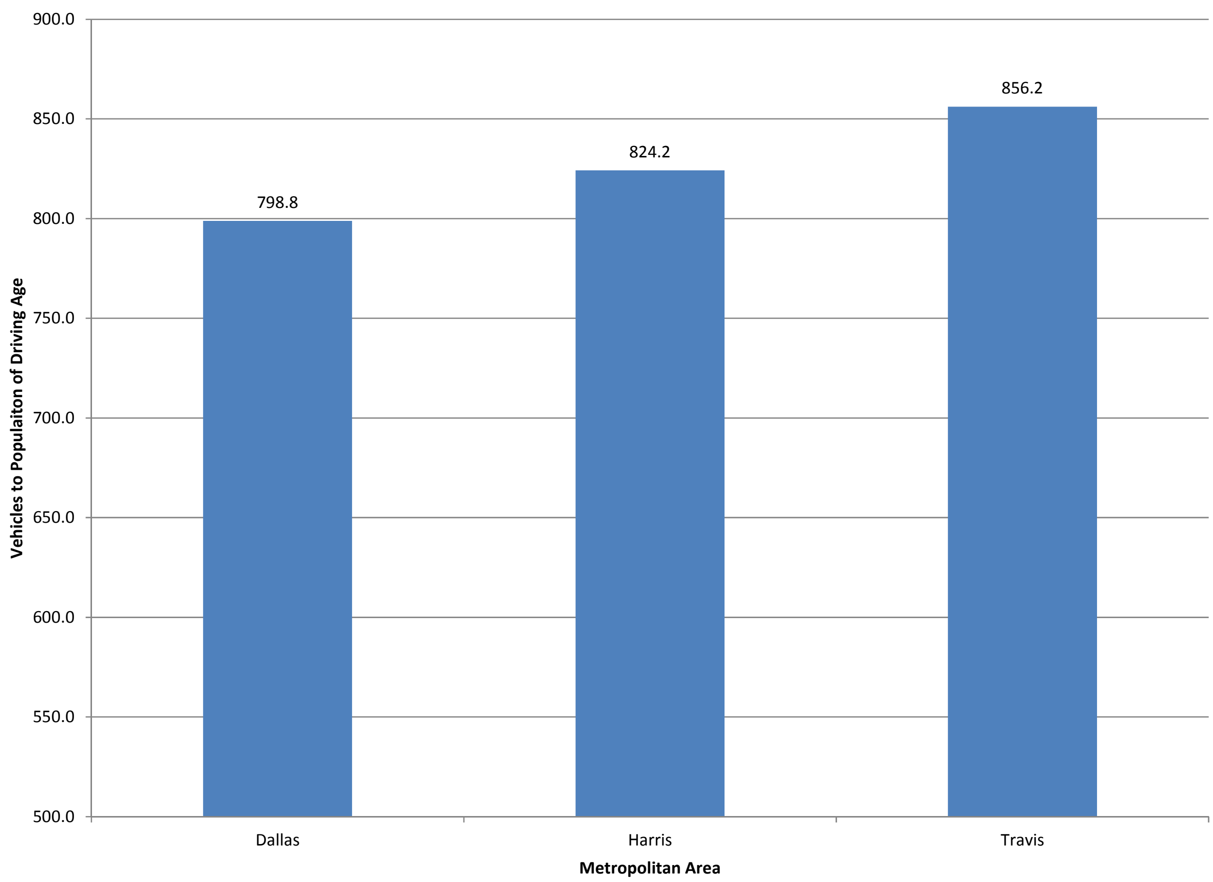
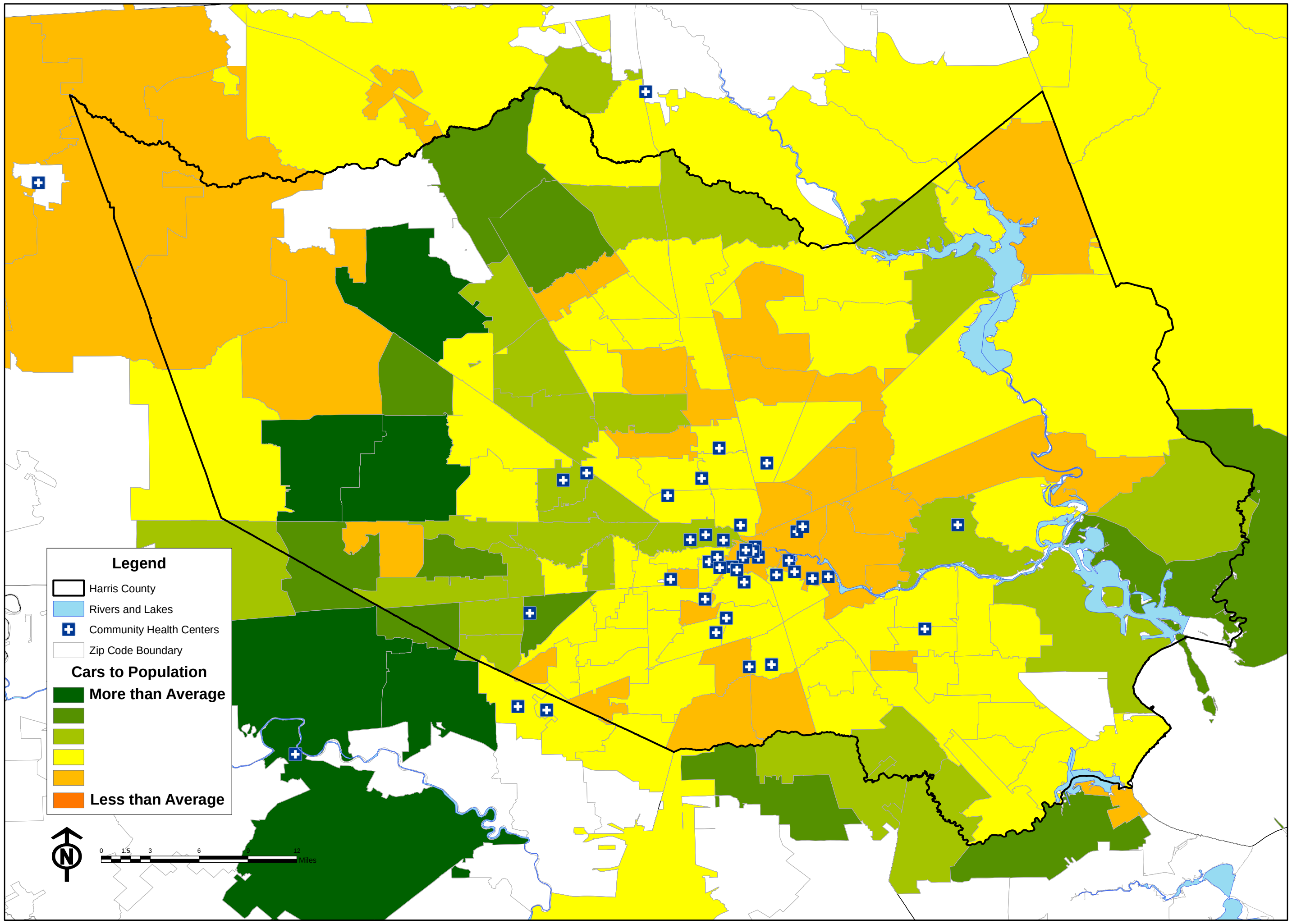


Figure 12: Rate of Vehicles per 1,000 Population of Driving Age by ZCTA: Houston, TX

Ratio of Vehicles to Population of Driving Age by Zip Code: Harris County, TX



Public Transit Accessibility

RATIONALE: Although somewhat dated, a 1997 study of children eligible for Head Start in New York City, the State of New York, Puerto Rico and the U.S. Virgin Islands examined family perceptions on broad range of barriers to health-related issues such as child health, screening practices, nutrition and family health. Transportation was perceived to be a barrier in all areas with the exception of the study population living within New York City (Giambruno, Cowell, Barber-Madden, & Mauro-Bracken, 1997). Indeed, New York City has one of the oldest and most extensive mass transit systems in the country. It is one of the few cities in the U.S. where the typical person can live comfortably without an automobile. Public transportation, however, does exist outside of New York City. Public transportation systems operate in places such as Albany and Buffalo. San Juan, Puerto Rico is served by a transit system. The question then becomes; "How accessible are the public transportation systems of cities like Albany and San Juan?"

FORMULA OR CALUCATION: Public Transit Accessibility

Assumptions:

1. We began by obtaining the transit routes and transit stops for the following systems:
    a. Dallas Area Rapid Transit (DART) – Dallas, TX
    b. Metropolitan Transit Authority of Harris County, Houston, TX (METRO)
    c. Capital Metropolitan Transportation Authority (Cap METRO), Austin, T
2. Using ArcGIS, we used a ¼ mile buffer around each transit stop as our measure of accessibility. Although there is some variation between cities and income groups, about 75 to 80% of those using mass transit walk about ¼ mile or less to a bus stop. Assuming a typical pace, this equates to approximately a 5 minute walk (Transit Cooperative Research Program, 2003). Where possible, we attempted to remove "Park and Ride" routes and specialty routes (i.e. airport shuttle) because it was most likely not representative of the type of public

transportation options those suffering from transportation barriers are likely to utilize.

3. After calculating the ¼ mile buffer for each transit stop, we then calculated the proportion of each ZCTA with access to public transportation.
4. Returning to the question of evaluating the accessibility of lesser developed public transit systems as compared to a city such as New York, we developed a weighting system based on a public transportation benchmarking study (Perk, Nilgun, & Salzer, 2004). For example, does the Houston family with children dependent on transit living within ¼ mile of a bus stop have the same level of mobility and accessibility as a similar family living within a ¼ mile of the subway or even a bus stop in New York City? Although common sense would dictate that New York family would have better mobility due to the extensive Metropolitan Transit Authority's network of subway, rail and bus service, we relied on the Perk et al. benchmarking study to weight the transit coverage calculation to give us a more appropriate measure of accessibility.

   The weight was derived as a percentage of the top score for each peer group. For example, the study ranked peer transit systems within several regions of the country. The Texas public transit systems were ranked among peer systems in the Southwest Region (Arizona, California, Colorado, Hawaii, Nevada, New Mexico, Oklahoma, Texas and Utah). The benchmarking scores are only valid within their respective group because the scores were standardized to each group. The methodology could, however, be applied across all transit systems so that an effectiveness/efficiency ranking system could be developed for the entire nation. Within the Southwest Region among large public transit systems, the San Francisco Municipal Transit Agency was scored highest at 25. The Houston Metro system was ranked 4th with a score of 21.50 or an Effectiveness Rating of .86.

Formula for Calculating Transit Accessibility Measure

$$= \text{\% of ZCTA w/in .25 Mile of Trans Stop} \times \text{Effectivenes Rating of Transit System}$$

SOURCE: Transit stop coordinates and route systems required to develop the coverage estimates are generally available from large urban public transit systems. In addition, transit systems are currently making more of their data publicly available for online public trip planning such as Google Transit. Because data currency is critically important for transit planning, these sites are updated frequently to reflect the most current route and service availability:

http://www.google.com/intl/en/landing/transit/#mdy

The Effectiveness Ratings were last developed in 2003. The methodology is clearly spelled out in the Perk et al. (2004) study and could be relatively quickly and easily updated from the NTD.

FREQUENCY DATA ARE UPDATED: Transit stop coordinates are local transit system dependent. The data required to develop the Effectiveness Ratings are updated annually and publicly available from the NTD.

Figure 13: Weighted Public Transit Accessibility - Median Value and Effectiveness Rating by Metropolitan Area

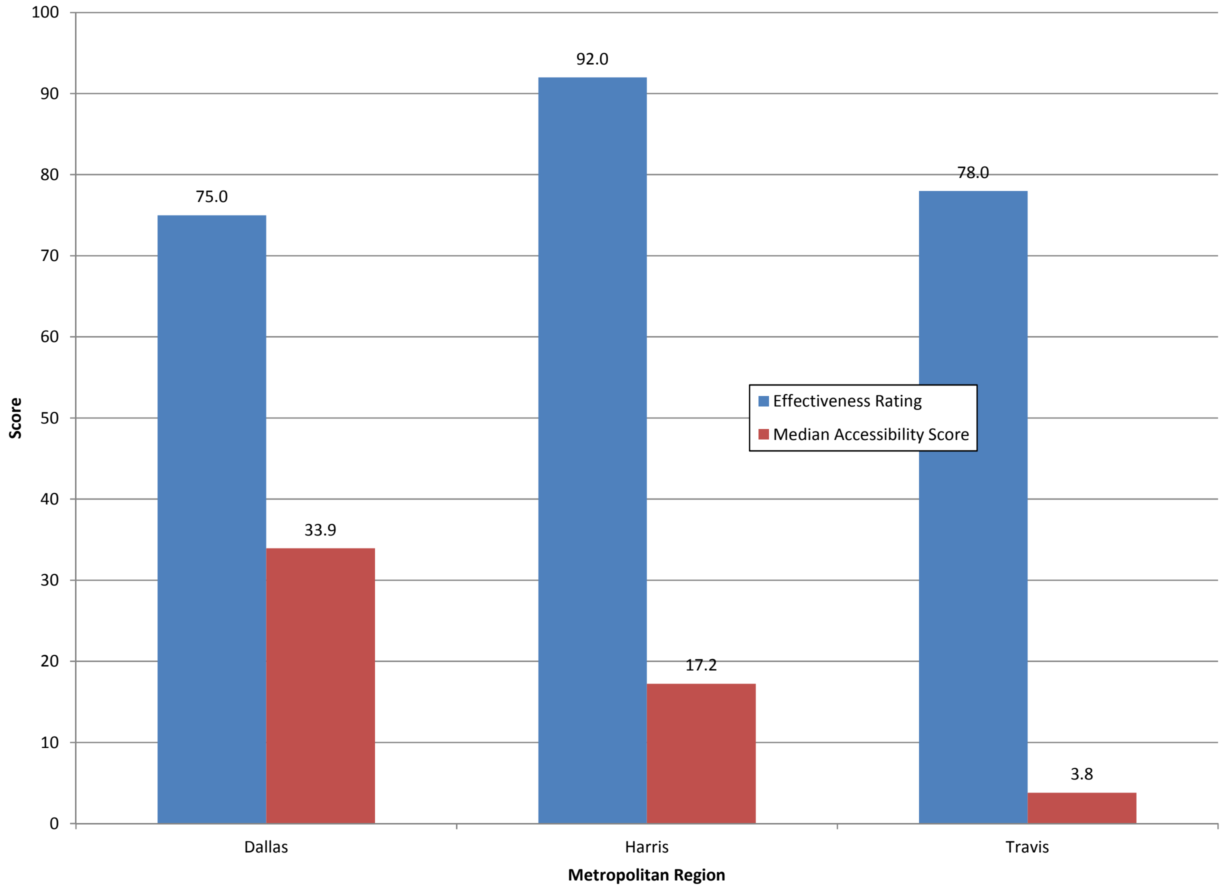
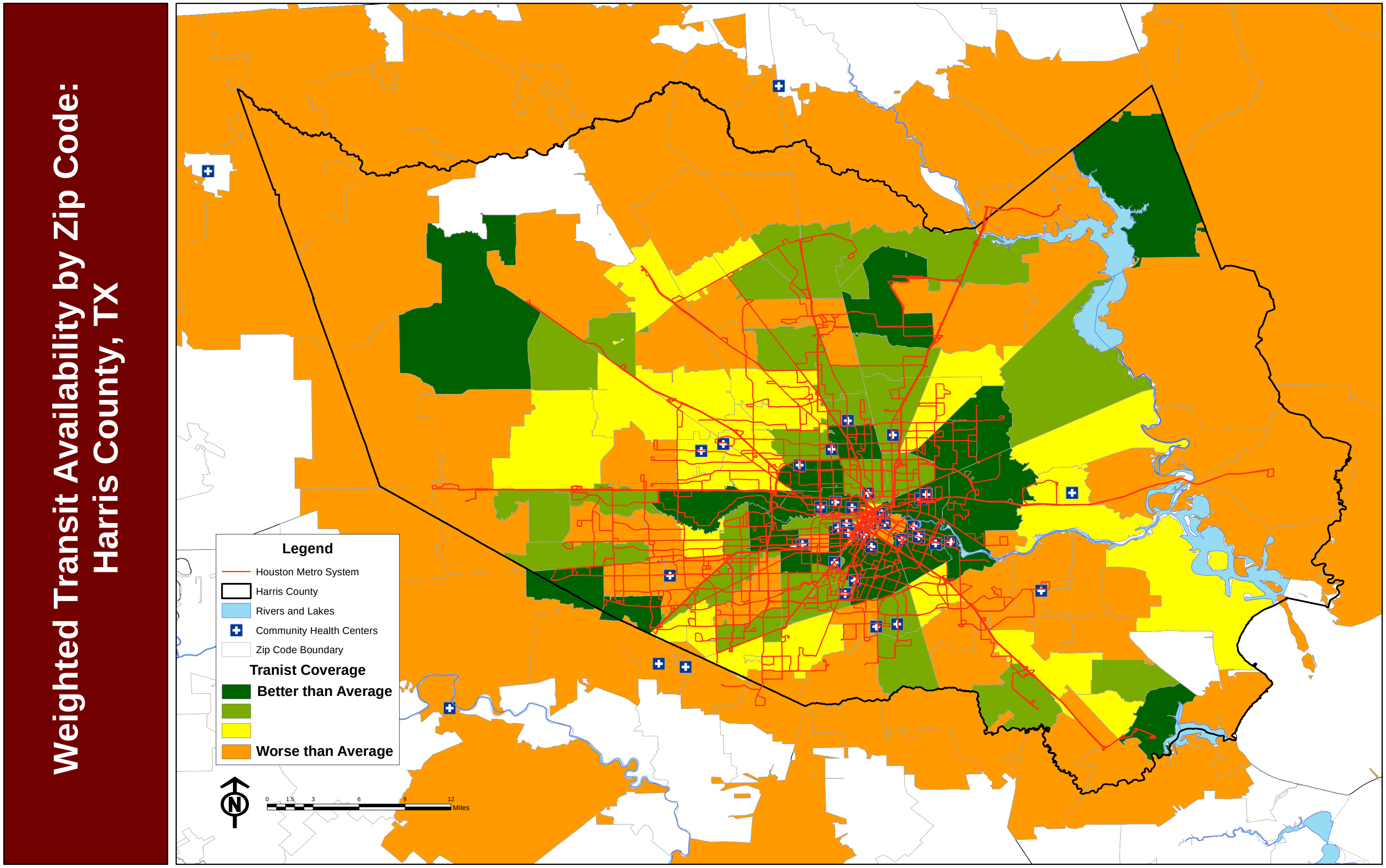


Figure 14: Weighted Public Transit Accessibility by ZCTA: Houston, TX



Provider Availability Factors

As a country, the U.S. has sought to reduce health disparities by expanding the availability of health coverage. In 1997, Congress created SCHIP, representing the single largest expansion of health insurance coverage for children since the Medicaid program was enacted in 1965. The program, now known simply as CHIP, was reauthorized by Congress in 2009 through FY 2013 (Centers for Medicare and Medicaid Services, 2011). In March of 2010, Congress passed the Affordable Care Act (ACA) which is projected to reduce the number of those without health coverage by 32 million (U.S. Department of Health and Human Services, 2011). Despite expanding health coverage, access for low-income and other vulnerable populations, provider access has eroded in many areas due to the fact that more and more physicians are restricting their caseloads because of low Medicaid and CHIP payment rates, especially relative to commercial payments (Felland, Felt-Lisk, & McHugh, 2004).

Primary Care Health Professional Shortage Areas

RATIONALE: National attempts to identify and quantify underserved areas date back to the 1930s, although it was not until the 1970s that Congress passed the Emergency Health Professional Personnel Act establishing the National Health Services Corps (Ricketts, et al., 2007). The Corps provides health services to people who live in urban and rural areas where health care is scarce. Today, there are two broad federal measures of underservice: Medically Underserved Areas (MUAs) and Health Professional Shortage Areas (HPSAs). The MUA definition was later expanded to include Medically Underserved Populations (MUPs). The MUA and MUP designations were developed about the same time as the HPSA designation, however through independent efforts. Researchers typically focus on the HPSA designation because by definition, any urban or rural area or population that is also designated a HPSA, is also automatically designated as a MUA/MUP (United States Government Accountability Office, 2006).

There are three types of HPSA designations, each with different methodological considerations: Primary Care HPSAs, Dental HPSAs and Mental Health HPSAs. The designation can come in the form of a geographic area, population group or a facility. Each are described below (Bureau of Health Professions, 2011a):

1. Geographic Areas – Geographic HPSAs can include entire counties, a portion of a county, or a group of contiguous counties
2. Population Groups – Population-group HPSAs can include migrant farmworkers, low-income populations and federally recognized Native American Tribes.
3. Facilities – Facility HPSAs can include federal or state correctional institutions, health care centers and rural health clinics.

These federal designations, however, are not without their critics. In 1995, the U.S. General Accounting Office found a number of problems with the HPSA designation, finding the methodology fundamentally flawed, resulting in an overstatement of provider shortages. In questioning the validity and currency of the measures, the GAO recommended replacing the measures. A 2006 follow-up report found HHS's work to revise the measure as lacking due to the face that many areas retained a HPSA designation and received federal benefits despite no longer meeting the criteria to retain a HPSA designation (United States Government Accountability Office, 2006) . Today, HRSA is utilizing the work undertaken by Thomas Ricketts and colleagues to revise and consolidate the criteria and processes for designating HPSAs and MUPs (Bureau of Health Professions, 2011b). Despite misgivings across a wide range of providers and policymakers, the HPSA and MUA/P designations continue to be the key metric of more than 30 federal programs to identify areas, populations and/or facilities to receive federal aid.

Because the HPSA designation is a requisite designation for many federal assistance programs in underserved areas, the degree of shortage was determined to be more important than the proportion of the population within a HPSA. While conducting a thorough analysis of the HPSA designation, we discovered a scoring system (see Figure 15) and the associated values with each HPSA designated area. The scoring system ranks the shortage of primary care providers, or need, relative to other HPSAs. HPSA scores assist in determining areas or facilities with the greatest need for health professionals. For example, the National Health Service Corps utilizes HPSA scores for priority assignment of clinicians. HPSA scores range from 0 to 25 for primary care and mental health, and 0 to 26 for dental. The higher the HPSA score is, the greater the need for health professionals.

Figure 15: HPSA Scoring Methodology

Factor 1: Population–to–primary care physician ratio[a]

Points	Criteria
10 points	If there is only 1 physician for every 10,000 or more people, or no physician for a population equal to or greater than 2,500
8 points	If there is only 1 physician for every 5,000–9,999 people, or no physician for a population equal to or greater than 2,000 but less than 2,500
6 points	If there is only 1 physician for every 4,000–4,999 people, or no physician for a population equal to or greater than 1,500 but less than 2,000
4 points	If there is only 1 physician for every 3,500–3,999 people, or no physician for a population equal to or greater than 1,000 but less than 1,500
2 points	If there is only 1 physician for every 3,000–3,499 people, or no physician for a population equal to or greater than 500 but less than 1,000

Factor 2: Percentage of population with income below 100 percent of the federal poverty level[b]

Points	Criteria
5 points	If the percentage is equal to or greater than 50
4 points	If the percentage is equal to or greater than 40 but less than 50
3 points	If the percentage is equal to or greater than 30 but less than 40
2 points	If the percentage is equal to or greater than 20 but less than 30
1 point	If the percentage is equal to or greater than 15 but less than 20
0 points	If the percentage is less than 15

Factor 3: Lower of infant mortality rate or rate of low birth weight babies[c]

Points	Criteria
5 points	If the infant mortality rate is equal to or greater than 20, or the low birth weight rate is equal to or greater than 13
4 points	If the infant mortality rate is equal to or greater than 18 but less than 20, or the low birth weight rate is equal to or greater than 11 but less than 13
3 points	If the infant mortality rate is equal to or greater than 15 but less than 18, or the low birth weight rate is equal to or greater than 10 but less than 11
2 points	If the infant mortality rate is equal to or greater than 12 but less than 15, or the low birth weight rate is equal to or greater than 9 but less than 10
1 point	If the infant mortality rate is equal to or greater than 10 but less than 12, or the low birth weight rate is equal to or greater than 7 but less than 9
0 points	If the infant mortality rate is less than 10, or the low birth weight rate is less than 7

Factor 4: Higher of travel time or distance to nearest available source of primary care

Points	Criteria
5 points	If the travel time is equal to 60 minutes or more, or the distance is equal to 50 miles or more
4 points	If the travel time is equal to 50 to 59 minutes, or the distance is equal to 40 to 49 miles
3 points	If the travel time is equal to 40 to 49 minutes, or the distance is equal to 30 to 39 miles
2 points	If the travel time is equal to 30 to 39 minutes, or the distance is equal to 20 to 29 miles
1 point	If the travel time is equal to 20 to 29 minutes, or the distance is equal to 10 to 19 miles
0 points	If the travel time is less than 20 minutes, or the distance is less than 10 miles

= HPSA score

Of particular interest to this project is that transportation is indeed one of the criteria set forth in the HPSA designation. What is less clear, however, is the precise nature of exactly how the scores are obtained with respect to travel times given HRSA's broad definition (United States Government Accountability Office, 2006):

> "HRSA defines a rational service area for the delivery of primary medical care services as (1) a county or group of contiguous counties whose population centers are within 30 minutes travel time of each other; (2) a portion of a county, or an area made up of portions of more than one county, whose population, because of topography, market or transportation patterns, distinctive population characteristics, or other factors has limited access to contiguous area resources, as measured generally by a travel time greater than 30 minutes to such resources; or (3) established neighborhoods and communities within metropolitan areas that display a strong self-identity (as indicated by a homogeneous socioeconomic or demographic structure or a tradition of interaction or interdependency), have limited interaction with contiguous areas, and that, in general, have a minimum population of 20,000. 42 C.F.R. pt. 5, app. A, I B.1, II A.1. (a) (2005)."

For example, are the travel time calculations based on using public transportation or a private vehicle? Including time walking to and from a transit stop as well as the possibility of transfers, travel times within a large city may well be in excess of 60 minutes, but may be less than 10 miles, especially if the measure were calculated by Euclidean Distance (i.e. shortest distance between two points). Given this scenario, would an area or population within a city (i.e. close to primary medical care) that is transit dependent receive the most severe rating (5 points) based on travel time or would they receive the least severe rating (0 points) because they are within 10 miles of a primary care? Furthermore, our analysis and the literature suggest that travel time or distance are among the crudest measures of transportation barriers and alone, are not sensitive enough to accurately assess the degree to which children are facing transportation barriers to primary care services.

FORMULA OR CALUCATION: Primary Care HPSA Score

Assumptions

1. In the Year 1 analysis, we used estimates of the proportion of the population living in a Primary Care HPSA. These estimates were developed for HRSA through the Dartmouth Atlas Project, a 20-year effort whereby Medicare data are analyzed to provide comprehensive information and analysis about national, regional, and local markets, as well as individual hospitals and their affiliated physicians (http://www.dartmouthatlas.org/). When analyzing the children's ACSC rates with the percentage of the population living in a Primary Care HPSA, there was little correlation between the two variables.
2. To better assess the degree of underservice (notwithstanding concerns related to the validity of the measure) we employed HPSA scores to determine the severity of underservice. Although HRSA calculates scores only for HPSA designated areas, we therefore assigned any area that was not a designated HPSA a score of 0.
3. Only designated HPSA areas were included in the analysis. HPSA designated facilities were dropped from the analysis, because they could include such things as prisons, which are well beyond the scope and interest of this project.
4. When assigning a HPSA designation to an area, the designations are assigned at either the Census tract level or for an entire county. Large urban counties such as Harris County, TX typically have within county HPSA designations applied to various Census tracts. Each Census tract was assigned the corresponding HPSA score developed by HRSA for the respective tract. When an entire county was a designated HPSA, we assigned each Census tract within that country the HPSA score of the respective county.
5. We apportioned the appropriate area of each Census tract to the corresponding ZCTA. The proportion of each Census tract that falls within the corresponding

ZCTA becomes the weight. (For more information on apportioning Census tracts to ZCTAs, please the section entitled General Approach and Key Assumptions)

6. The Primary Care HPSA Score variable is the average HPSA score apportioned to its corresponding ZCTA. For example, the equation below provides a hypothetical calculation for ZCTA 78705 if it were comprised of two Census tracts (C.T.). Census tract 1 is wholly contained within the boundaries of the ZCTA with a HPSA score of 20 while Census tract 2 is only 50% is contained within the ZCTA with a HPSA score of 10.

$$= \frac{(\text{ C.T. 1 HPSA Score} \times \text{ C.T. 1 Area}) + (\text{C.T. 2 HPSA Score} + \text{C.T. Area})}{\text{Total Number of C.T. Comprising ZCTA (Full or Partial)}}$$

$$\text{ZCTA 78705 Primary Care HPSA Score} = \frac{(20 \times 1) + (10 \times .5)}{2}$$

$$\text{ZCTA 78705 Primary Care HPSA Score} = 12.5$$

SOURCE: HRSA Data Warehouse Report Tool – Data Exploration, Export, and Formatted Reporting – Primary Care Health Professional Shortage Areas

http://datawarehouse.hrsa.gov/customizereports.aspx

FREQUENCY DATA ARE UPDATED: Dynamic – reporting is constantly updated.

Figure 16: Median HSPA Score by Metropolitan Area

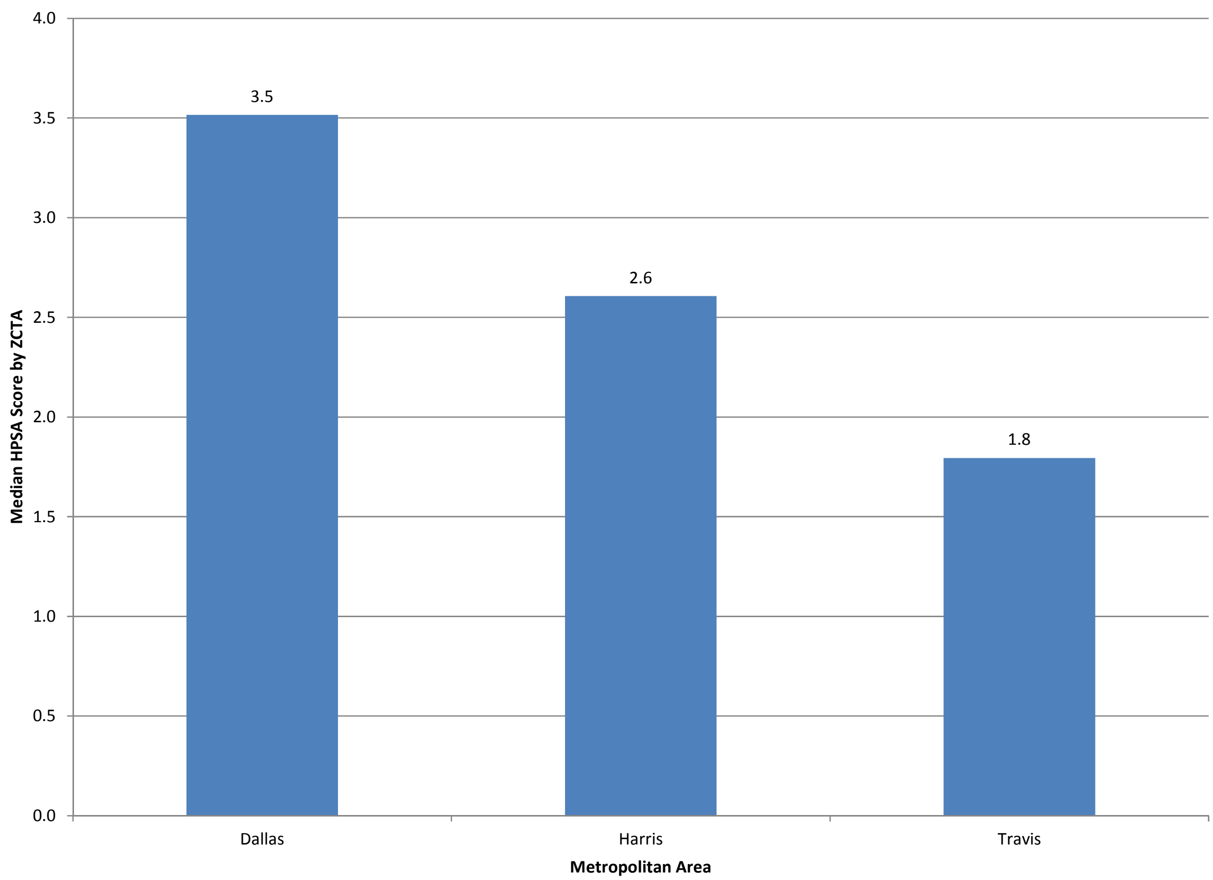
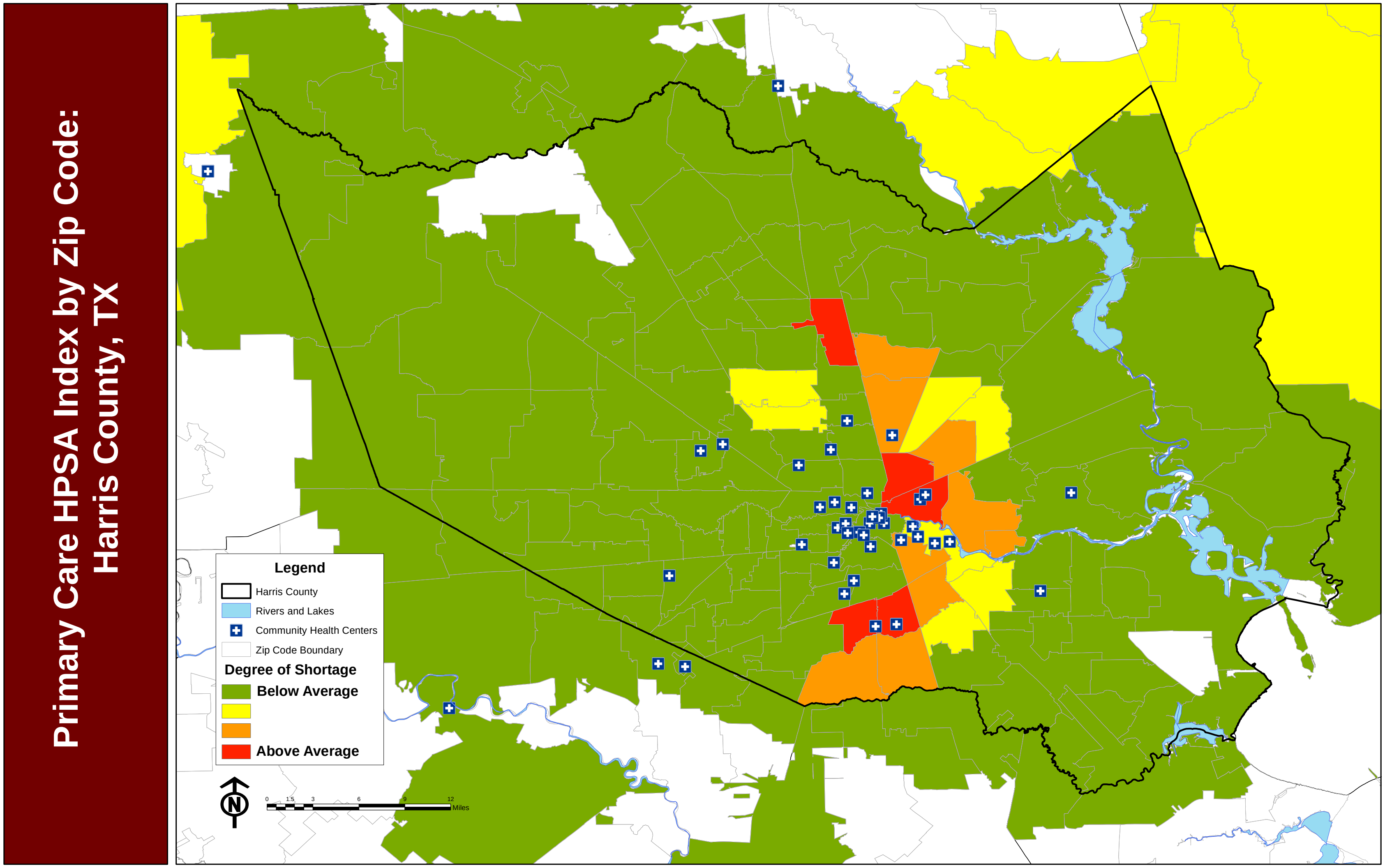


Figure 17: HPSA Scores by ZCTA: Houston, TX



Distance to Nearest Community Health Center

RATIONALE: Community health centers (CHCs) serve a variety of underserved populations and areas and fall under one of two categories: 1) Grant-Supported Federally Qualified Health Centers (FQHCs) or 2) FQHC look-alikes. FQHCs receive federal funds under the Public Health Service Act while FQHC look-alikes are health centers that have been identified by HRSA and certified by the CMS as meeting the definition of "health center", but do not receive federal funding (Health Resources and Services Administration, 2011b). CHCs are a critical component of access, especially to underserved populations by providing low or no cost services to patients. CHCs provide broad-based primary and preventive services as well as enabling services such as case management, health education and in some cases, transportation (Politzer et al., 2001; Wells, et al., 2009). Enabling services are often provided because on average, patients accessing services at CHCs tend have poorer health status and face barriers to care. Further, studies have shown that enabling services and removing or reducing financial barriers have positive outcomes. When adjusted for socioeconomic status, patients receiving services through community health centers had better access to care and preventive services than those receiving care in other settings (Politzer, et al., 2001; Shi & Stevens, 2007). Wells et al. (2009) explicitly examined the reasons that community health centers provided enabling services, such as transportation. They found that among patients receiving care at a CHC, 14% cited transportation barriers that served as a direct cause of impeding access to needed care in the previous six months. Among Latino children receiving services at an inner-city clinic, 21% of parents cited transportation as an obstacle to care. HRSA, however, no longer releases data on enabling services provided by community health centers, ending the practice in 2004 (Wells, et al., 2009).

FORMULA OR CALUCATION: Distance to Nearest Community Health Center

Assumptions

1. The measure was based on the Euclidean distance (shortest distance) between the ZCTA centroid and the point location of the physical address of the community health center where services are actually delivered. There are some mobile community health centers that were excluded from the analysis. The centroid is the mean center of the polygon which gave us an x and y coordinate value for the centroid.
2. The location of the CHC was plotted using an Address Geocoding procedure that similarly assigned x and y coordinate values to a street address.
3. Only the distance between the ZCTA centroid and the nearest CHC was selected for inclusion. Although the study focused on the three metropolitan areas in Texas, the distance to the nearest CHC may have been outside the area of focus. Because of this realization, the nearest distance value was calculated from all CHCs in Texas.

SOURCE: HRSA Data Warehouse Report Tool – Data Exploration, Export, and Formatted Reporting – Community Health Centers

http://datawarehouse.hrsa.gov/customizereports.aspx

FREQUENCY DATA ARE UPDATED: Dynamic – reporting is constantly updated.

Figure 18: Median Distance to Nearest Community Health Center by Metropolitan Area

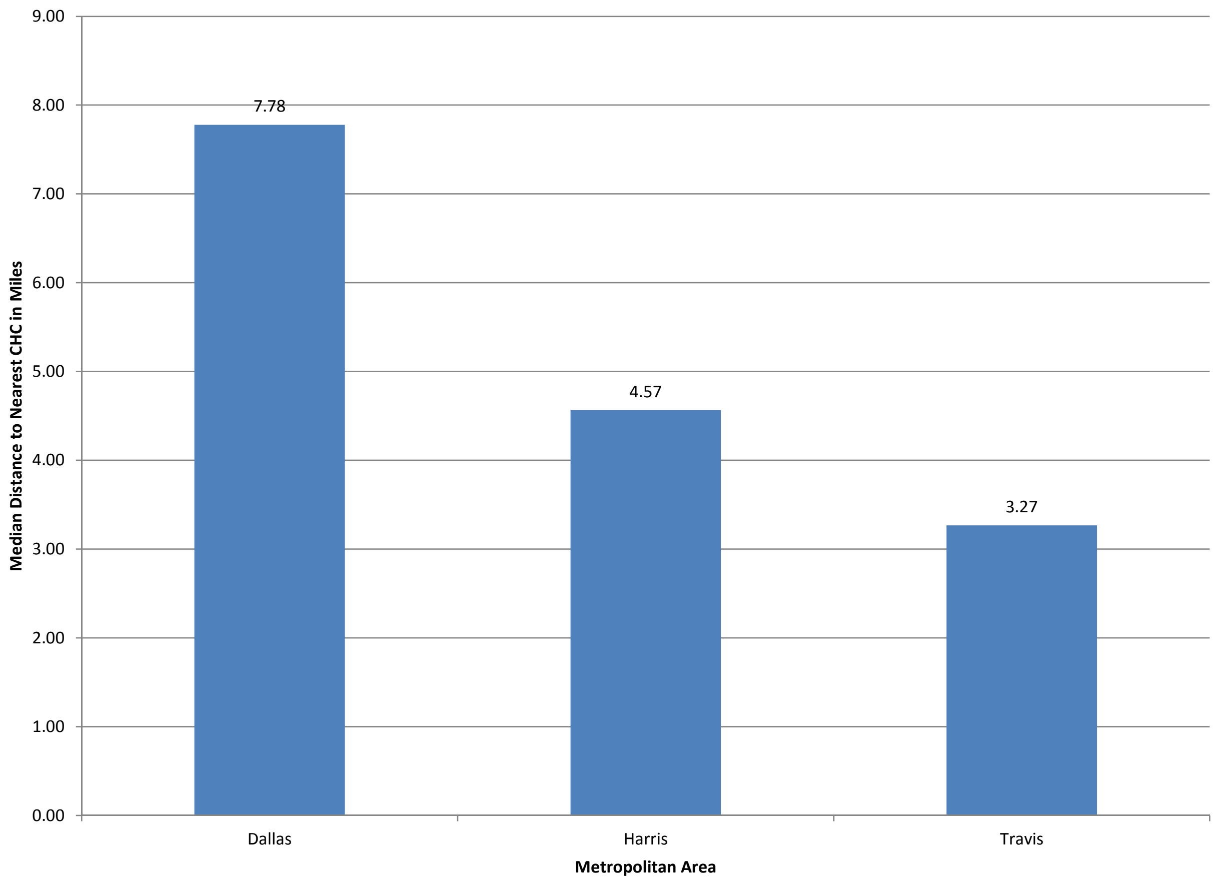
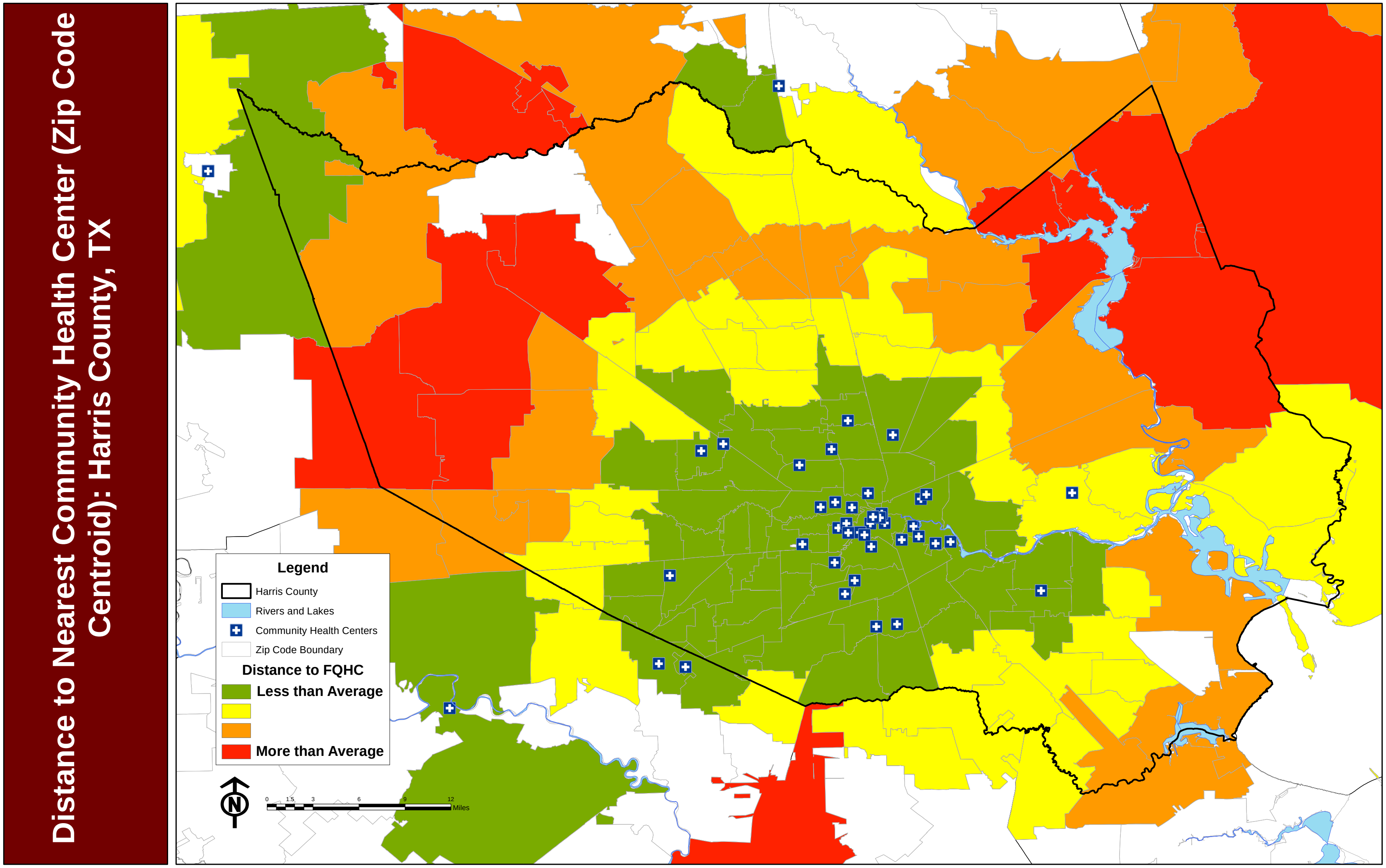


Figure 19: Median Distance to Nearest Community Health Center: Houston, TX



Percent of Population Living in Rural Area

RATIONALE: Children in rural areas are more likely to face a gauntlet of daunting economic, social and health challenges as compared to children living in urban areas. Studies consistently show that rural children are typically poorer than their urban peers and are also less likely to have health coverage. They are often particularly challenged in terms of accessing essential health services. Rural areas typically have fewer hospital beds, licensed providers and specialists per capita than urban areas. According the National Rural Health Association (National Rural Health Center, 2007):

- Only about ten percent of physicians practice in rural America despite the fact that nearly one-fourth of the population lives in these areas;
- Rural residents are less likely to have employer-provided health care coverage or prescription drug coverage, and the rural poor are less likely to be covered by Medicaid benefits than their urban counterparts;
- Although only one-third of all motor vehicle accidents occur in rural areas, two-thirds of the deaths attributed to these accidents occur on rural roads;
- Rural residents tend to be poorer. On the average, per capita income is $7,417 lower than in urban areas, and rural Americans are more likely to live below the poverty level. The disparity in incomes is even greater for minorities living in rural areas. Nearly 24% of rural children live in poverty;
- People who live in rural America rely more heavily on the federal Food Stamp Program;
- Abuse of alcohol and use of smokeless tobacco is a significant problem among rural youth. Forty percent of rural 12th graders reported using alcohol while driving compared to 25% of their urban counterparts. Rural eighth graders are twice as likely to smoke cigarettes (26.1% versus 12.7% in large metro areas);
- There are 60 dentists per 100,000 people in urban areas versus 40 per 100,000 in rural areas;

- Twenty percent of nonmetropolitan counties lack mental health services versus five percent of metropolitan counties;
- The suicide rate among rural men is significantly higher than in urban areas, particularly among adult men and children; and
- Rural residents have greater transportation difficulties reaching health care providers, often travelling great distances to reach a doctor or hospital.

FORMULA OR CALUCATION: Percent of Children Living in a Rural Area

Assumptions:

I. There are many methods to classify "rural" areas. Some, such as the Office of Management and Budget (OMB) make the classification at the county level as either metropolitan or non-metropolitan. Metropolitan counties (urban) are those with a recognized population nucleus and the adjacent communities that are highly integrated with the nucleus (Strayhorn, 2001). Other classification systems seek to classify urban and rural at the ZIP Code level or at the county level. Each of these classification systems has their tradeoffs between ease of use and accuracy of measurement. Because of our high dependence on Census data for this project, we thought it prudent to adopt U.S. Census definitions for urban and rural areas.

II. The U.S. Census Bureau defines "urban" as all territory, population, and housing units located within an urbanized area (UA) or an urban cluster (UC). It delineates UA and UC boundaries to encompass densely settled territory, which consists of:
    - core Census block groups or blocks that have a population density of at least 1,000 people per square mile and
    - surrounding Census blocks that have an overall density of at least 500 people per square mile (U.S. Census Bureau, 2002).

The Census Bureau's classification of "rural" is not so much a definition of "rural" as it is the absence of the area being considered an UA or UC.

III. At the time of the analysis, the U.S. Census Bureau had not developed estimates for the population living in UAs or UCs. We therefore, relied on data from the 2000 Census to derive our estimates.

Calculation

$$= \left(\frac{\text{Total population: Outside urbanized areas}}{\text{Total population}} \right) \times 100$$

SOURCE: 2000 Census, Summary File 3 (SF3), Census Tract Level (Converted to ZIP Code Tabulation Area Level)

http://www.census.gov

FREQUENCY DATA ARE UPDATED: Typically after the decennial census.

Figure 20: Mean Rural Population by Metropolitan Area

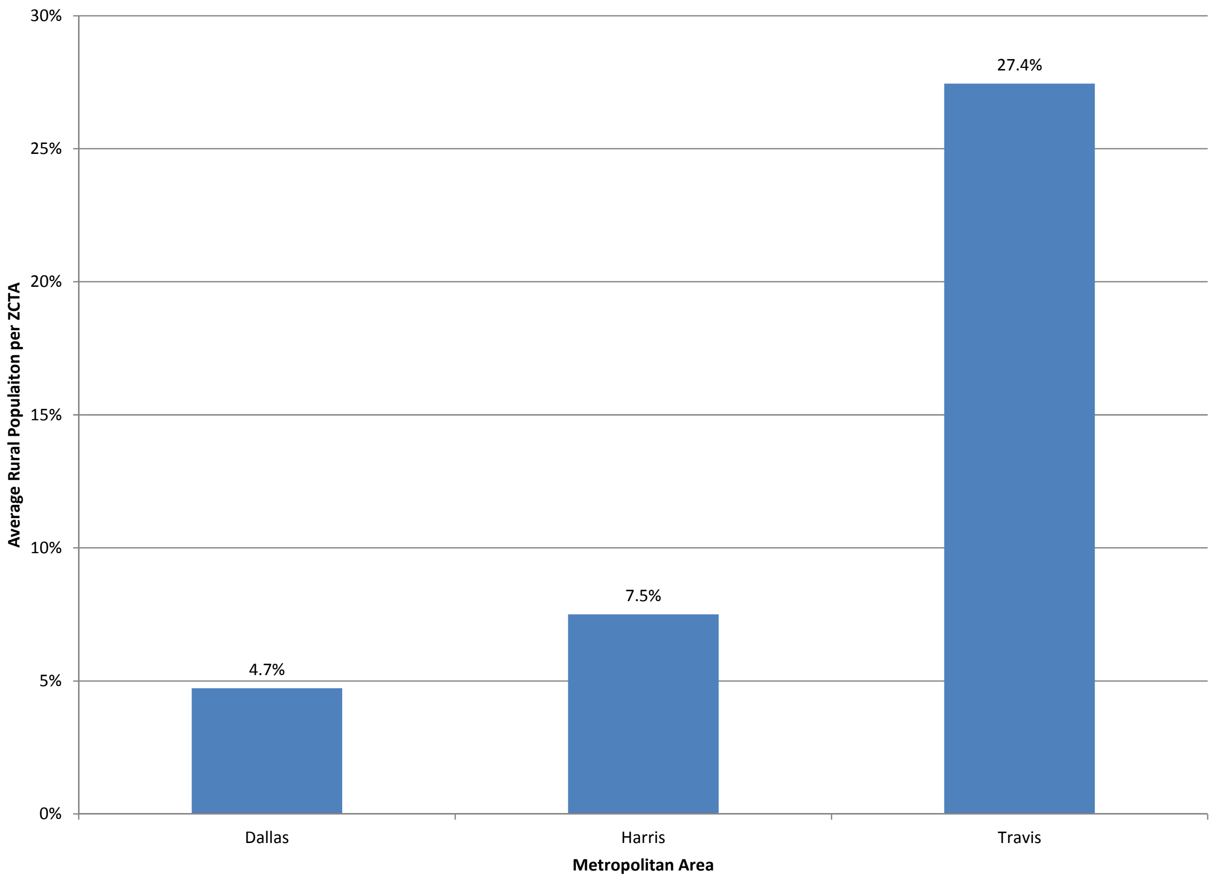
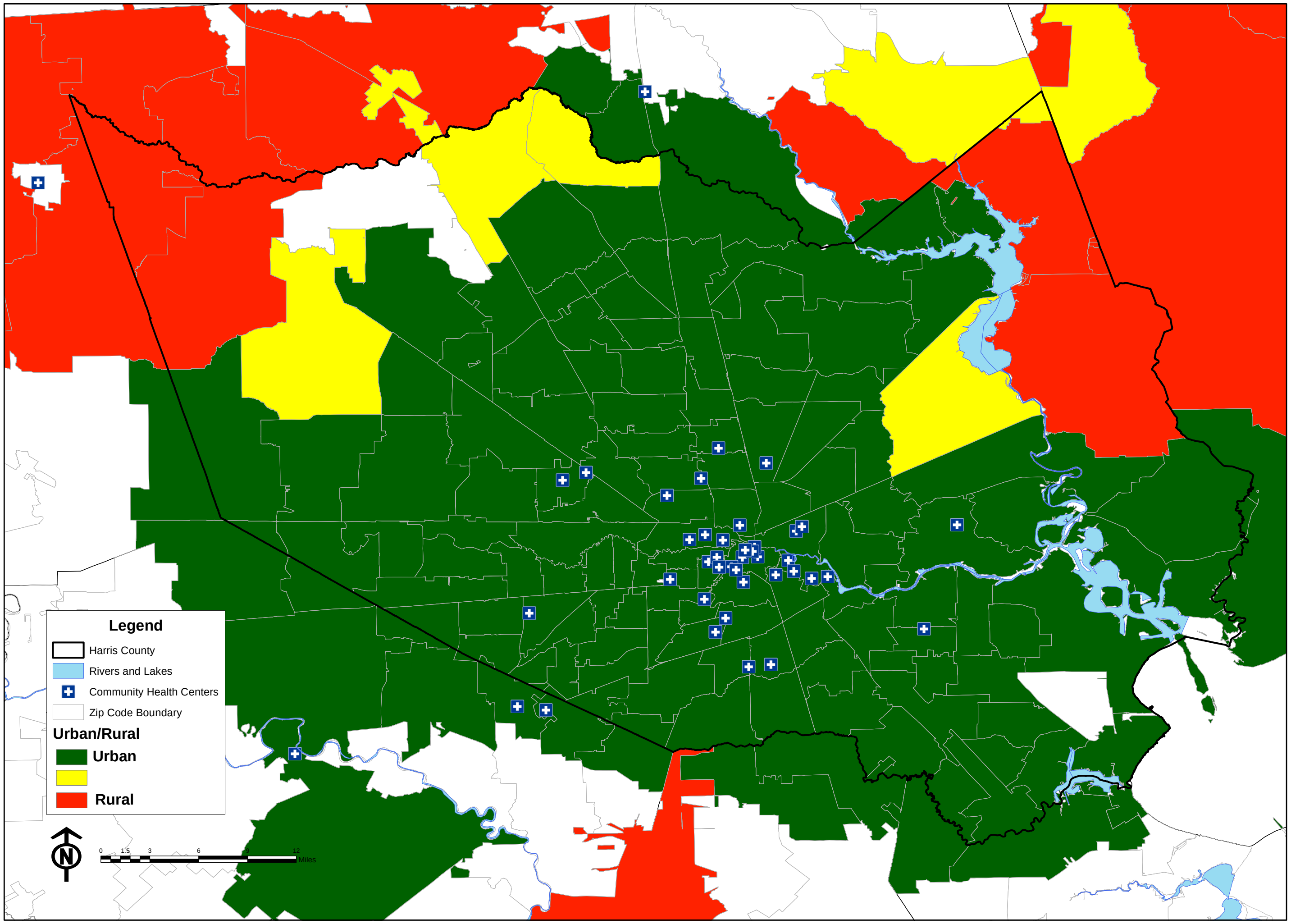


Figure 21: Proportion of the Population Designated as Rural by ZCTA: Houston, TX

Urban and Rural Composition by Zip Code: Harris County, TX



Health Disparity Factors

Although some use and think of the term "health disparity" as synonymous with race or ethnicity, those working closely with minority groups understand real and perceived inequalities in health outcomes often have less to do with ethnicity than with socioeconomic factors. On the surface, one may question the wisdom of including health disparity variables in an analysis of transportation barriers to children's primary care services. We now, however, more fully understand the interconnectedness of the factors related to health outcomes and overall health status.

Percentage of Children Living Below Poverty

RATIONALE: Poverty is linked to host of negative outcomes for children, including educational, health-related, and emotional. Poverty has been clearly linked to negative health outcomes among children and the profound negative effects of poverty often pervade throughout development into an adult (Spencer, 2000). Children living in poverty are more likely than children from non-poverty families to develop disease. Further, when children living in poverty do develop disease, the effects are often more severe when compared to children living above poverty. In addition, children who live in poverty are also much more likely than other children to experience developmental problems (Bradley & Corwyn, 2002).

FORMULA OR CALUCATION: Percent of Children Living Below Poverty

$$= \left(\frac{\text{Income in the past 12 months below poverty level; Males and Females 0 to 17}}{\text{Total Population for whom poverty is determined; Males and Females 0 to 17}}\right) \times 100$$

SOURCE: American Community Survey 5 Year Estimates, Census Tract Level (Apportioned dot to ZIP Code Tabulation Area Level)

http://www.census.gov/acs

FREQUENCY DATA ARE UPDATED: Yearly.

Figure 22: Median Percent of Children Living in Below Poverty by Metropolitan Area

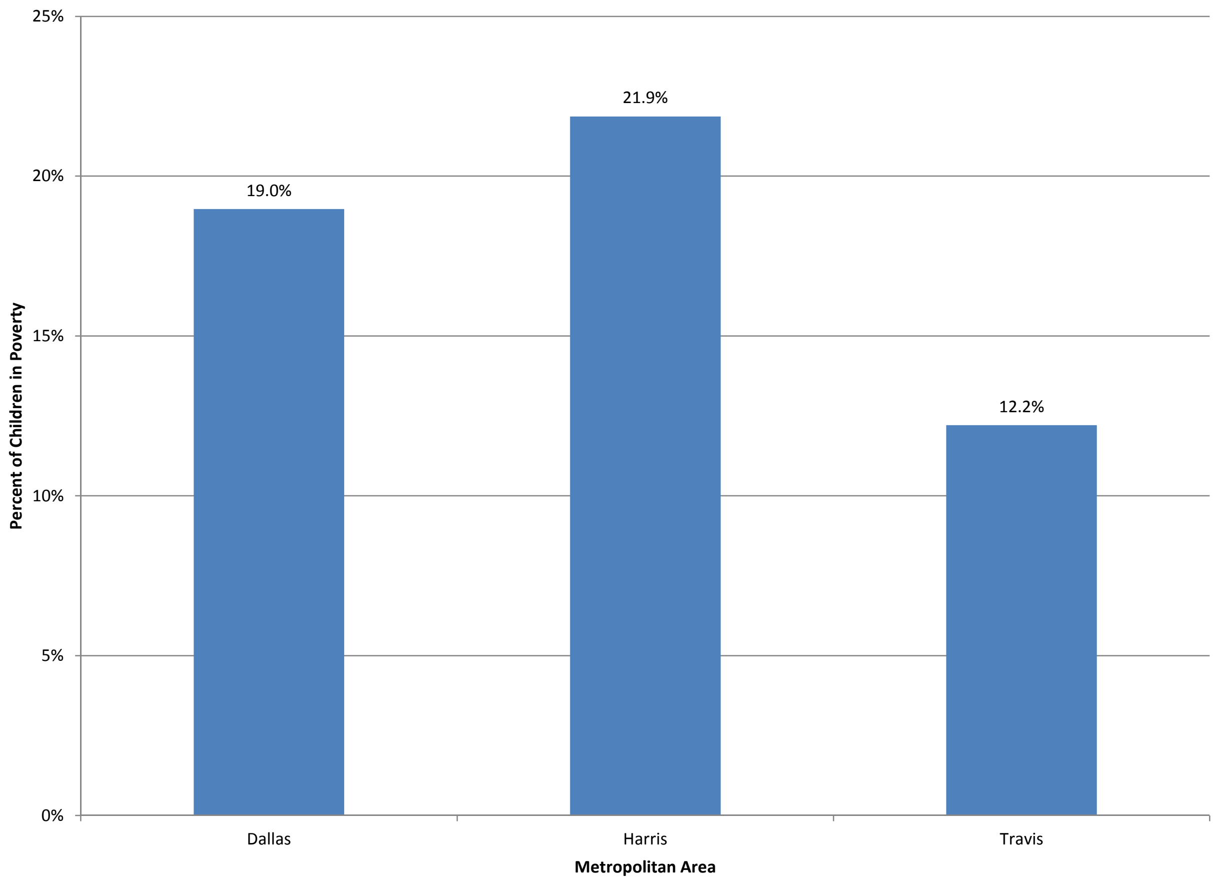
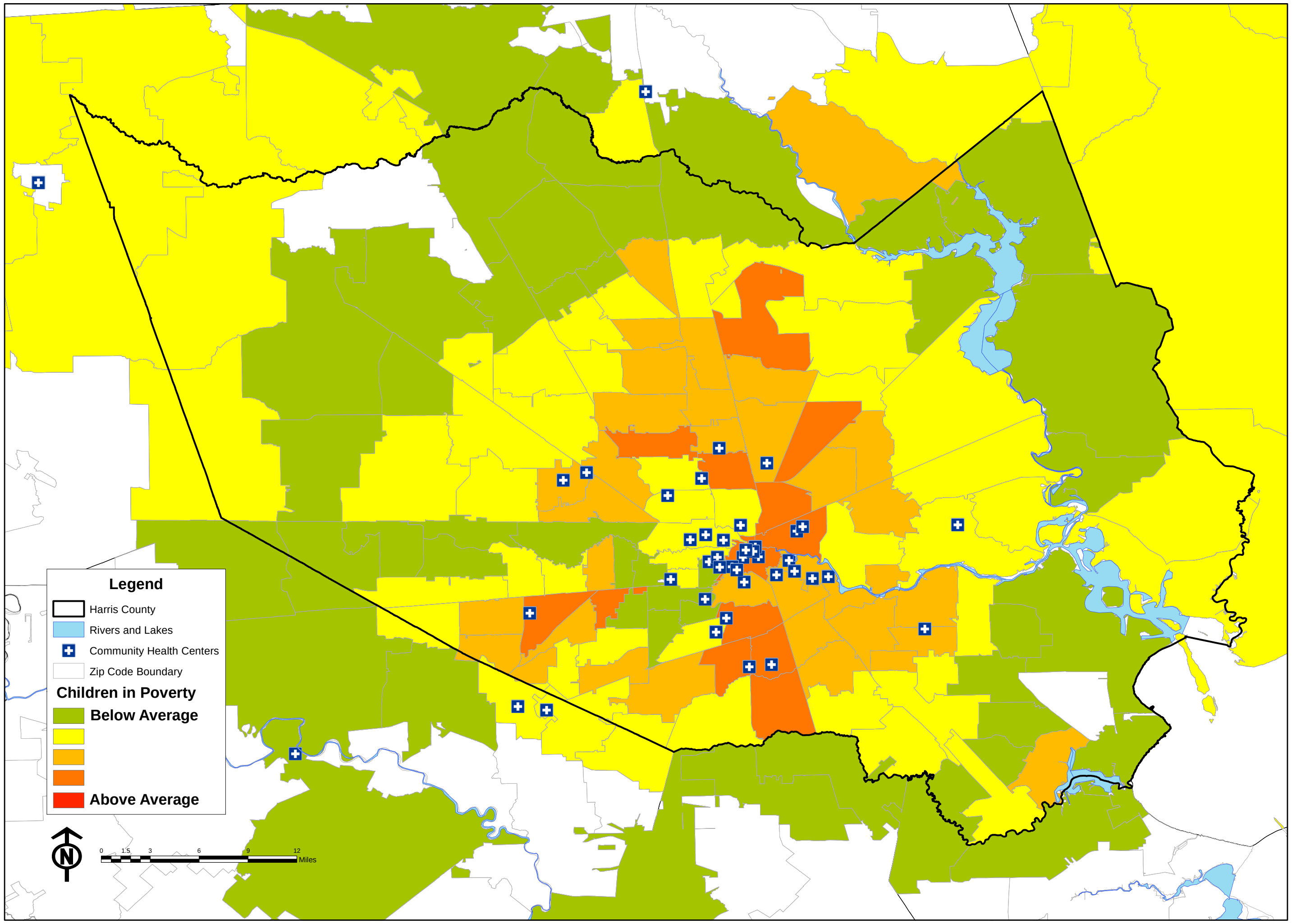


Figure 23: Percent of Children Living Below Poverty: Houston, TX

Proportion of Children Living Below Poverty by Zip Code:Harris County, TX



Percentage of Non-White Children

RATIONALE: Even when insurance status, age and income are comparable, racial and ethnic disparities exist. Ethnic minorities suffer higher rates of death from cancer, heart disease and diabetes than their white peers (Nelson, 2002). As racial and ethnic characteristics are associated with primary care access, demographic variables are an important component to measuring and understanding health disparities.

FORMULA OR CALUCATION: Percent of Non-White Children

$$= \left(\frac{(\text{Total Males \& Females 0 to 17} - \text{White Alone Males \& Females 0 to 17})}{\text{Total Males \& Females 0 to 17}} \right) \times 100$$

SOURCE: American Community Survey 5 Year Estimates, Census Tract Level (Apportioned dot to ZIP Code Tabulation Area Level)

http://www.census.gov/acs

FREQUENCY DATA ARE UPDATED: Yearly.

Figure 24: Percentage of Non-White Children by Metropolitan Area

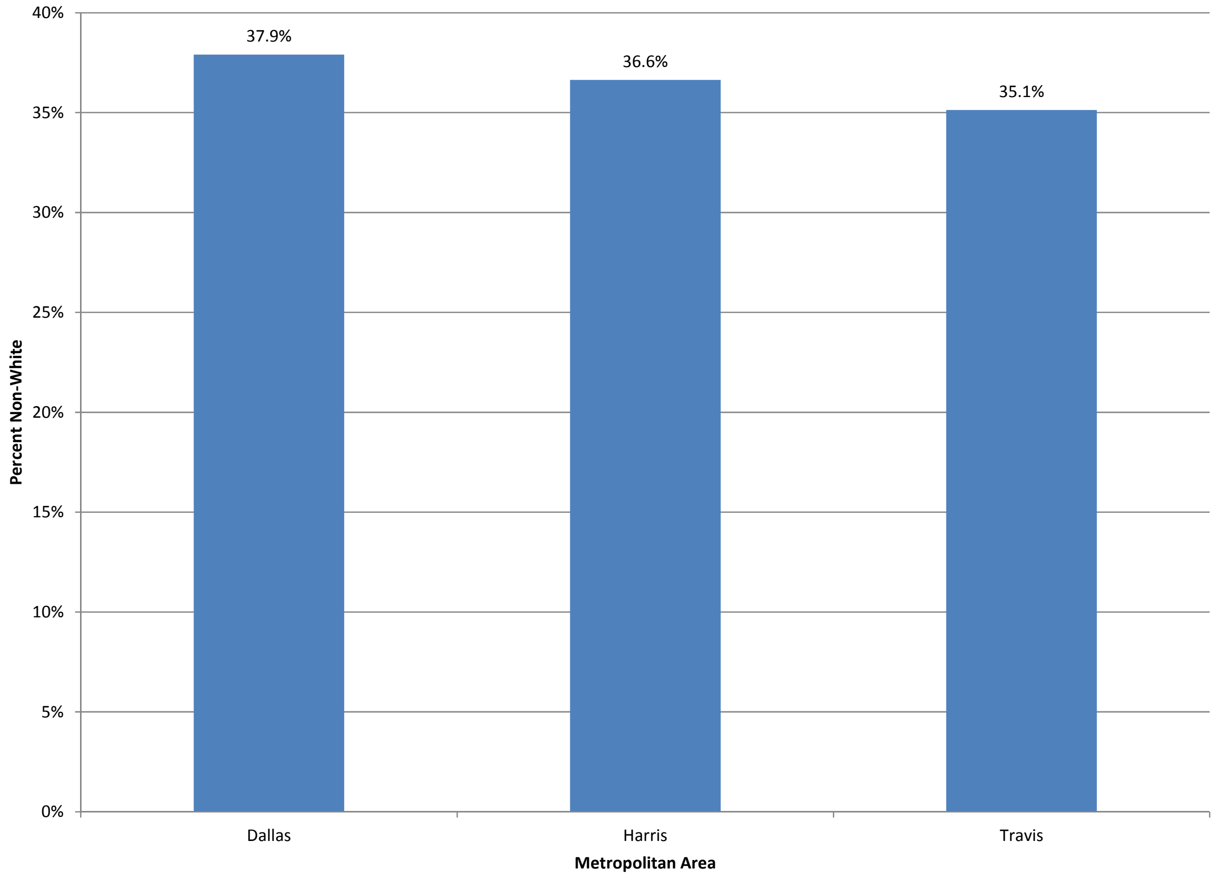
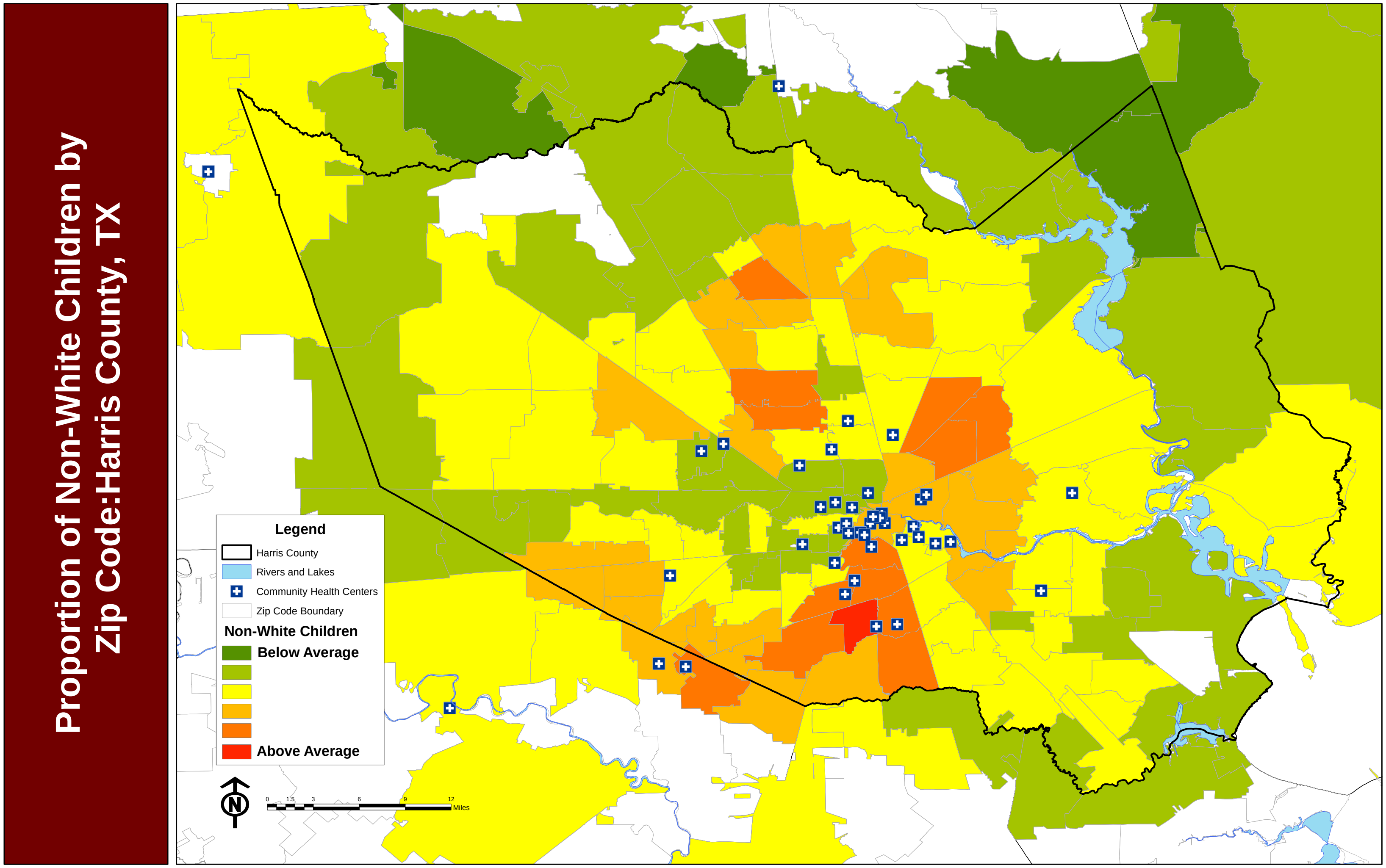


Figure 25: Percent of Non-White Children by ZCTA: Houston, TX



Percentage of Hispanic Children

RATIONALE: According to a recent 2010 Census release, ethnic minorities accounted for 89% of the population growth in Texas over the past decade with Latino growth accounting for two-thirds of the state's population gains between 2000 and 2010. Today, Latinos now make up 38% of the population while Non-Hispanic whites dropped to 45% (U.S. Census Bureau, 2011a). Racial and ethnic characteristics are associated with primary care access, thus demographic variables are an important component of measuring health disparities.

FORMULA OR CALUCATION: Percent of Hispanic Children

$$= \left(\frac{(\text{Hispanic or Latino Males \& Females 0 to 17})}{\text{Total Males \& Females 0 to 17}}\right) \times 100$$

SOURCE: American Community Survey 5 Year Estimates, Census Tract Level (Apportioned dot to ZIP Code Tabulation Area Level)

http://www.census.gov/acs

FREQUENCY DATA ARE UPDATED: Yearly.

Figure 26: Percent of Hispanic Children by Metropolitan Area

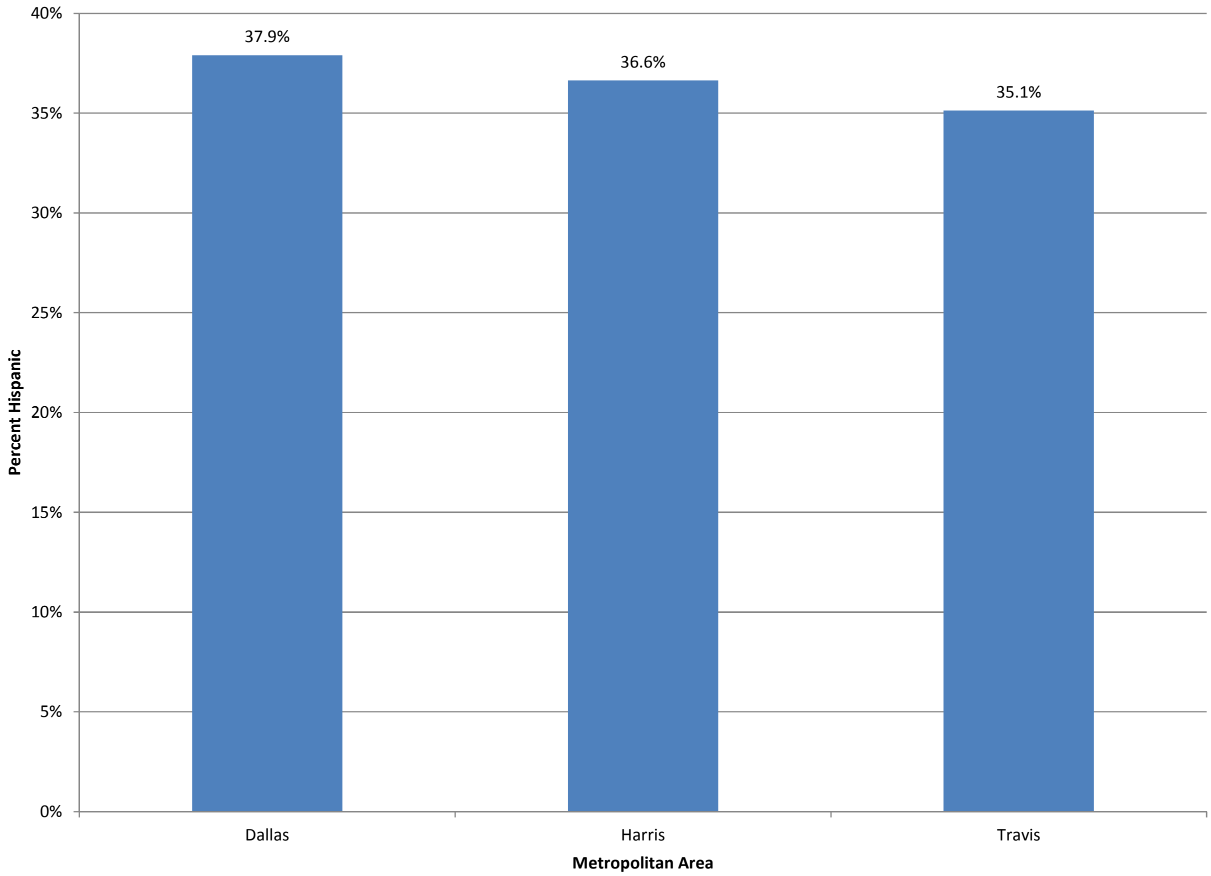
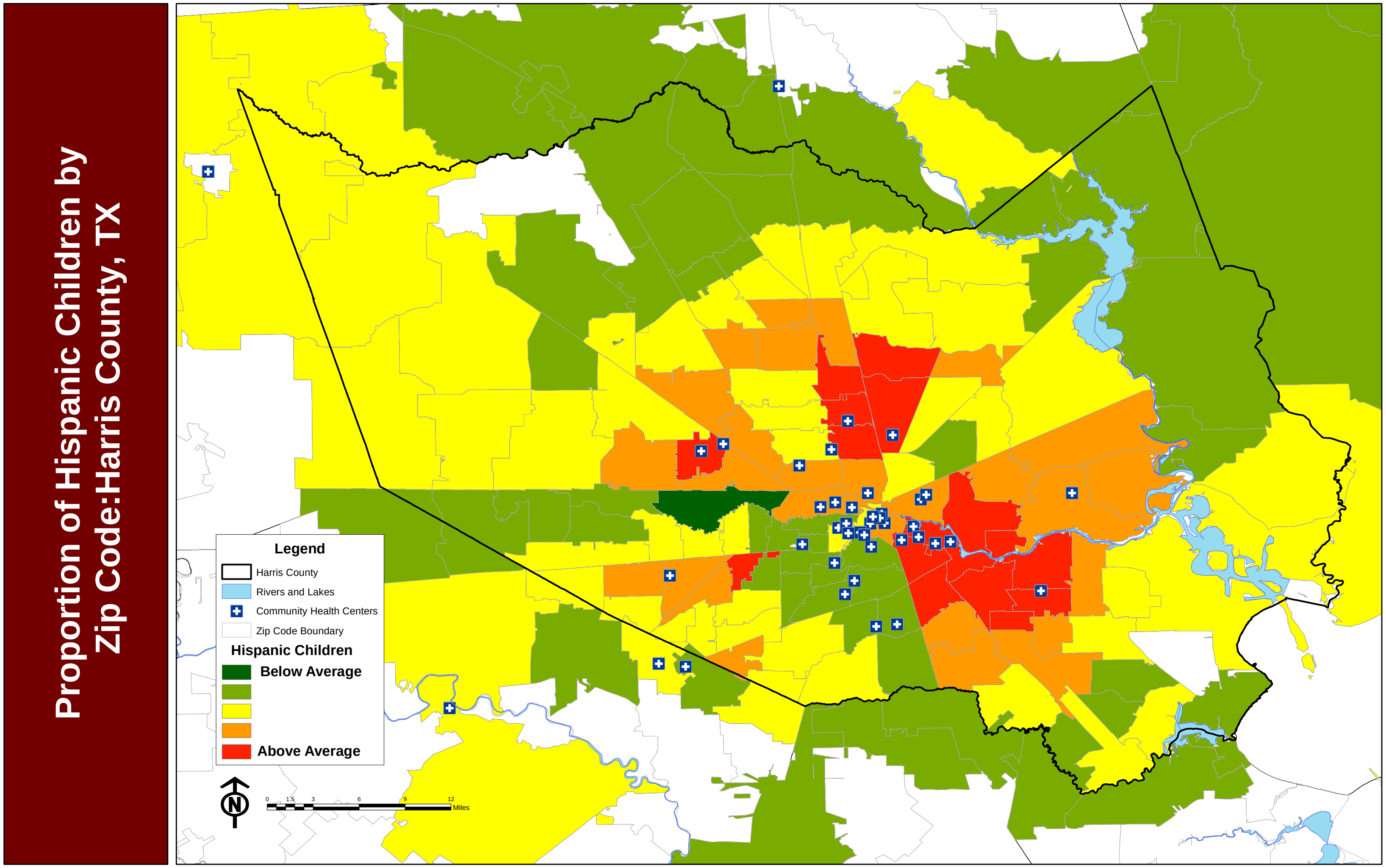


Figure 27: Percent of Hispanic Children by ZCTA: Houston, TX



Outcomes

As Congress debated and ultimately passed the ACA, the focus on health outcomes was of particular interest. With nearly $1 trillion of expected federal expenditures on health care over the coming decade, many Americans will want to know what we, as a nation, received from our investments. Measuring the end results or outcomes of our health care programs and policies can help answer basic questions of the impact new investments in health care have on the well-being of our children. Measuring health outcomes is a process in which a standardized attempt is made to observe an often complex picture, as with the case of transportation and health care accessibility. We must measure outcomes to assist decision making about how to invest limited resources wisely.

Rate of Children's Ambulatory Care Sensitive Conditions

RATIONALE: Direct data on utilization of preventive care services for children are difficult to obtain because they are not collected in a systematic way nor do they exist in a single database. We chose to measure access to care through analyzing ambulatory care sensitive (ACSC) conditions as a proxy for access. Researchers have argued that certain conditions like asthma are ACSC—that is, hospitalization is largely preventable by timely and appropriate primary and preventive health care. Thus, high rates of hospitalization for these conditions serve as indicators of a need for improved access to appropriate primary care services. Using a database of all hospital discharges between the years of 2004 -2006 from the Texas Department of State Health Services, we examined the ICD-9 code, known as the International Statistical Classification of Diseases and Related Health Problems. Each health condition is assigned to a unique category and given a code. For example, childhood asthma is assigned an ICD-9 code of 493.0. By examining these codes in depth, we are able to determine emergency department (ED) admissions classified as ACSC.

Examining ACSC rates have gained wide acceptance as indicators for policy actions in a number of states. In Nebraska, ACSC conditions were used to assess overall system adequacy (Nebraska Health Informaiton Project, 1996). In New York, these same measures were used to evaluate health professional recruitment and retention (Schreiber & Zielinski, 1997). To evaluate overall health care system performance, the states of Utah (Silver, Babitz, & Magill, 1997), Virginia (Shukla & Pestian, 1996) and West Virginia (Cockley, 1996) have all used such measures. In North Carolina, researchers used ACSC measures and GIS to evaluate problems in local primary care systems, finding that access to effective primary care was reflected in lower rates of ACSC admissions, even after accounting for the health care resources in a particular area (Ricketts, Randolph, Howard, Pathman, & Carey, 2001). In California, researchers found a 33 percent lower rate of hospitalizations for ACSCs conditions in mandatory managed care when compared with fee-for-service, suggesting that that Medicaid managed care is associated with a large reduction in hospital utilization (Bindman, Chattopadhyay, Osmond, Huen, & Bacchetti, 2005).

FORMULA OR CALUCATION:

Assumptions

ACSC conditions were identified using an algorithm developed by the NYC Center for Health and Public Services Research. The algorithm was designed to help classify ED utilization and was developed with the advice of a panel of ED and primary care physicians. It is based on an examination of a sample of almost 6,000 full ED records. Data abstracted from these records included the initial complaint, presenting symptoms, vital signs, medical history, age, gender, diagnoses, procedures performed, and resources used in the ED. Based on this information, each case was classified into one of the following categories:

- <u>Non-emergent</u> - The patient's initial complaint, presenting symptoms, vital signs, medical history, and age indicated that immediate medical care was not required within 12 hours;

- Emergent/Primary Care Treatable - Based on information in the record, treatment was required within 12 hours, but care could have been provided effectively and safely in a primary care setting. The complaint did not require continuous observation, and no procedures were performed or resources used that are not available in a primary care setting (e.g., CAT scan or certain lab tests);
- Emergent - ED Care Needed - Preventable/Avoidable - Emergency department care was required based on the complaint or procedures performed/resources used, but the emergent nature of the condition was potentially preventable/avoidable if timely and effective ambulatory care had been received during the episode of illness (e.g., the flare-ups of asthma, diabetes, congestive heart failure, etc.); and
- Emergent - ED Care Needed - Not Preventable/Avoidable - Emergency department care was required and ambulatory care treatment could not have prevented the condition (e.g., trauma, appendicitis, myocardial infarction, etc.).

The information that was used to develop the algorithm required analysis of the full medical record. Since such detailed information is not generally available on computerized ED or claims records, these classifications were then "mapped" to the discharge diagnosis of each case in our sample to determine for each diagnosis the percentage of sample cases that fell into these four categories. For example, patients discharged with a final diagnosis of "abdominal pain" may include both patients who arrived at the ED complaining of stomach pain, as well as those who reported chest pain (a possible heart attack). Accordingly, for abdominal pain, the algorithm assigns a specific percentage of the visit into the categories of "non-emergent", "primary care treatable", and "preventable/avoidable" based on what they observed in the sample for cases with an ultimate discharge diagnosis of abdominal pain (Billings, 2001). (For more information about the NYU algorithm, please see: http://wagner.nyu.edu//chpsr/index.html)

Our analysis focused solely on Preventable/Avoidable ACSCs for the simple reason that it was the best proxy to accessibility problems due to the fact that the admission was potentially preventable or avoidable if timely and effective ambulatory care had been received. Therefore, we reckon that if these admissions were due to transportation barriers, far less expensive, agonizing and much more humane policy solutions exist to these problems than care delivered in the ED.

SOURCE: Texas Department of State Health Services Hospital Discharge Dataset – Public Use Data File

www.dshs.state.tx.us/thcic/hospitals/HospitalData.shtm

FREQUENCY DATA ARE UPDATED: Quarterly

Figure 28: Avoidable ED Admissions per 1,000 Children by Metropolitan Area

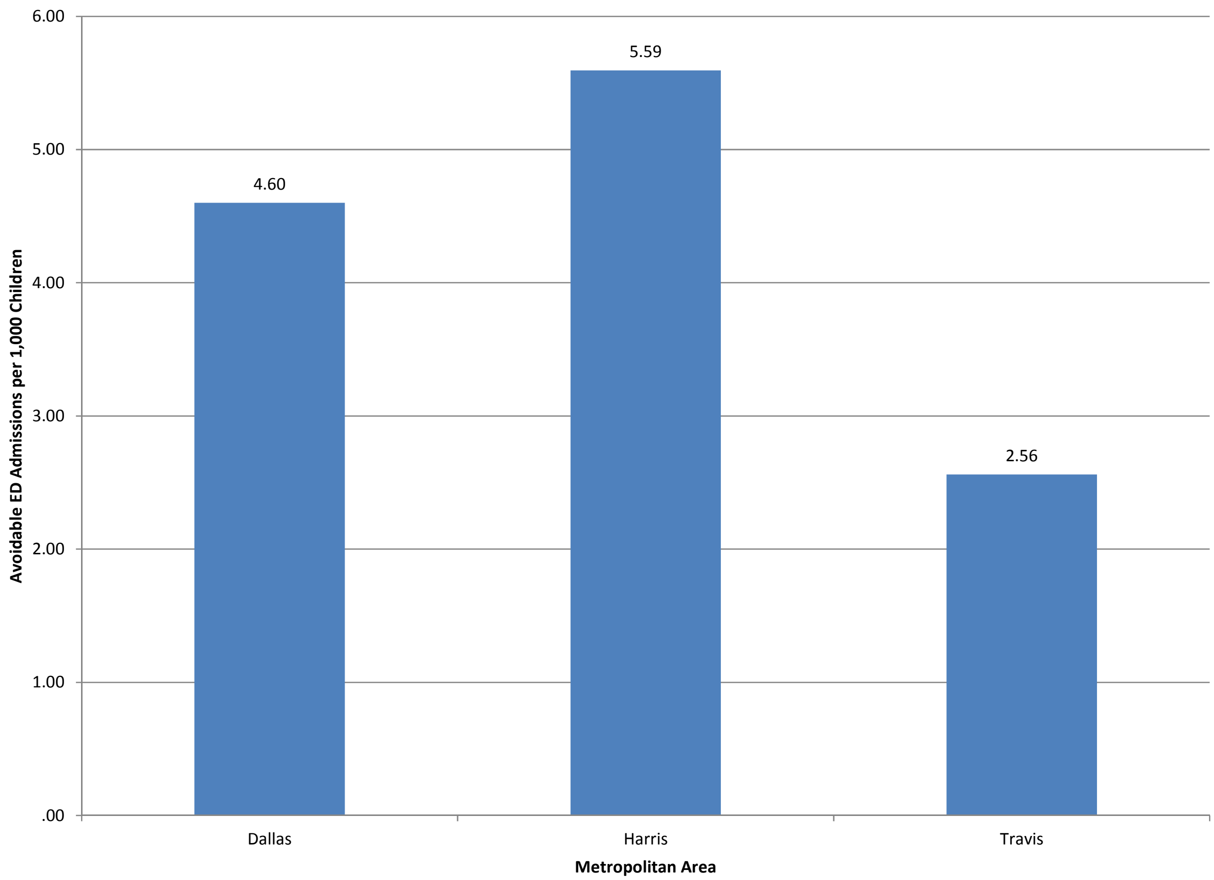
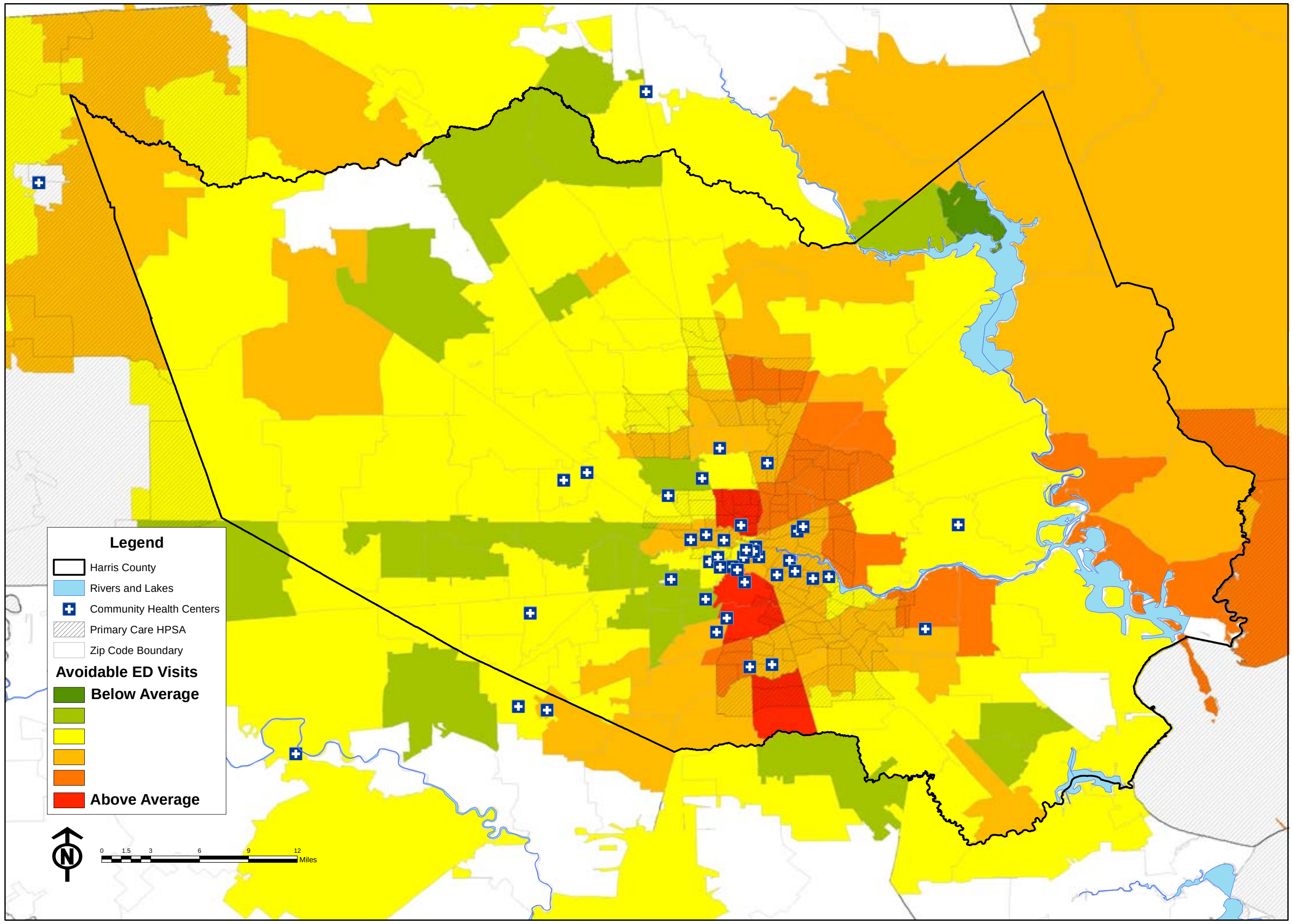


Figure 29: Avoidable ED Admissions by ZCTA: Houston, TX

Rate of Children's Avoidable ED Visits by Zip Code: Harris County, TX



VI. Measuring Transportation Accessibility – A Weighted Approach

In our efforts to better understand the extent and location to where children face the greatest barriers to transportation and health care services requires the need for comparisons across communities based on a single score. Composite scoring is widely used across many disciplines where measures are aggregated into a single score. The aggregation of several complex indicators into a single dimension can also assist ordinary consumers with their understanding of important, but often intricate messages (Landrum, Bronskill, & Normand, 2000). Although the concepts of automobile access and transit access are not complex subjects, combining those two components into a single measure of transportation access seemed most appropriate. We approached the measure by asking two separate questions:

1. How well is the population's access to private automobile?
2. How well is the population's access to public transportation?

As detailed in the previous section, we examined access to a private automobile or vehicle through two measures:

- The percentage of households without a vehicle, and
- The ratio of vehicles to the population of driving age.

In examining access to public transportation (also detailed in the previous section) we used two measures:

- The proportion of each ZCTA within walking distance (defined as ¼ mile or less) to a mass transit stop.
- The proportion of each ZCTA accessible to public transit was then weighted using a public transportation Effectiveness Rating developed by researchers at the University of South Florida.

Because there are some areas within the three metropolitan areas where a private vehicle is unnecessary due to an individual's proximity to public transportation, work and other amenities, we developed a weighting system within the index to account for such areas to develop a more complete measure of transportation accessibility. The result of the weighting scheme is that in areas where public transportation is highly available (i.e. - high transit score), the model weights down or de-emphasizes the importance of a private vehicle. Where transit options are not available (i.e. – low transit score), the model places more emphasis on the availability of a private vehicle.

$$= (Z_{Transit} \times \%\, Trans\ Cover) + [(Z_{No\ Car} + Z_{Ratio}) \times (1 - \%\, Trans\ Cover)]$$

Where:

$Z_{Transit} = Standaridized\ Transportation\ Accessibility\ Score$

$Z_{No\ Car} = Standardized\ Percentage\ of\ Households\ with\ No\ Vehicle$

$Z_{Ratio} = Standardized\ Rate\ of\ Vehicles\ per\ 1{,}000\ Population\ of\ Driving\ Age$

$\%\, Trans\ Cover = Percentage\ of\ ZCTA\ within\ Walking\ Distance\ to\ Transit$

In the following three maps, the Weighted Transportation Accessibility Index (WTAI) is displayed for the Dallas, Houston and Austin metropolitan areas. There is one slight variation in each map. In the Dallas map, we provided the network of major road arteries. In the Harris County (Houston) map, we provide no road or transit networks. In the final map of Travis County, we provide the transit routes as a variation on the final analysis.

Figure 30: Weighted Transportation Accessibility Index by ZCTA: Dallas, TX

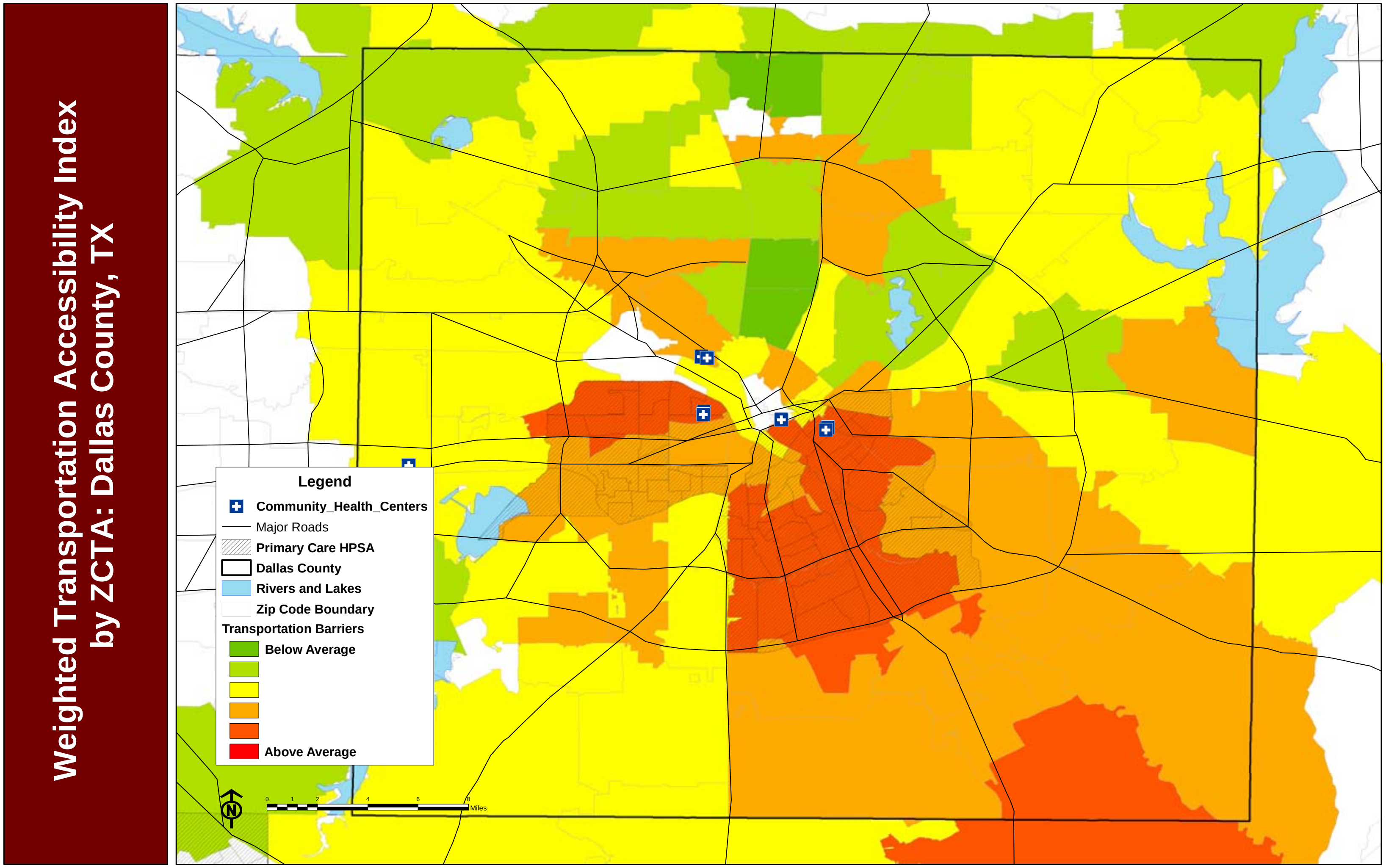


Figure 31: Weighted Transportation Accessibility Index by ZCTA: Houston, TX

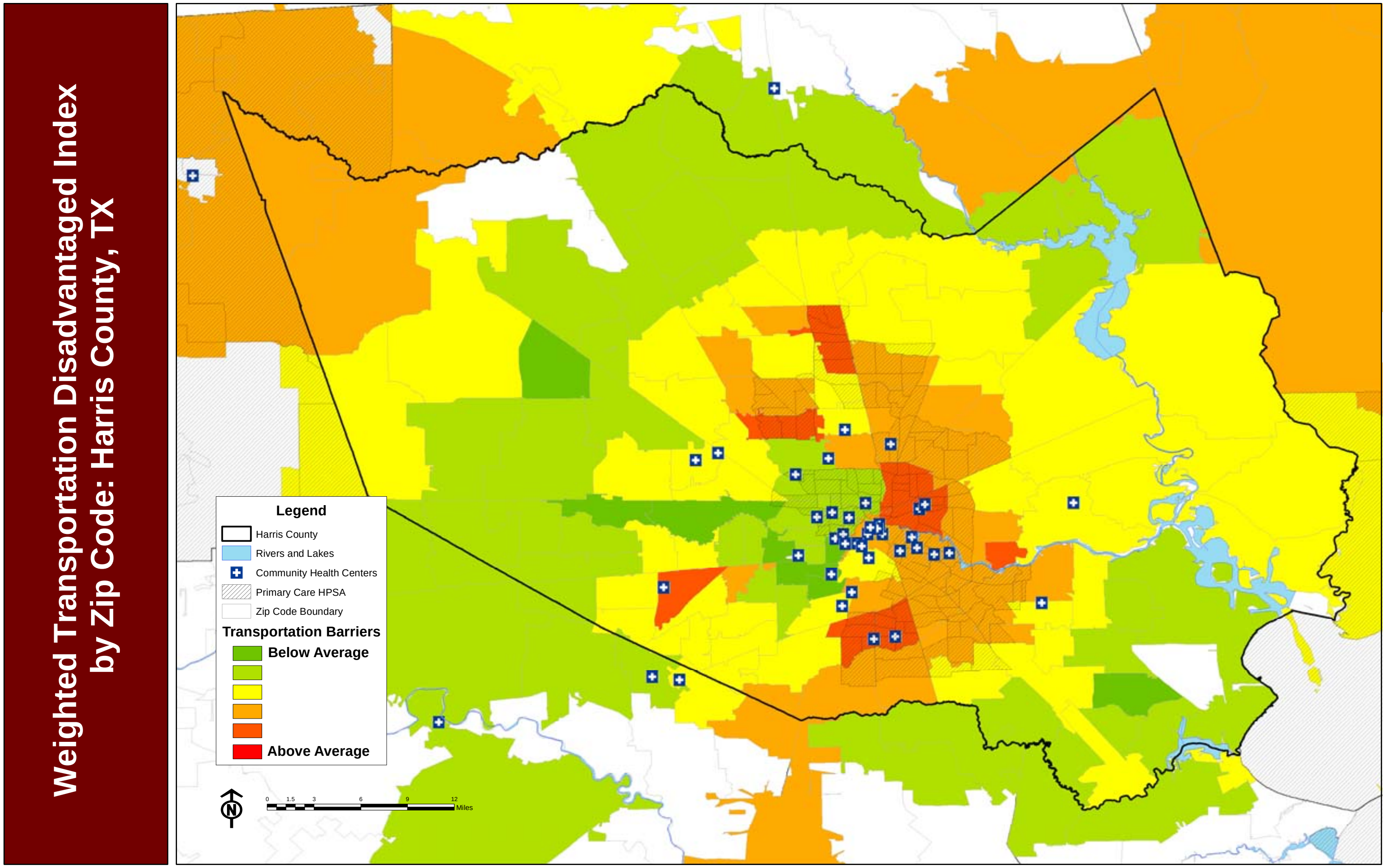
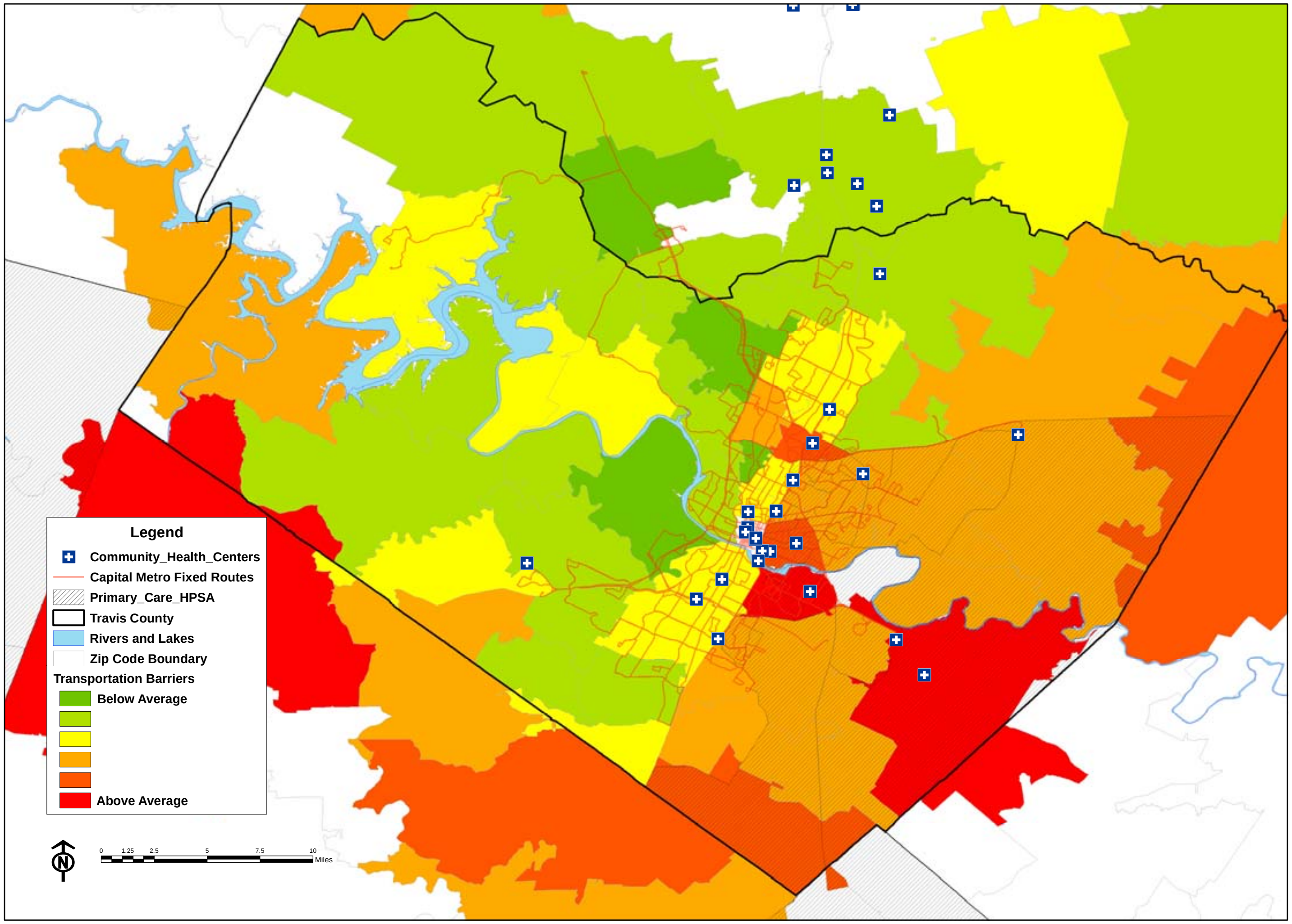


Figure 32: Weighted Transportation Availability Index by ZCTA: Austin, TX

Weighted Transportation Accessibility Index by ZCTA: Travis County, TX



VII. The Health Transportation Shortage Index

Interest in summary health measures has surged in recent years. The widespread proliferation of information technology has brought about what many experts call the "democratization of data" meaning that information and data that once was available to only a select few is now available to everyone. Through a concept first proposed by Dempsey in 1947 to address the inadequacy of mortality related to tuberculosis, one of the first widespread summary health measures was offered by the World Bank in 1993. Their measure, the disability-adjusted life year (DALY) was developed as a method of more appropriately measuring the burden of disease by accounting for the number of years of life lost (premature mortality) as a result of disease-related disabilities (The World Bank, 1993). Dempsey's work paved the way for user-friendly analytical tools for assessing health trends and gaps, providing the analytical tools and the means to understand and identify stark disparities in a relatively simple manner.

In the United States health and social indicators are widely used to measure progress at the state and county level. While numerous organizations have developed indicators for broad geographies most of these indicator efforts lack a single summary measure reducing their usefulness. Despite identifying broad trends, the most effective initiatives increasingly occur at much more localized levels. Given the need to develop a summary index at a localized level, the HTSI was developed by building upon nationally and internationally recognized efforts. The following were the most influential in developing the HTSI:

- HRSA's and The Cecil G. Sheps Center for Health Services Research at The University of North Carolina at Chapel Hill's *Designating Places & Populations as Medically Underserved: A Proposal for a New Approach* (http://bhpr.hrsa.gov/shortage/proposedrule/designatingplaces.html) (Ricketts, et al., 2007);

- The United Kingdom's *English Indices of Deprivation* (http://www.communities.gov.uk/publications/corporate/statistics/indices2010) (Bradshaw, et al., 2009), and;
- The University of Wisconsin Population Health Institute's *County Health Rankings* (http://www.countyhealthrankings.org).

For example, current indicator projects such as the *County Health Rankings* show us that where we live matters to our health. Yet while base rates of important indicators are useful at the state, county or even city level, they are often aggregated in a way that mask particularly acute problems at the community level. Houston is home to The University of Texas M.D. Anderson Cancer Center, one of the most revered cancer research and treatment centers in the world, yet HRSA estimates that around 522,000 people living in Houston live in a Primary Care HPSA. Recognizing that broad geographic areas are insufficient for developing appropriate policy and resource responses, the *English Indices of Deprivation* was the first summary index of overall child-well being created for small geographies (Bradshaw, et al., 2009). The sound underpinnings, the empirically based methodological approach and the well documented steps for using administrative data to develop a single measure of underserved communities provided a sound foundation for the overall concept and methodology for the HTSI (Bradshaw, et al., 2009; Office of the Deputy Prime Minister, 2004; Ricketts, et al., 2007). Finally, national efforts to update the HPSA and MUA definitions with a methodologically sound approach were also very influential, especially since the HPSA designation is a key component to the HTSI.

Combining the Domains into the HTSI

In developing the HTSI, recall that the model was developed around three domains related to children's health and transportation accessibility: transportation, provider and socioeconomic. Table 3, presents a correlation matrix of the individual measures comprising each domain and the key outcome variable, the rate of children's avoidable ED admissions. This analysis helps us determine if the domains are indeed linked to outcomes. Since the measures are highly inter-correlated, this seems to suggest they are appropriate candidates for modeling health and transportation barriers with respect to children's ACSCs. For example, the first column shows that the rate of children's ACSC's and the percentage of households without an automobile are positively correlated (0.491), meaning in ZCTAs with high rates of children's ACSC's there are also typically high rates of households without an automobile. In the third column, the ratio of available automobiles to the population of driving age and the percentage of Hispanic children living in each ZCTA are negatively correlated (-0.730). A negative correlation means that in ZCTAs where the there is a high proportion of available automobiles to the population of driving age there are typically lower percentages of Hispanic children.

In developing the HTSI, each of the three domains serves as an independent dimension of the HTSI, with each resulting in its own additive impact on the HTSI. Yet it is clear from the correlation matrix that the individual measures have varying degrees of impact on health and transportation accessibility, assuming that the rate of children's ACSCs is an appropriate proxy. The ultimate impact each measure has on the HTSI is related to its overall importance to children's health and transportation accessibility. Therefore, simply summing the results of each domain into a single overall measure is likely to lead to a poor predictive model. In order to combine each of the domains into a single measure, the HTSI calculation required two steps:

I. Standardizing the data from each of the three domains, and
II. Constructing weights so that each domain is influences the HTSI based on its relative importance.

Table 3: Correlation Matrix: Health Transportation Shortage Domains

	DOMAINS									
	Outcome	**Transportation**			**Provider**			**Health Disparity**		
	Children's Rate of ACSCs	Transit Coverage	Ratio of Cars to Driving Pop	HH with no Car	HPSA Score	Rural Pop	Distance to Nearest FQHC	Children in Poverty	Hispanic Children	Non-White Children
Outcome										
Children's Rate of ACSCs	1.00									
Transportation										
Transit Coverage	-.018	1.00								
Ratio of Cars to Driving Pop	-.191	-.284	1.00							
HH with no Car	.491	.304	-.509	1.00						
Provider										
HPSA Score	.278	.094	-.372	.333	1.00					
Rural Pop	-.201	-.258	.236	-.304	.001	1.00				
Distance to Nearest FQHC	-.093	-.304	.435	-.453	-.250	.421	1.00			
Health Disparity										
Children in Poverty	.270	.308	-.730	.639	.499	-.191	-.491	1.00		
Hispanic Children	.315	.246	-.537	.345	.302	-.158	-.427	.651	1.00	
Non-White Children	.214	.219	-.543	.320	.390	-.185	-.329	.578	.280	1.00

Standardization

Because many of the underlying measures of each domain are reported in different scales (i.e. some are percentages, some are rates or some are distances) this necessitated that we standardize each measure into a common metric prior to combing the indicators or measures into the HTSI. Standardization gives each individual measure a mean (average) value of 0 and a standard deviation (measure of spread) of 1. In statistics, we call this a z-score. The z-score developed for each ZCTA is relative to the other ZCTAs in the study area for the measure of interest. A positive z-score indicates a value for the ZCTA that is higher than the average as compared to the rest of the study area while a negative z-score indicates a value for the ZCTA that is lower than the average of study area. Other standardization procedures were considered, such as ranks and logarithmic transformation. Each of these methods has their strengths and weaknesses, but we selected the z-score primarily because of the relative simplicity and interpretation of this type of standardization.

It is worth noting, however, that exponential transformations were chosen as the most appropriate method by Ricketts et al. (2007) and Bradshaw et al. (2009) for their respective projects. Logarithmic or exponential transformation of the variables is viewed as advantageous because "good" scores on one domain do not cancel out "bad" scores on another domain. This is true because the logarithmic or exponential transformation increases the degree of the magnitude of the intensity of the measure as the scale increases. For example, each step in the scale corresponds to an increase in amplitude of a power of ten so a "good" (low) score on one domain will have far less impact on the overall index than a "bad" (high) score. The canceling effect as a result of employing z-score standardization created a dilemma in calculating the HTSI. Recall that within the transportation domain we evaluate transportation accessibility by examining public transit and private automobile availability. In areas well-served by public transportation systems (i.e. that have "good" scores), the availability of private automobiles ("bad" scores) is much less problematic to the overall question of mobility. We also recognize, however, that the cumulative effective of poverty, transportation barriers and the lack of primary care services have severe consequences on children's health outcomes, making the exponential transformation a seemingly logical choice. Given the fact that we know of no theoretical basis or literature where differing standardization strategies were used to combine or adjust for different standardization strategies, we opted to employ the z-score standardization process.

Weighting

In building a summary index, the important question is: To what extent does each domain contribute to transportation and health shortages? This can be accomplished by assigning a weight to each measure where the weight is the measure of importance attached to each component in the overall composite HTSI. We considered a variety of approaches to select the appropriate weighting methodology, such as examining the inter-correlations and the theoretical constructs of the three domains. Our considerations also included regression strategies which are generally considered to provide quite robust results, however the spatial autocorrelation (the degree to which ZCTAs with high rates of ACSCs and low rate of children's ACSC's cluster together) present in the data violates the underlying assumptions of the analysis. These violations often lead to invalid or misleading results. While spatial autocorrelation can be overcome through spatial regression techniques, the complicated nature of the model was inconsistent with stakeholder desire to produce an end-product that would be more transparent and easily understandable to those without a background in statistics. We did, however, create a spatially lagged regression model using the variables form each our domains that resulted in model R^2=.51 meaning that our model accounts for 51% or about half of the variability in a data. This is a large improvement over the Year 1 model where the R^2 was below .3.

We settled on an approach employed in the UK (Bradshaw, et al., 2009) using factor analysis to generate the weights for the individual indicators developed through their work on the English Indices of Deprivation. Factor analysis seemed an appropriate choice given the assumption of the latent construct related to the question of accessibility. Yet in a technical report detailing the methodology of the English Indices of Deprivation (developed as part of the ongoing work of Bradshaw and colleagues (2004 and 2009)) the authors recommend a single factor solution through employing maximum likelihood (ML) factor analysis. They cite the advantages ML factor analysis versus principal components in developing the weights because of ML's ability to overcome a number of problems associated with identifying underlying factors, such as: the variables have different levels of statistical accuracy, different distributions, may or may not apply to the same individual and imperfectly measure the underlying factor (Office of the Deputy Prime Minister, 2004). Upon developing a satisfactory solution, a factor score was estimated for each of our nine indicator variables as the basis of the weighting. The weights generated through the ML factor analysis are summarized in Table 4.

Table: 4 Individual Component Indicator Weights for the HTSI

Indicator	Indicator Weight
Transportation	
Transit Coverage	.066
Ratio of Cars to Driving Pop	.147
HH with no Car	.125
Provider	
HPSA Score	.096
Rural Pop	.049
Distance to Nearest FQHC	.104
Health Disparity	
Children in Poverty	.176
Hispanic Children	.125
Non-White Children	.114

Upon calculating the final weights for the model, we were able to complete the calculation for the HTSI. Please note that the Provider and Health Disparity variables are condensed into a single category for brevity of demonstration in the following example:

$$HTSI = (WTAI) + (w_{Provider} * Z_{Provider}) + \left(w_{Health\ Disparity} * Z_{Health\ Disparity}\right)$$

Where:

$WTAI = Weighted\ Transportation\ Accessibility\ Index$

$w = Individual\ weights\ for\ each\ indicator\ or\ measure$

$Z = Standardized\ variable\ for\ each\ indiactor\ or\ measure$

Figure 33: Health Transportation Shortage Index: Dallas, TX

Health Transportation Shortage Index by ZCTA Type: Dallas, TX

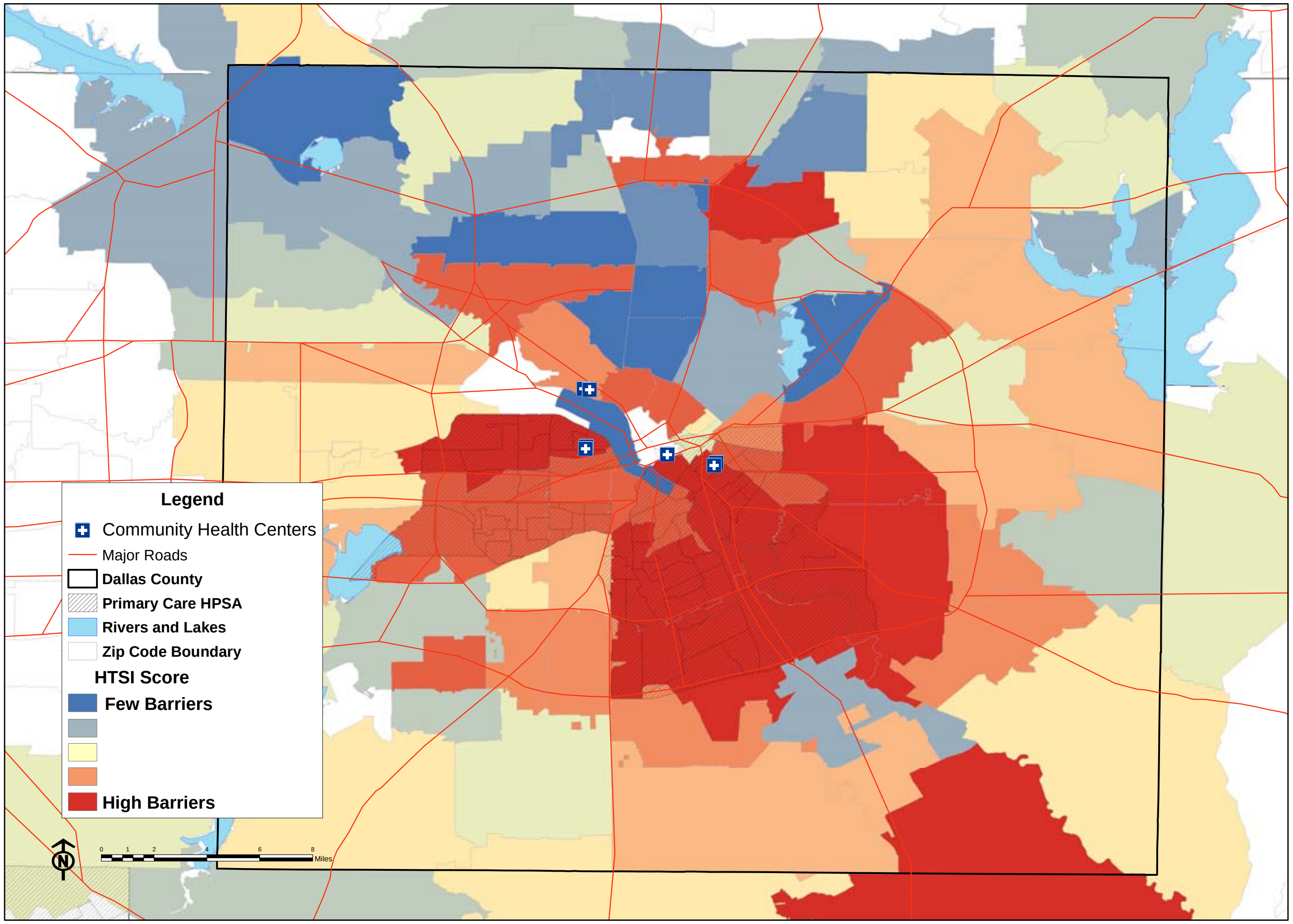


Figure 34: Health Transportation Shortage Index: Houston, TX

Health Transportation Shortage Index by ZCTA Type: Houston, TX

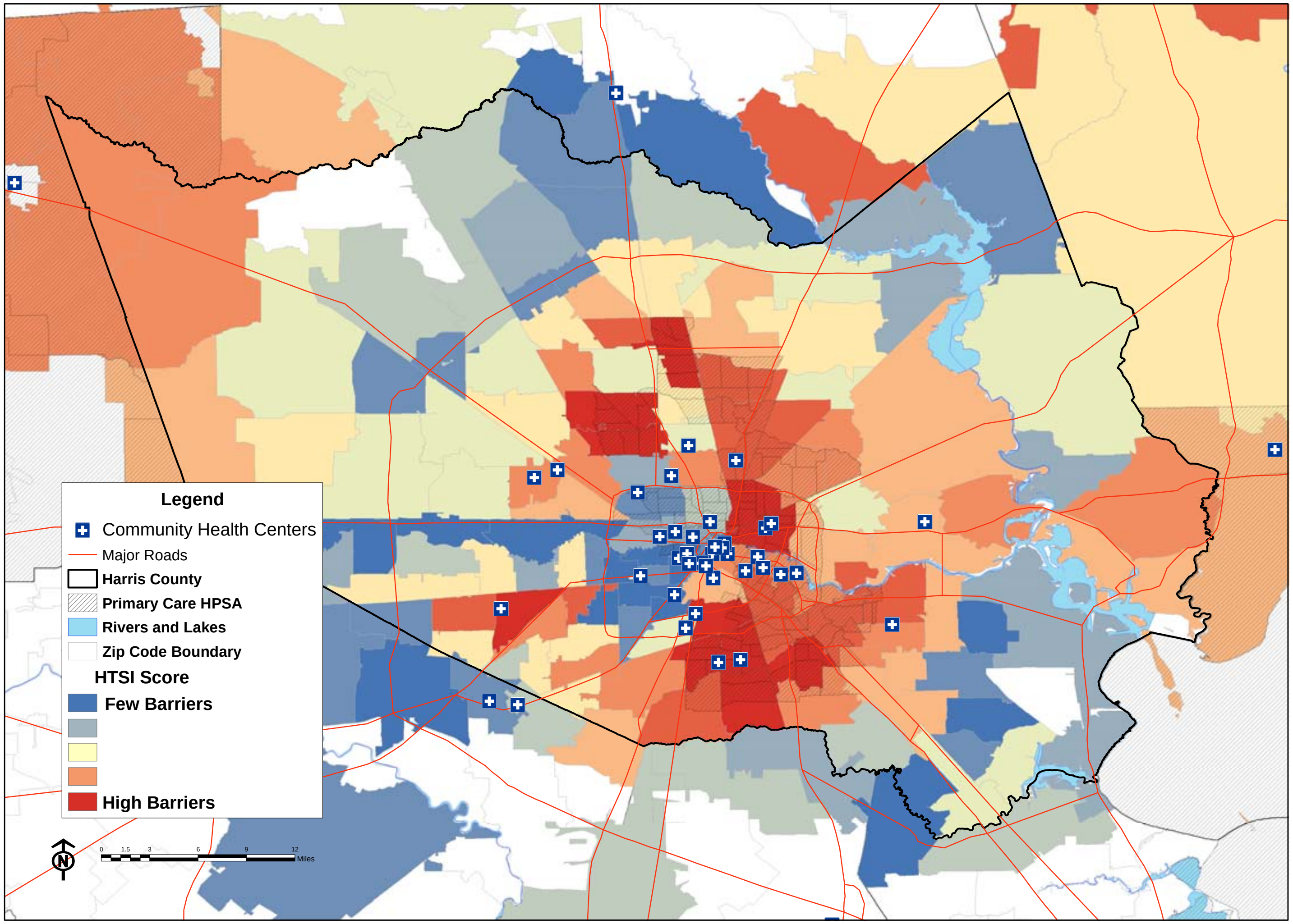
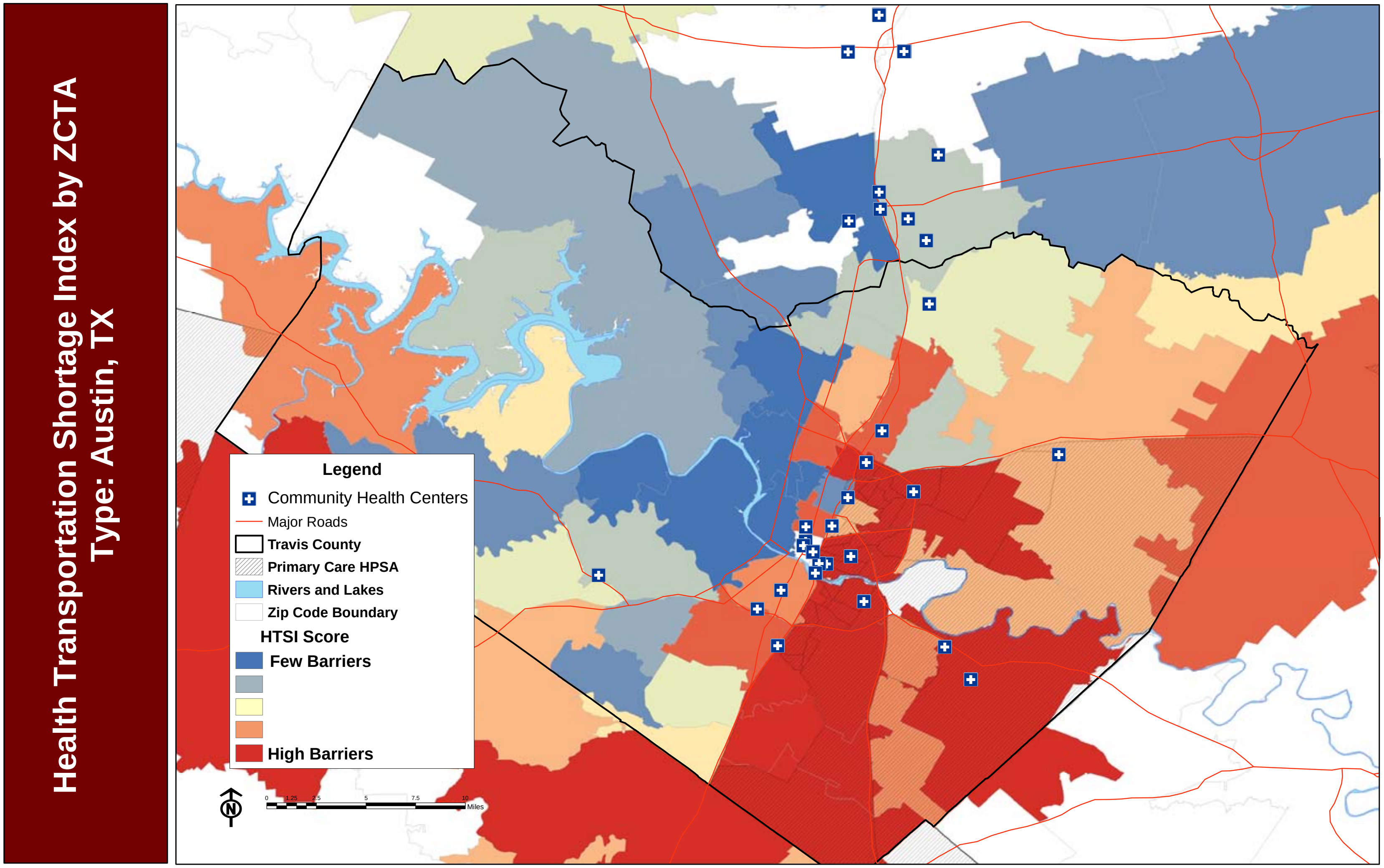


Figure 35: Health Transportation Shortage Index, Austin, TX



VIII. Identifying Areas of Need - Hot Spot Analysis of Children's ACSCs

Hot spot analysis is one way of targeting areas where ACSC problems may be particularly acute. Typically called hot spots or hot spot areas, these are simply concentrations of ACSC within a limited geographical area that appear over time. Hot spot analysis evaluates the ACS data by comparing the local mean to the global mean and then determining whether the difference between them is statistically significant. In other words, how likely it is that we might see a pattern of ACSC in the Houston metropolitan area if the underlying processes are random?

In the ArcMap GIS software, there is a Hot Spot Analysis tool that calculates the Getis-Ord Gi statistic for each feature in a dataset. The resultant Z score tells us where features with either high or low values cluster spatially. This tool works by looking at each feature within the context of neighboring features. A feature with a high value is interesting, but may not be a statistically significant hot spot. To be a statistically significant hot spot, a feature will have a high value and be surrounded by other features with high values as well. The local sum for a feature and its neighbors is compared proportionally to the sum of all features; when the local sum is much different than the expected local sum, and that difference is too large to be the result of random chance, a statistically significant Z score results.

The following three maps represent the results of the hotspot analysis for our three children's ACSCs. By examining the rate of ACSCs per 1,000 children, the hot spot analysis is therefore comparable across zip codes and provides a good relative analysis of those areas suffering from the greatest access barriers.

Figure 36: Children's Rate of Avoidable ED Admissions Hotspot Analysis: Dallas, TX

Children's Avoidable ED Admissions Hot Spot Analysis: Dallas County, TX

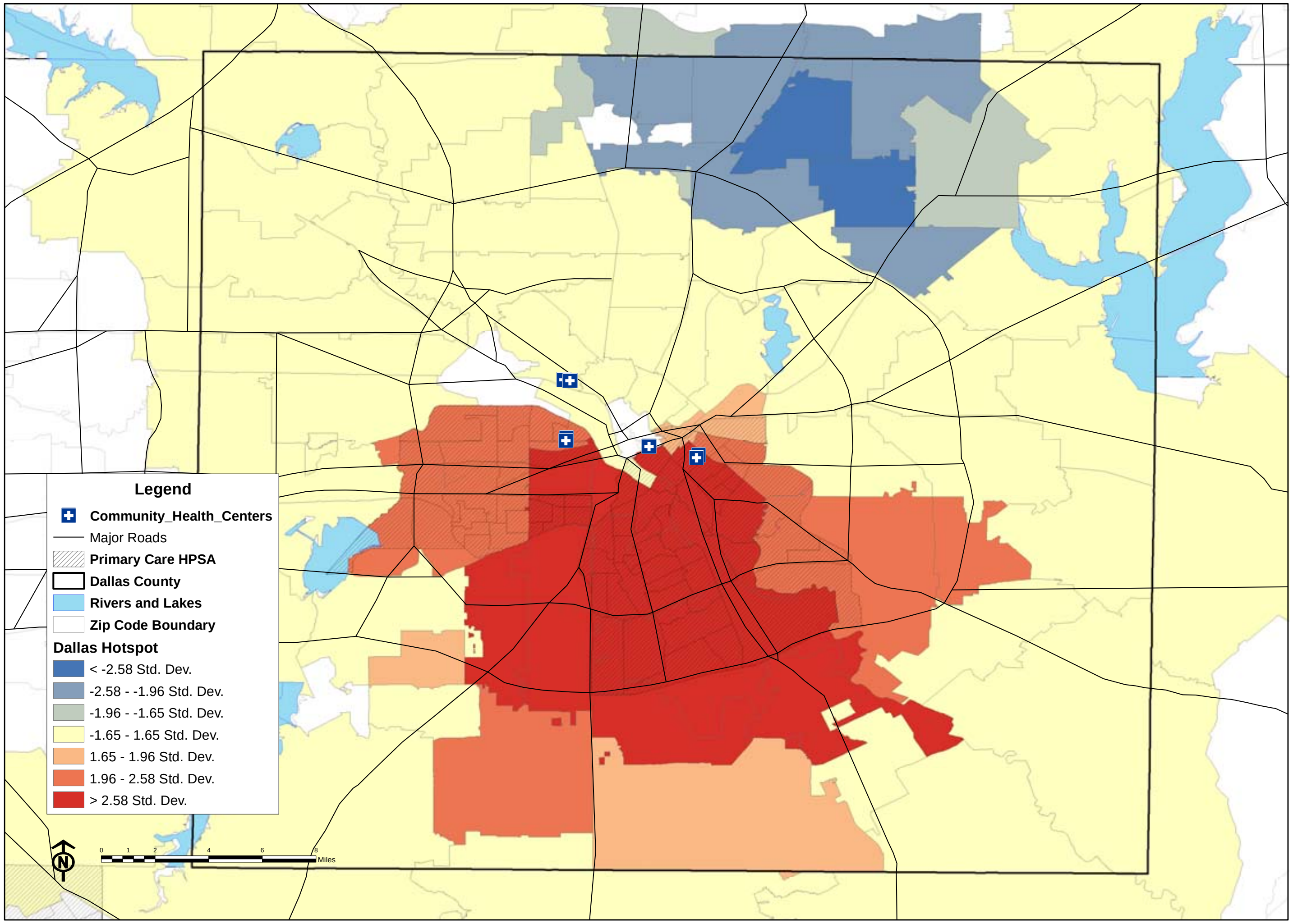


Figure 37: Children's Rate of Avoidable ED Admissions Hotspot Analysis: Houston, TX

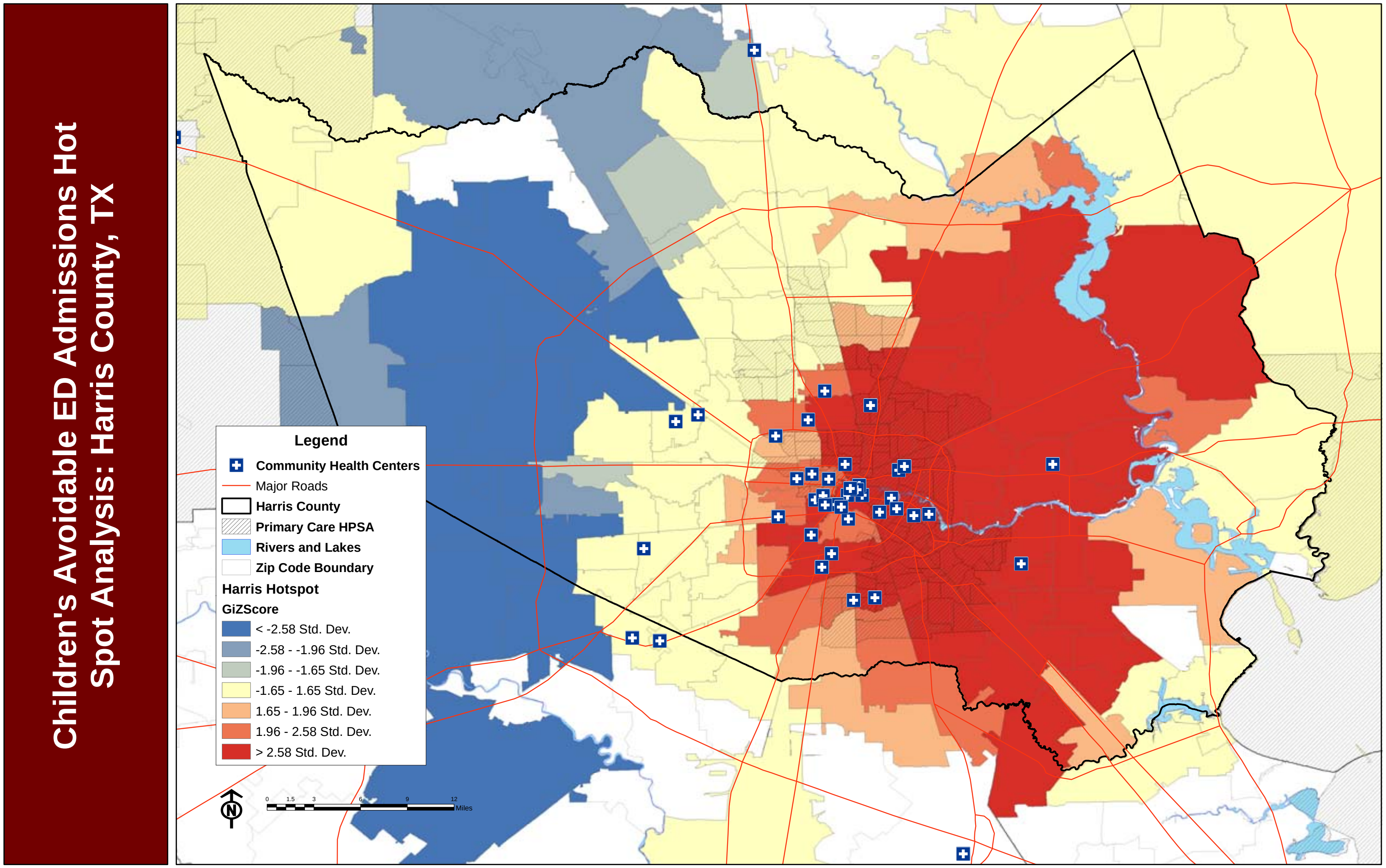
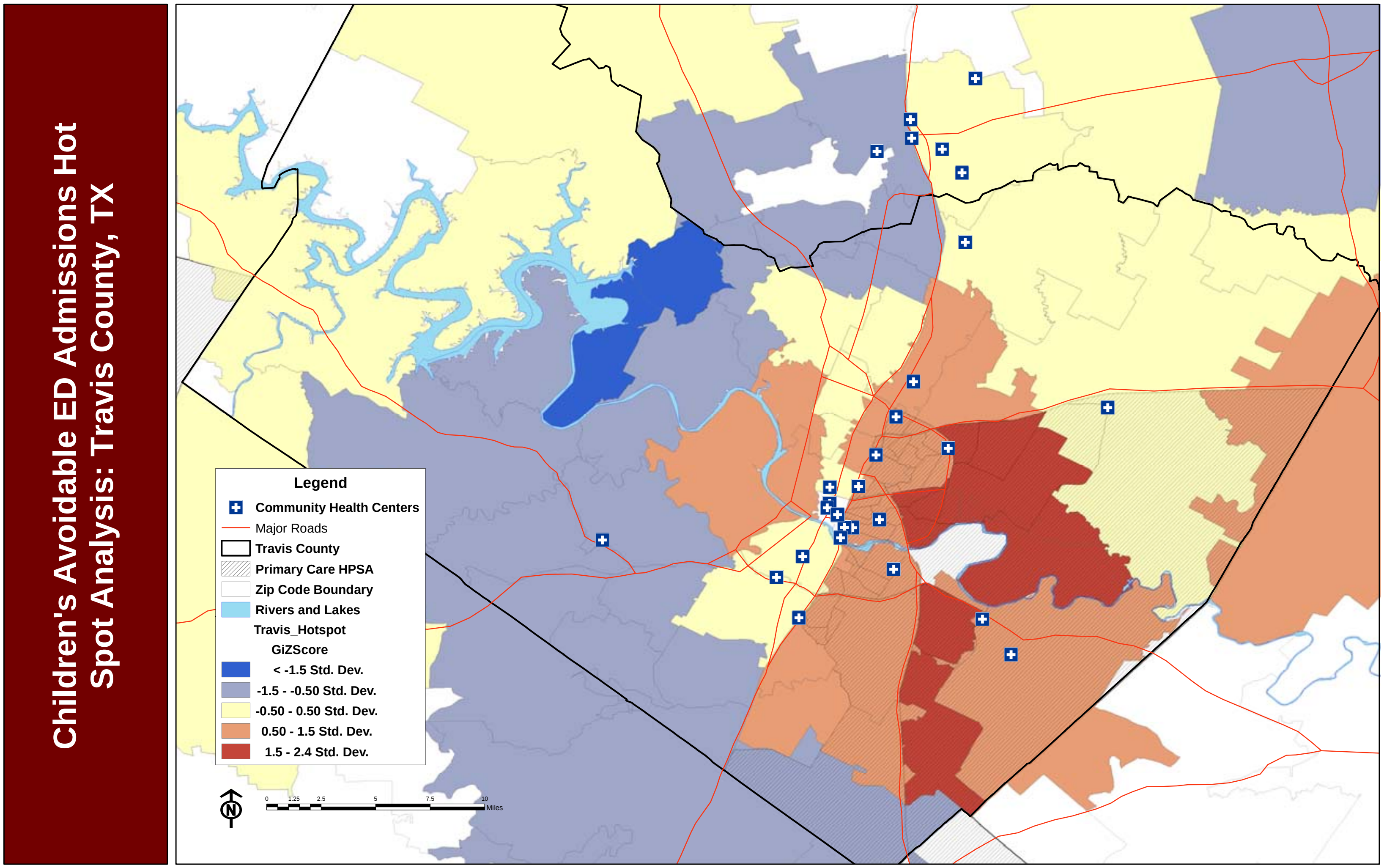


Figure 38: Rate of Avoidable ED Admissions Hotspot Analysis: Austin, TX



IX. Convergence of Transportation and Health Accessibility Barriers

In Sections II and III of the report we reviewed a number of public transit accessibility measures and found the model to determine Transit-Supportive Areas (Transit Cooperative Research Program, 2003) to be appropriate for this project. Recall that the Transit-Support Area analysis identifies areas that could support public transit systems by intersecting the service coverage areas with those that are currently not serviced by public transit, but potentially have the density and other important characteristics that make them good candidates for transit expansion.

Employing a similar model, we identified areas exhibiting high rates of poor health outcomes for children through mapping the rate of ACSCs (i.e. avoidable ED visits) by ZCTA. We also identified areas exhibiting high rates of transportation barriers through developing the Weighted Transportation Accessibility Index. Areas exhibiting high rates of ACSCs and transportation barriers converge, we identified those are being Health Transportation Shortage Areas.

Figure 39: Conceptual Model of Identifying Health Transportation Shortage Areas

The Transit-Supportive Areas model has clear decision criteria on identifying "underserved" transit areas. These criteria are based on well-established measures of density, network modeling and other characteristics that when exceeding a certain threshold are demonstrated to support public transit in a given area. In the case of determining those critical thresholds for the Health Transportation Shortage Index, there are no guidelines or accepted measures of an unacceptably high rate of ACSCs or what truly constitutes transportation barriers to the point where they impede access. Given little guidance in the area, we established two cut-off points based on the percentile rankings of the rate of ACSCs and the combined score of the WTAI. After examining the distribution of both measures, we developed percentile ranks for the WTAI and the rate of ASCSs by ZCTA. All scores in the top 3rd of the percentile ranks were determined as "high":

- Percentile rank > 65% = High Rate of ACSCs
- Percentile rank > 65% = Weighted Transit Accessibility Index

In Figure 37, we provide an example of how we identified ZCTAs. ZCTAs identified by the thatch or diagonal shading are those exhibiting high levels of transportation barriers. ZCTAs identified with the rose shading are those exhibiting high levels of ACSCs. Where high levels of transportation barriers and high rates of ACSCs converge, those are identified as un-served areas by the Health Transportation Shortage Index.

Figure 40: Convergence of Transportation and Health Care Access Barriers - Focused Analysis of Houston, TX

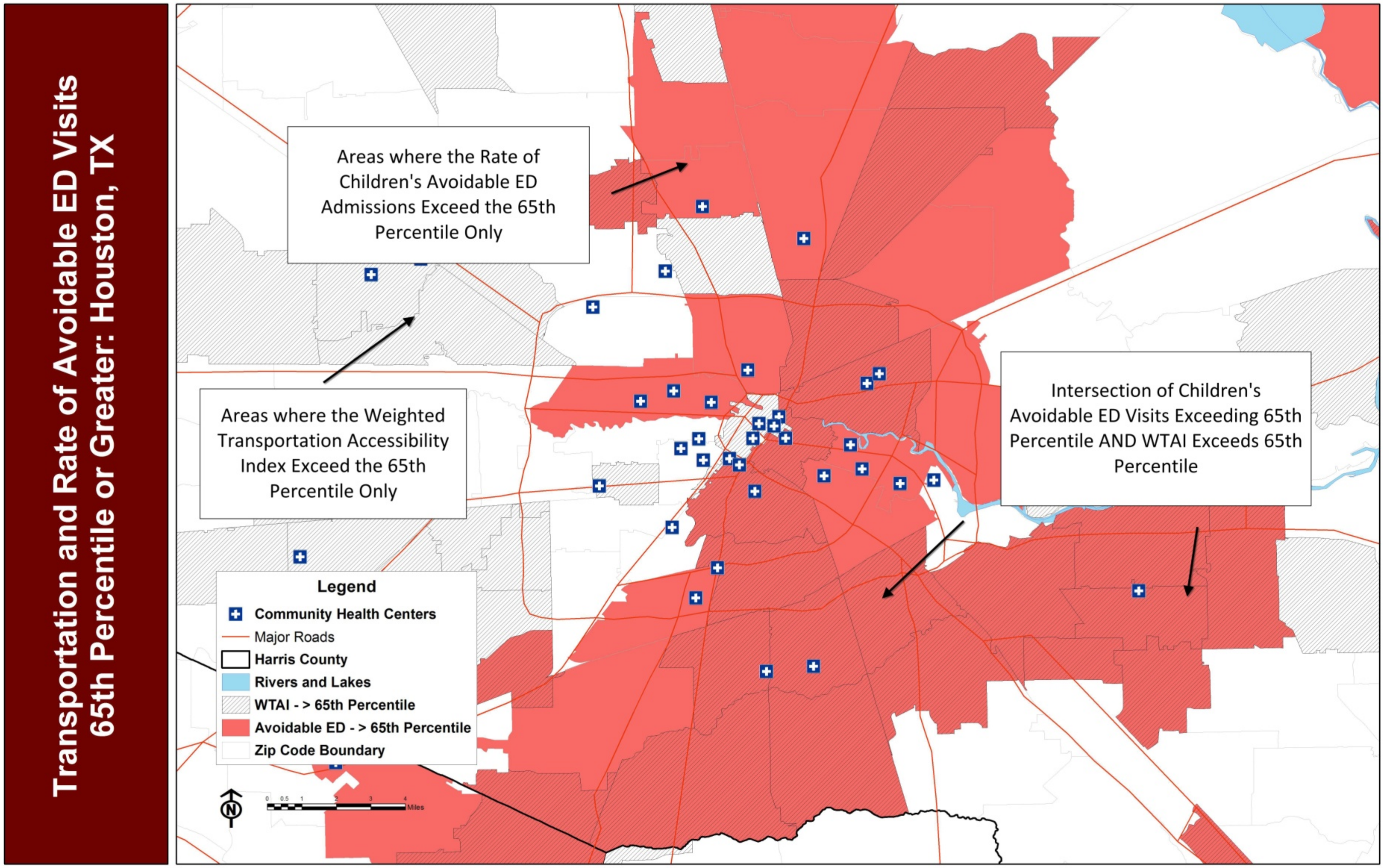


Figure 41: Health Transportation Shortage Areas: Dallas, TX

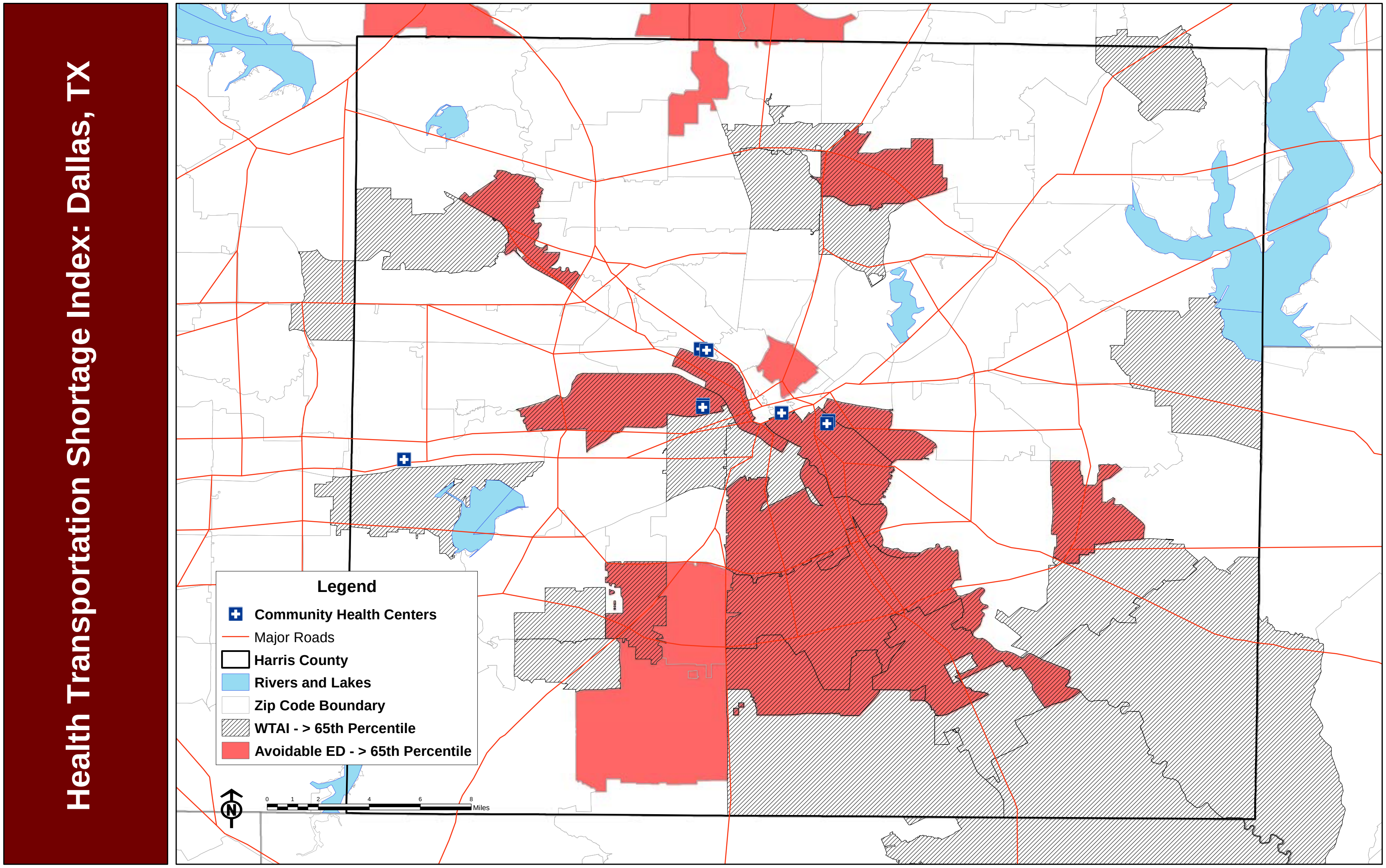


Figure 42: Health Transportation Shortage Areas: Houston, TX

Health Transportation Shortage Index: Houston, TX

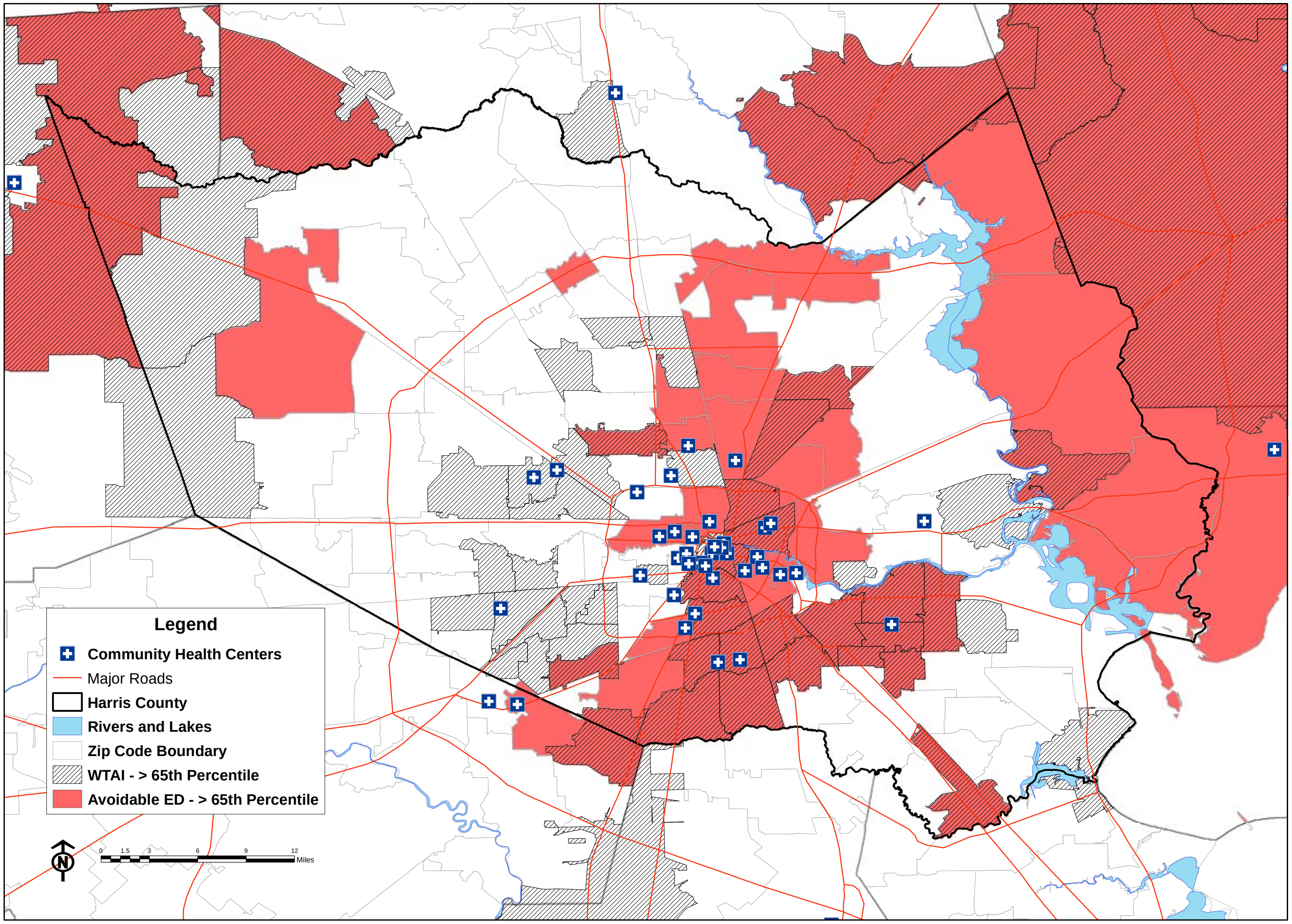
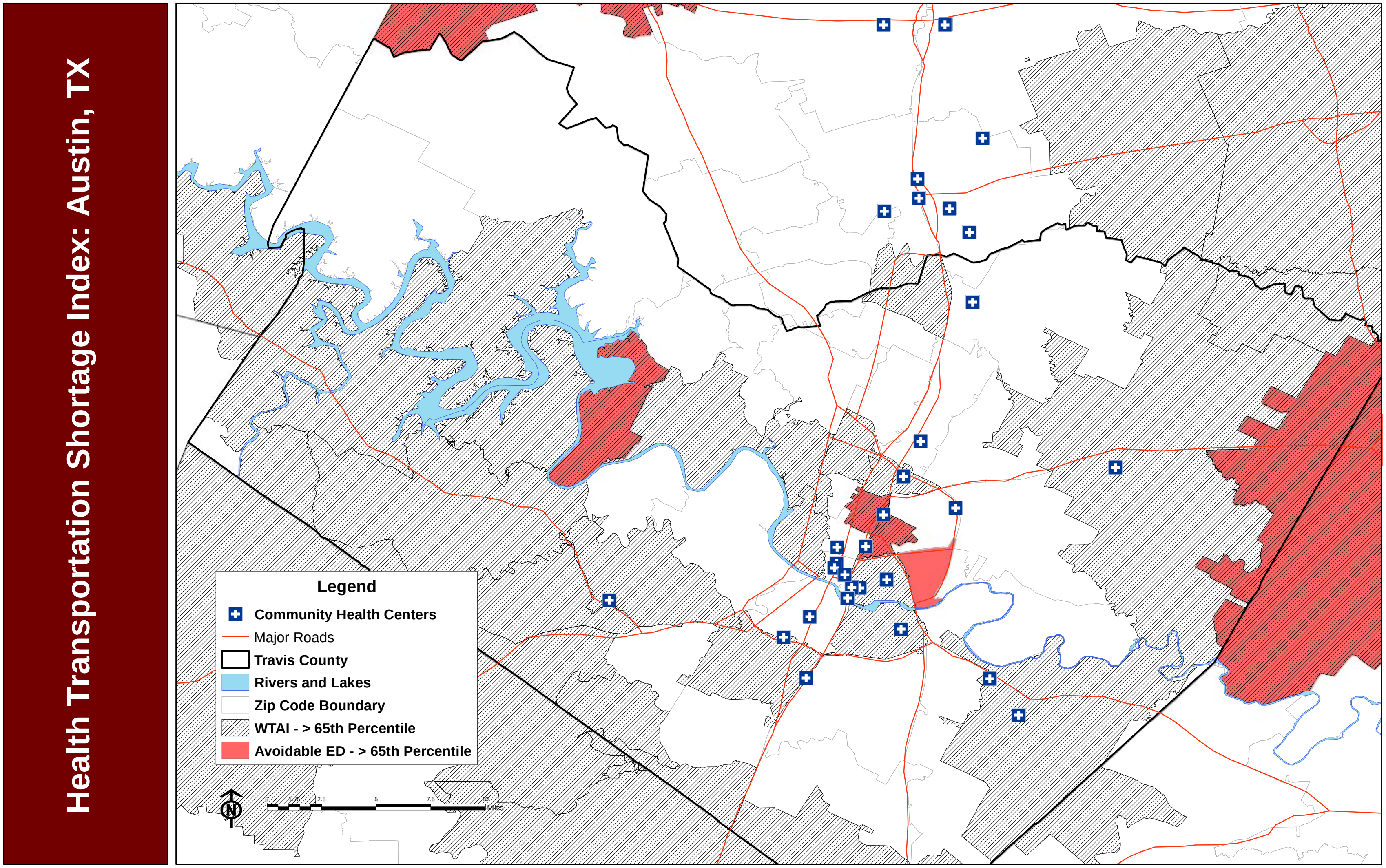


Figure 43: Health Transportation Shortage Areas: Austin, TX



X. Strategies for Identifying Areas with Need

The first results from the decennial U.S. Census began trickling out in early 2011. A recent article from the *Houston Chronicle* reported that Texas is growing increasingly urban and Latino. Latino's accounted for two-thirds of the state's growth between 2000 and 2010, accounting for 38% of the state's population while the Anglo population declined from 52 to 45%. Nearly all of the state's population growth is expected to have come in just four areas: Houston-Galveston, Dallas-Fort Worth, the Austin-San Antonio corridor and the lower Rio Grande Valley. Houston remained the state's largest city, with 2.1 million residents, an increase of 7.5% from 2000. Harris County also remained the larger county in the state with a population of 4.1 million, tallying a growth rate of 20.3% since 2000.

While these facts are interesting in and of themselves, aggregate analysis at the levels mentioned above are too large to broaden our understanding of children's health transportation difficulties at a more localized level to develop potential solutions. It is only by closely examining subgroups within each county, can we begin to understand our communities and their particular needs. Anyone familiar with Houston and Harris County knows full well the differences between the demographic and income characteristics of the tony River Oaks neighborhood and Houston's Fourth Ward, known as Freedmen's Town for the freed slaves that settled there after the Civil War. They further recognize the differences in Houston's gritty shipping channel and the posh shopping available in the Galleria area. Examining adjacent or nearly adjacent communities *within* Harris County reveals that some communities have far less in common with each other than communities far beyond the borders of Harris County and even Texas.

In identifying Health Transportation Shortage Areas, we know little about the children and their families residing in these areas. Acknowledging that children living in different areas are likely to have different backgrounds and needs, we employed factor analysis to assist in better understanding the characteristics of children in HTSAs.

Factor analysis is a data reduction method that tests the data for the existence of clusters within multiple variables. The existence of clusters suggests that a group of variables could be measuring aspects of the same underlying dimension. These underlying dimensions are known as factors. By reducing the dataset from a group of interrelated variables into a smaller set of uncorrelated factors, factor analysis achieves parsimony by explaining the maximum amount of common variance using the smallest number of explanatory concepts.

By examining each of our transportation, provider availability and health disparity indicators simultaneously on the areas identified as ACSC hotspots in each of the three metropolitan areas, factor analysis reduced our broad set of indicators or measures into three components or factors as displayed in Table 5 on the following page. Table 5 contains the loadings for each variable onto each factor. The factor structure matrix represents the correlations between the variables and the factors. The factor analysis component matrix represents the linear combination of the variables.

For example, Factor or Component 1 is comprised of each variable in the table for which there is a score. If there is no score in matrix, that particular variable is not associated with the overall factor. In the case of Factor 1, there is no association among the population classified as rural and it should not be assumed that the absence of a value for the Percent of the Population Living in a Rural Area implies the opposite.

A second component to interpreting the factor scores is through examining the direction of the relationship. Again, in examining Factor 1, the component score for Percent of Children Living in Poverty was .919. This indicates that among ZCTAs most representative of Factor 1, they are likely to have high rates of children living in poverty. On the other hand, the coefficient for the Ratio of Vehicles or Cars to the Population of Driving Age is negative or -.849. This indicates that among ZCTAs most representative of Factor 1, they are likely to have low ratios of vehicles to the population of driving age.

A third and final point in interpreting the factor scores is to understand the strength of association or the relationship. Positive factor scores can have values between 0 (no association) and 1 (perfect association). Negative factor scores can have values between 0 (no association) and -1 (perfect negative association). The closer the value is to 1 (positive factor scores) or -1 (negative factor scores) the stronger the association. Although factor scores can be generated for all variables, we used a cutoff of .35 to ensure that only the variables with the strongest association for each factor remained part of the final solution.

Below is a short summary of how one could interpret the traits or characteristics associated with Factor 1:

- High percentage of children living in poverty;
- Very likely to be without a vehicle;
- Low ratio of vehicles to the population of driving age;
- Likely to live in a HPSA;
- More likely to be non-white;
- Likely to live close (relative) to a CHC or FQHC;
- Moderate access to public transit; and
- Moderately percentage of Hispanic children.

Table 5: Factor Analysis Component Matrix

Socioeconomic Variable	**Component**		
	1	2	3
Percent of Children Below Poverty	.919		
Percent of Households without a Car	.881		
Ratio of Cars to Population of Driving Age	-.849		
HPSA Score	.652		.356
Percent of Non-white Children	.649	.544	
Distance to Nearest FQHC	-.629	.484	
Transit Coverage	.446	-.391	
Percent of Hispanic Children	.365	-.718	
Percent of the Population Living in a Rural Area			.908

By examining the common themes or characteristics of each factor, we developed a typology or classification scheme for each of the three factors to help in summarizing our findings by giving each factor a name.

- **Factor 1 – Children with Extreme Transportation Needs**. The proportion of the population exhibits many factors that would put them at risk of poor health care accessibility. Children living in these ZCTAs are near universally low-income with poor access to a private vehicle, while having only moderately good public transportation choices. These areas are most likely to have been identified as Primary Care HPSAs and therefore are likely to have requisite investments in increasing health care access such as a CHC or FQHC, but appear that children living in these areas simply have extremely limited transportation means to obtain primary care services.

- **Factor 2 – Public Transit and Distance Hindered Children**. Children living in these ZCTA are likely to be non-white, but yet are not likely to be Latino or Hispanic. These children typically live relatively far from the nearest FQHC or CHC. Further, they are very unlikely to have access to a public transportation.

- **Factor 3 –Rural HPSA Children**. Only two variables loaded on the final component or factor, HPSA score and the percent of the population living in a rural area. It could be argued that this factor be discarded because it contains just two factor loadings. But given the need and desire to begin to understand transportation impacts on rural children, we believe this factor is worth of further exploration. It was quite interesting to see how prevalent this factor was in the Austin – Travis County area, which is much more rural than either Dallas or Harris County. Children living in these ZCTAs are very likely to live in a highly rural area. Although most of the HPSAs identified by HRSA are rural areas, the HPSA score was only moderately associated with this final factor meaning that there are likely to be areas that may indeed by HPSAs, but are not identified.

We summarized the ZCTAs that were hotspots for ACSCs into one of the three aforementioned categories based on the factor scores. It must be noted that every tract receives a score on each of the three factors, but we chose only to highlight ZCTAs demonstrating the greatest needs based on their factor scores and that were identified as an ACSC hotspot. This interpretation is guided by theory, but invariably contains a subjective component. Thus, there is no single solution in identifying communities in need. We designate each ZCTA as having a definable need based on the previous analysis into a single, best-fitting type.

Figure 44: HTSI Classification Scheme by Children's Need: Dallas, TX

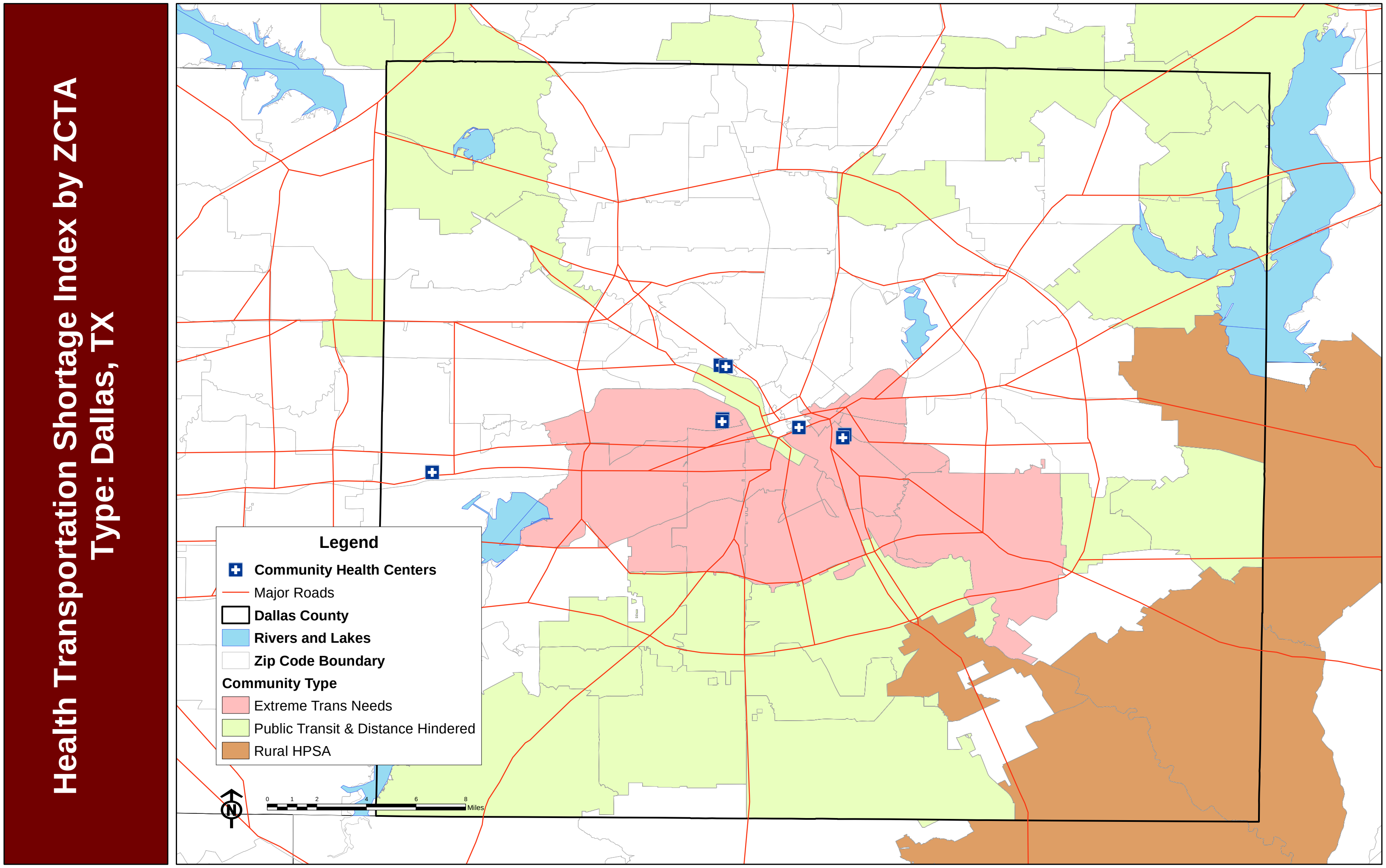


Figure 45: HTSI Classification Scheme by Children's Need: Houston, TX

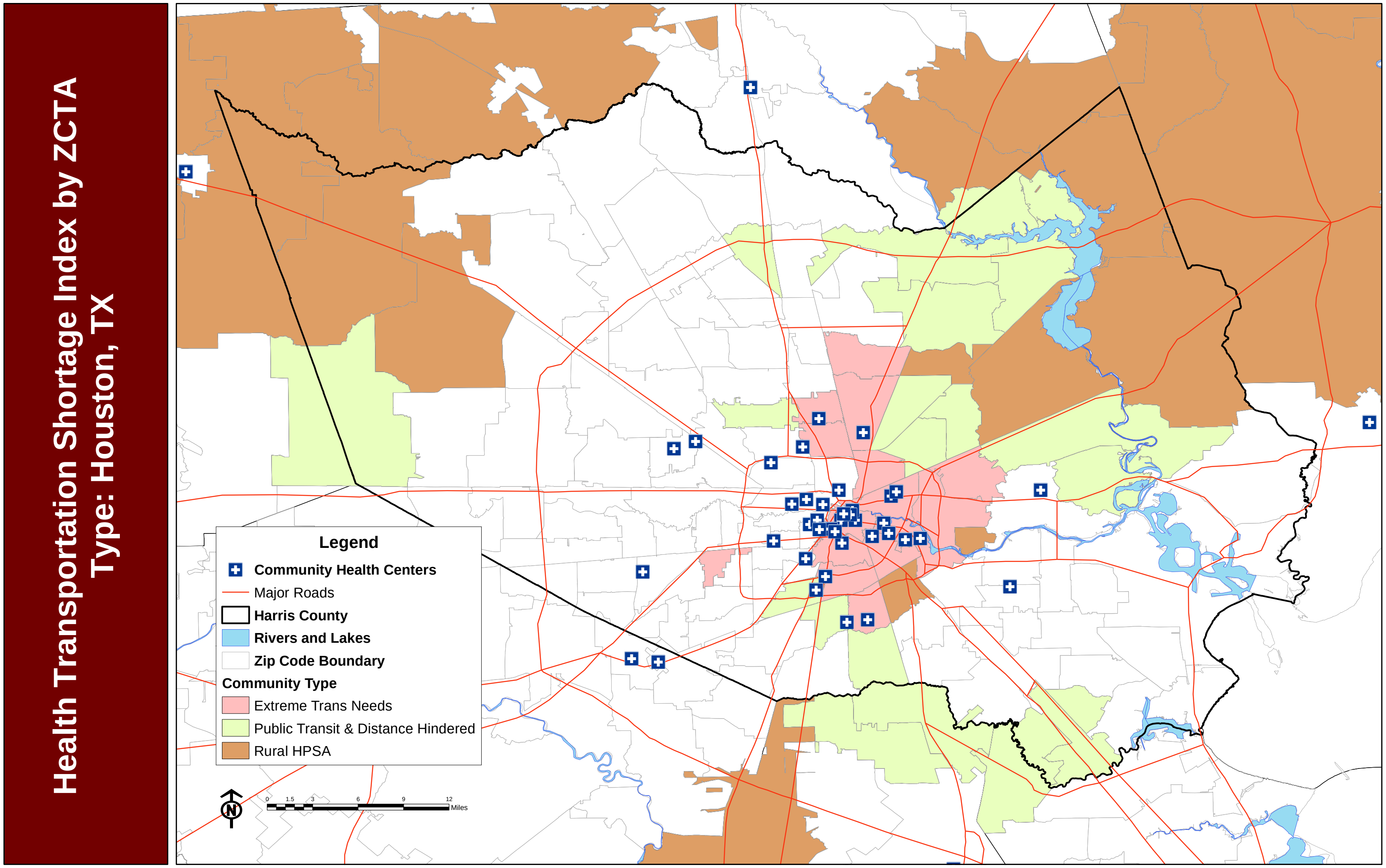
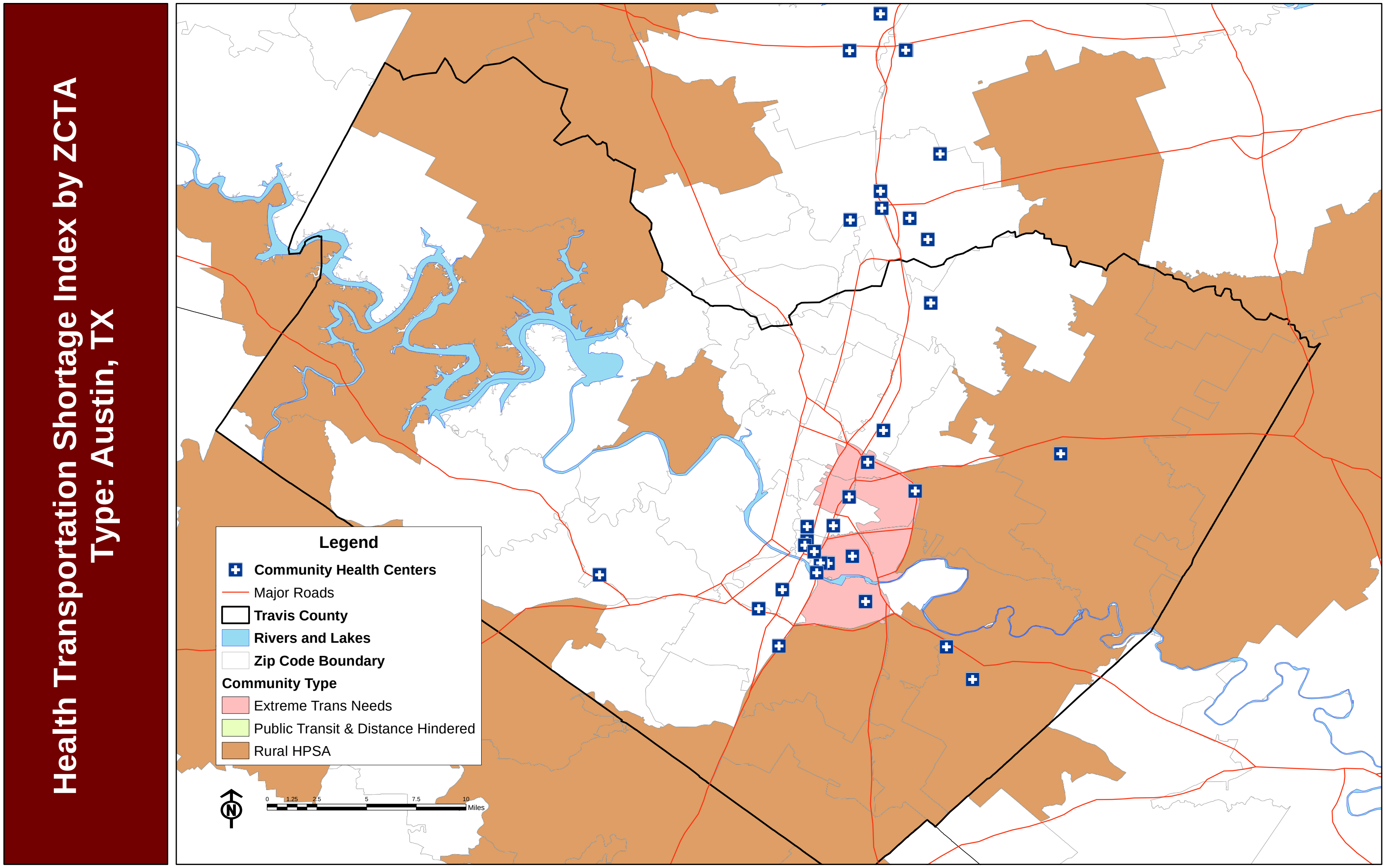


Figure 46: HTSI Classification Scheme by Children's Need: Austin, TX



Using the factor analysis approach to the hotspot analysis was used in developing a simplified system in light of the difficulties faced in obtaining all the needed data sources to develop the HTSI. The guidelines for developing the Simplified HTSI without the use of GIS are as follows:

1) Type of area, based on population
    - Rural, population <5,000, 4 points
    - Small town, population >5,000 and <=10,000, 3 points
    - Small city, population >10,000 and <=20,000, 2 points
    - Urban area, population >20,000 and <=50,000, 1 point
    - Metropolitan area (Big city), population >50,000, 0 points

2) Child poverty rate (% in poverty) exceeds US
    - Yes, by 1.25x or greater, *3 points*
    - Yes, by less than 1.25x, *2 point*
    - No, same as US, *1 point*
    - No, lower than US, *0 points*

3) Public transportation (fixed route – not demand response or shared use vehicles)
    - None, *2 points*
    - Limited (does not run full-time and/or routes do not cover target area), *1 point*
    - Yes, *0 points*

4) HPSA designation
    - Yes, *1 point*
    - No, *0 point*

5. FQHC in area (for high poverty areas)

- No, *2 points*
- One, *1 point*
- Two or more, *0 points*
- Not Applicable (not a high poverty area), *0 points*

For local level planning, assess *personal vehicle ownership* within the community or geographic area targeted with the HTSI.

<u>**Provisional cut points for assessment scoring**</u>

Health transportation shortage area: *5 points or higher*

Target area to improve access; not necessarily transportation barriers: *4 points*

Not a target area: *0-3 points*

In our analysis that led to the development of the HTSI, the Austin metropolitan map because very interesting. This map was created after receiving a number of comments from other colleagues on the overall HTSI measure. The map represents the ACSC hotspots with the Austin Metro transit system overlaid on the map. A number of other observers posed the question:

- Perhaps the over-reliance of the ED for primary care is a function of children's proximity to the ED? Meaning that children in hotspots relied on the ED simply because it was close or convenient.

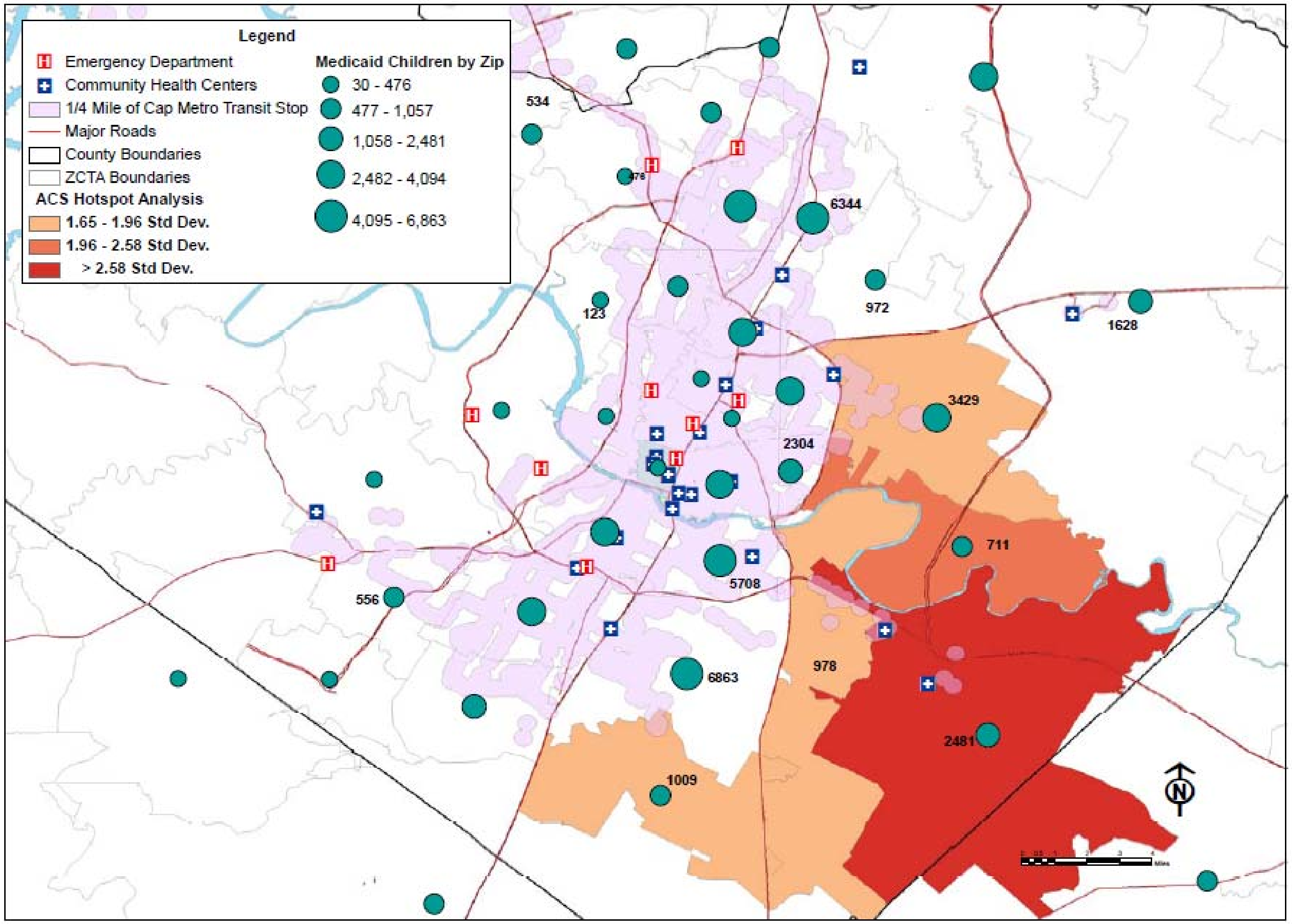
To refute that analysis, we plotted not on the CHCs on the map, but also the location of the EDs. Notice that there is no elevated use of the ED for ACSCs in areas within close proximity to an ED.

- Perhaps the over-reliance of the ED for primary care is a function of the number of low-income children? Meaning that – most of the children on Medicaid are confined to those hotspots.

We added the approximate number of children on Medicaid by ZCTA and find one striking result. The only apparent relationship from the data is the fact that the ZCTAs *accessible to the Capital Metro* system with high proportions of children on Medicaid DO NOT live in ACSC hotspots. Children living in ZCTAs with high proportion of children on Medicaid *with no accessibility to the Capital Metro* system DO live in ACSC hotspots.

Figure 47: Children's Avoidable ED Admissions and Children on Medicaid by ZCTA: Austin, TX

Children's Avoidable ED Admissions and Public Transportation Network: Austin, Texas



XI. Summary and Recommendations

The Health Transportation Shortage Index or HTSI is the first attempt to analyze and empirically link transportation barriers and children's health outcomes in a systematic and sweeping way. Further, the focus of the index at a small area level (ZCTA) is also a significant step forward in providing policy makers a new tool in creating appropriate policy to address this key access barrier. The HTSI and the maps created as part of this effort clearly demonstrate that the patterns of elevated ED utilization of potentially avoidable health conditions and the presence of transportation barriers are not random events. While there is little surprise ZCTAs plagued by high rates of children's ACSCs are often the same ZCTAs exhibiting high poverty, low automobile ownership, and high numbers of minority children, the HTSI offers policy makers the ability to more closely examine the relative barriers and access problems within communities so that ZCTAs exhibiting high access barriers might be given priority for the allocation of resources. As budgetary pressures continue to mount at all levels of government, the ability to appropriately target resources where they are most in need is and will be an imperative. Budgetary pressures aside, our investments in expanding children's health insurance can only be actualized if the means for children to access those services are available.

Likewise, new provisions in the ACA have created incentives and programs for delivering services by offering doctors and hospitals financial incentives to provide good quality care while controlling costs for care coordination. For example, the HRSA recently made $42 million available over the next three years to FQHCs as part of a demonstration project to coordinate care for Medicare patients. Called the FQHC Advanced Primary Care Practice demonstration project, the goals are to show how the patient-centered medical home model can improve quality of care, promote better health, and lower costs (U.S. Health and Human Services, 2011). Another new initiative is called Accountable Care Organizations (ACOs). ACOs are networks of healthcare providers and hospitals that share in the responsibility for providing care. Under the new law, an ACO would agree to manage *all* of the health care needs of its patients. While most of the buzz about ACOs has been confined to the Medicare population, the ACA requires the Secretary of the U.S. Health and Human Services to establish a pediatric ACO demonstration pilot. Just as Section 3022 of the ACA permits providers to form ACOs for the purpose of receiving incentive payments tied to savings to Medicare, Section 2706 states permits pediatric medical providers to form ACOs to receive payments tied to savings to Medicaid ("Patient Protection and Affordable Care Act,," 2010). While these two initiatives do not specifically address transportation, the approach is one born from the idea that ensuring appropriate access to health care services is our nation's best opportunity to provide proven cost-effective preventive and screening services. For low-income populations, young and old, health insurance alone is not enough to ensure access to care.

The HTSI and Guiding Principles

Although the project was structured around five guiding principles, one of the primary objectives of the research and project was simply to demonstrate the possibilities of quantifying the impact of transportation barriers on children's health care services. We evaluated the HTSI against the five guiding principles in our efforts to further our understanding of transportation barriers on primary care services and to shape national policy in the area. The five guiding principles are:

1. Simplicity;
2. Data are Broad Based, Regularly and Consistently Measured;
3. Science-Based;
4. Community-focused; and
5. Replicablility.

The final HTSI model presented within this report is undoubtedly methodologically and computationally complicated for those without a background in statistics and GIS. Given that, the final HTSI model certainly violates the guiding principal of simplicity. Our efforts to develop a Simplified HTSI Scoring System (see Section IX) that does not require a background in statistics and GIS is an adequate approximation of the HTSI. The Simplified HTSI Scoring System, however, is most likely not sensitive enough to provide community-level analysis that the maps provided within this report detail. Without that level of detail, especially in large urban and socioeconomically diverse areas, the Simplified HTSI Scoring System violates the community-focused principle. The Simplified HTSI may certainly be more appropriate for rural areas that are more socioeconomically homogenous.

Our singular focus on administrative data for the HTSI is also a strength and weakness. Certainly utilizing data from the ACS satisfy the need and desire of the measure to be broad based, regularly and consistently measured. The transit data are certainly more problematic because of the reliance on local transit authorities to provide network data. For the most part, the transit agencies that we contacted for their transit data and the X and Y coordinates for the transit stops were willing to provide that data. Indeed the difficulties accurately measuring transit access in rural areas required their exclusion from our model as did the children's ACSC data. Given the challenges, we believe most, if not all of these challenges can be overcome as our familiarity with these and other data have grown over the course of the project. In addition, other researchers have encountered similar challenges and we believe there are appropriate methodological considerations which can be employed in future development efforts of the HTSI.

From the outset, the approach to developing the HTSI centered on deriving an empirical measure of transportation barriers through a data driven process. The HTSI model is grounded in the most relevant literature and leading research efforts associated with health disparities. The relationships between children's avoidable ACSCs and transportation barriers are strong and clearly demonstrable from the results provided within this report. We sought to build the model around the leading and most respected national and international efforts. Although the HTSI is not without limitations, we believe each of the domains and the overall model to have good face validity and effective in identifying areas where children are most likely to experience transportation barriers to primary health care services.

The determination to focus on community-level analysis was correct. While there are also limitations with ZCTA level data, the ability to examine transportation barriers at more localized levels is surely one of the greatest contributions of this effort. It is clear that without a sharper focus, the smaller communities and areas identified as having transportation barriers by the HTSI would masked and unidentifiable had the measure been calculated at the county or even city level. Only by properly identifying and documenting needs at the community-level can the appropriate investments and policy decisions to reduce access barriers be made.

By employing only administrative in the HTSI the barrier and expense of primary data collection is removed. The ACS data is obviously a major and important component of the HTSI and the clear advantage of using these data are they are quick and easy to obtain. Because they are collected nationally and future data will be collected as required by the U.S. Constitution, we can be confident that the ability to use these data going forward to make comparisons and replicate the model in other areas of the country are possible. Further, the ongoing national efforts of HRSA and Ricketts and colleagues to improve the quality and accuracy of the HPSA measure will undoubtedly ease efforts to replicate the HTSI on a broader scale. Challenges, however, do remain. Among them, the difficulty in obtaining similar levels of hospital discharge data of the same variety in all states remains out of reach. Furthermore, the incompleteness of the data in rural areas of Texas and most likely in other states forces a reexamination of the model strategy in rural areas or areas where the data are less than complete.

Lessons Learned and Moving Forward

In reflecting on the work developing the HTSI over the past two years, we conclude the report with recommendations in two sections. The first section of recommendations is related to refining the HTSI. While the results of this research and the development of the HTSI are indeed promising, there are undoubtedly a number of improvements that can be made to the measure. These recommendations are designed to realign the original goals of the project so that the HTSI can become a valid *national* measure of children's health and transportation accessibility, including both urban and rural populations. The second section of recommendations are related to raising policymaker and public awareness of the extent to which transportation plays in child access to preventive health care services.

Improving the HTSI

Data limitations were perhaps the greatest factor limiting the broader development of the HTSI. Our efforts were constrained on a number of fronts, such as the inability to obtain ED utilization data not only for the rural areas of Texas, but for the entire state of Mississippi. Mississippi has only recently begun to collect similar hospital discharge data, such as the PUDF we obtained from the State of Texas. Although we made several requests to the Mississippi Hospital Association and the Mississippi Department of Health, we were unable to obtain a similar dataset. Without an outcome variable, there appeared no way to model children's access barriers. We also noted the difficulties in estimating public transit availability in rural areas as well as obtaining the X and Y transit stop coordinates for each major metropolitan transit authority in Texas. Despite these challenges, we gained a deeper understanding of alternative data sources and other methodological considerations that could be adequate substitutes for the HTSI.

- **Recommendation:** While we remain convinced that measuring children's rates of ACSCs is the best proxy for access to preventive care, we are also convinced that there is not sufficient data to develop the HTSI for rural areas with the same level of precision as developed in the urban areas of Texas. Although it is possible that another state may have much more complete hospital discharge data for rural areas, we are not aware of a state with complete rural data at this time. Given these realities, concurrent work on another project may offer a suitable substitute for the rate of children's ACSCs.

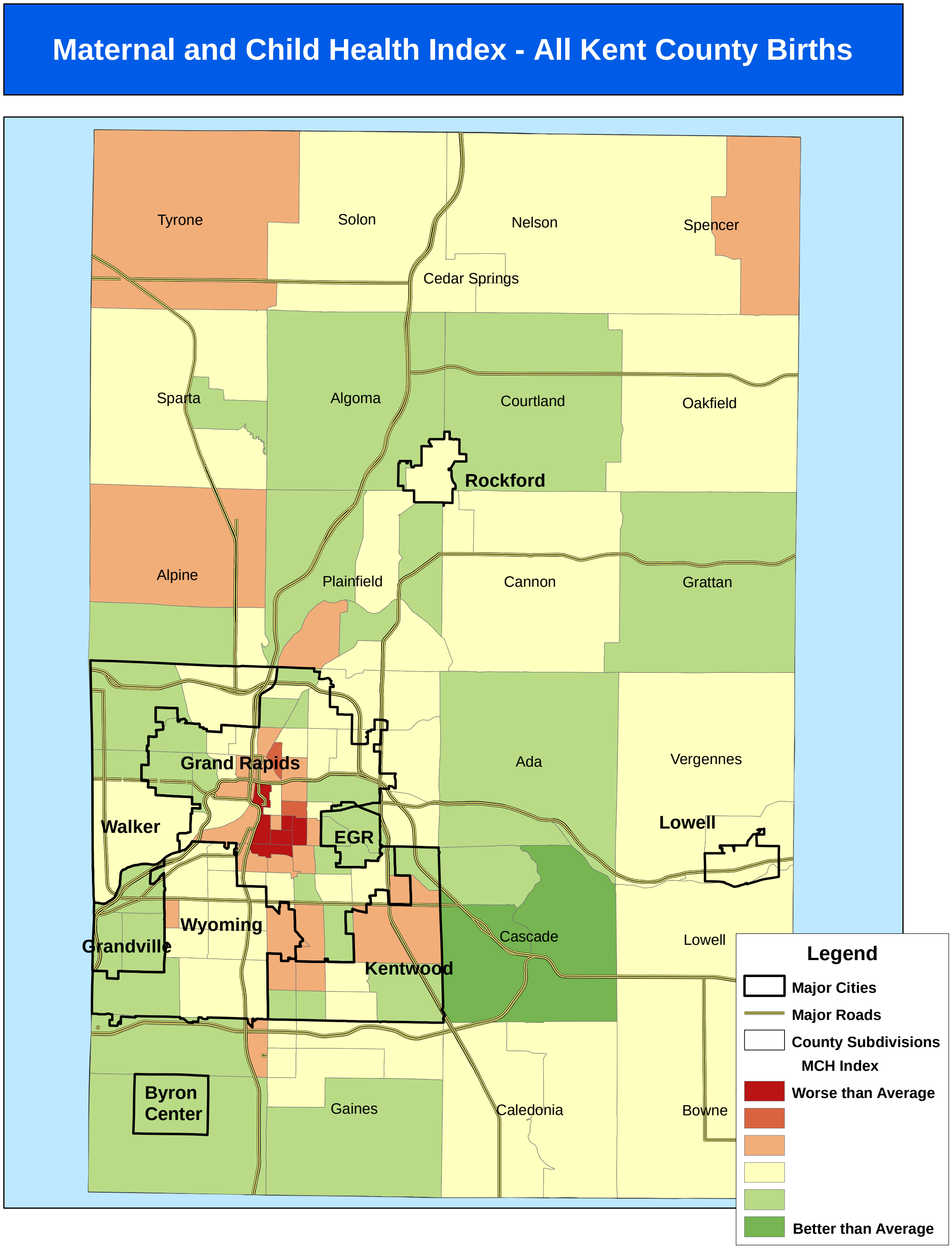
  We are currently undertaking a children's indicator project for First Steps of Kent County, Michigan. First Steps is a public-private partnership of over 40 community providers that works to strengthen and coordinate early childhood services within the county. First Steps partners share a guiding principle: all children deserve the opportunity to reach their full potential. Over the past year, we built several key indicators for five core elements of the group's early childhood community vision.

One of the indicators selected for the First Steps project is called the Maternal and Child Health Index (MCHI). The MCHI is a composite of three items derived from vital records (records of life events kept under governmental authority, including birth certificates, marriage licenses, and death certificates) data taken from the birth certificate. The MCHI is calculated by summing the following items and then rescaling those values into an overall index:

- The percentage of births delivered at full-term (greater than 38 weeks of gestation, but less than 43);
- The percentage of births where prenatal care began within the first trimester; and
- The percentage of births resulting in a satisfactory birth weight (greater than 2,500 grams).

Only singleton births were used in the calculation of the MCHI because multiple births are more likely to be born at less than full-term and with low birth weight. Restricting the analysis to singleton births avoids potential bias that may be introduced into the calculation from births more inclined to poor outcomes (Borders & Risley, 2011). A map summarizing the MCHI for Kent County, MI is presented in Figure 48.

Figure 48: Maternal and Child Health Index: Kent County, MI



The MCHI may be a suitable proxy for access to care since the components of the index are important indicators of early childhood well-being. Children delivered pre-term are more likely to have significant behavioral problems in early adolescence (Gray, Indurkhya, & McCormick, 2004) and suffer from higher rates of morbidity and mortality (The Consortium on Safe Labor, 2010). Children born with low birth weight are also more likely to have poor educational outcomes (Hack et al., 2002) and are also likely to suffer from higher rates of morbidity and mortality. Early onset of prenatal care is universally associated with better birthing outcomes and the relationship between low birth weight and pre-term birth is also well documented (Herbst, Mercer, Beazley, Meyer, & Carr, 2003). Perhaps what is most advantageous about the vital records data is that all 50 states collect these same data. Data, such as those utilized for the Michigan project are also available through the Centers for Disease Control and Prevention, National Center for Health Statistics (http://www.cdc.gov/rdc/)[1]. We currently have a somewhat dated vital records dataset for the entire State of Texas (2000 – 2004) and the State of Michigan (2004 – 2006). We recommend obtaining the most recent vital records from the Texas Department of State Health Services and re-running the analysis in Dallas, Houston and Austin using the MCHI in place of the rate of children's ACSCs as the outcome variable. Upon comparing the results, we can better determine if the MCHI is indeed, a suitable proxy for children's health care accessibility.

[1] It should be noted that NCHS also makes a national hospital discharge dataset available based on a 10% sample. Given experience with the most complete data available from the Texas Department of State Health Services, our impression is that it would possess similar shortcomings as the Texas data and believe it to be inadequate for this project.

While we were able to develop a measure of transportation accessibility through the Weighted Transportation Accessibility Index (WTAI), this sub-measure of the larger HTSI contained no analysis of rural transit programs. As noted in Section V, rural transit systems exist in all rural counties in Texas, yet they typically do not provide fixed-route service with clearly designated transit stops the way the state's larger metropolitan transit authorities do. Developing a clear understanding to the extent of children's accessibility to transit services in urban and rural areas is paramount to developing the HTSI on a national level.

- **Recommendation:** Recall that the Benchmark Rankings for Transit Systems in the United States (Perk et al., 2004) was used to develop the effectiveness scores for each of the three public transit systems as part of the WTAI. We believe that we can follow the methodology developed by Perk and colleagues to develop more current efficiency and effectiveness benchmarks for all publicly funded transit systems in the U.S. While Perk and colleagues calculated effectiveness and efficiency scores by peer group, we propose standardizing the results across all transit systems (large metropolitan to rural) because peer comparisons are not important. What is important is the level of transit availability to those without other means of transportation. So if many small rural transit systems provide equally sparse service, normalizing the effectiveness scores to a subset of rural peer systems almost certainly overstates the availability of public transportation in a given area if compared to a system such as New York City. What we anticipate from this analysis would be identifying the most complete transit system in the U.S., such as the NYC Metropolitan Transit System. After identifying the transit system with the highest effectiveness score, we will then develop a comparison metric to determine the level of effectiveness of the transit systems relative to the "best" transit coverage in the U.S. This strategy should help us to provide a deeper understanding of the level of service available to rural children. Using data from the NTD, we recommend developing such a metric to better determine the effectiveness of the urban and rural transit systems in the U.S.

Policy Initiatives

There is ever increasing interest in the relationships between health and transportation. Unfortunately, the majority of recent literature and interest in the area is much less about health care access for vulnerable populations. Current literature and the efforts in the area of health and transportation are aimed at such topics as the built environment and its impacts on obesity. Other topics include the effect of noise generated from various modes of transportation on mental health. In addition, there is also a deep collection of research on the effects of air pollution caused by the private automobile and the impact on public health. The American Public Health Association (APHA) has become more and more involved in transportation as well. Indeed, transportation is now listed as a "priority" area for APHA (http://www.apha.org/advocacy/priorities/issues/transportation). Yet despite this focus on transportation, APHA lists no articles published in either the *American Journal of Public Health (AJPH)* or *The Nation's Health* on transportation and accessibility. While each of the two aforementioned periodicals contains articles on transportation, each of the articles addresses issues such as the built environment and environmental concerns.

- **Recommendation:** While still in a rather nascent stage, the creation of the HTSI is a clear step forward in advancing the debate over children's health care access. Armed with more than anecdotal evidence of the impacts of transportation on children's primary health services as seen in much of the previous literature in the area, the HTSI is a powerful tool in showing policymakers not only where transportation barriers are most present, but the impacts of those barriers (i.e. higher rates of costly ACSCs). To advance the issue of transportation disadvantaged children, we must continue to seek opportunities to advance the cause on a number of fronts. While all parties with interest in the HTSI have sought to publish various transportation and health accessibility research in a number of outlets, we must continue our efforts to publish this work in important and respected journals such as *AJPH* and make presentations at high profile events such as the annual APHA and Academy Health. Further, we can continue to influence policy at many levels by mimicking the efforts of other researchers who have advanced similarly conceptually difficult concepts through developing a web portal to deliver content and results of their work. One group that seems to have been quite effective in promoting their work and shaping discussion and policy around housing and transportation is the Center for Neighborhood Technology (CNT) in Chicago. CNT developed the Housing and Transportation Affordability Index (http://htaindex.cnt.org/) which offers the true cost of housing based on its location by measuring the transportation costs associated with place. We have begun to experiment with placing much of the content from this analysis online on a beta site. We believe its continued development could be an effective tool for promoting the HTSI and as a platform for including deeper and more thoughtful inclusion of transportation and accessibility issues into the larger debate recently undertaken by the likes of organizations such as APHA.

It is unclear exactly how close the 28 member Committee to review the criteria for the designation of MUAs and HPSA is in adopting final rules at this juncture. To date, the Committee had met 12 times, beginning in September of 2010 (http://www.hrsa.gov/advisorycommittees/shortage/Meetings/index.html).

- **Recommendation:** As the Committee moves forward to adopt final rules on the HPSA and MUA designation, CHF may consider using its influence to shape the final rules. One of the reasons we chose to develop the separate WTAI as a sub-measure of the HTSI was to precisely coincide with the Committee's work in establishing new rules governing the identification and definition of a HPSA and MUA. Given that the MUA/HPSA model developed by Ricketts and colleagues (2007) contains no provision for transportation barriers, the WTAI (if developed on a wide scale) is methodologically similar to the new MUA/HPSA model and could theoretically be added as a component to the measure.

The required pediatric ACO demonstration pilot for Medicaid-covered children offers an opportunity to interject transportation accessibility into the overall model.

- **Recommendation:** Despite the availability of NEMT services, utilization among Medicaid eligible population is less than 10% and much lower among the non-disabled population. Low utilization of NEMT services appears to be a function of two domains: unmet need and poor understanding or knowledge of NEMT and available services. Typically, Medicaid recipients requesting NEMT services must request transportation services at least 48 hours in advance of the appointment. Nationally, about 30% of all children reported missing a medical appointment due to transportation difficulties. Missed opportunities for routine health care services typically result in costly and inefficient use of health care services later. We believe it wise to shift national dialogue from the narrowly defined NEMT benefit relating exclusively to medical care services to a fuller array of enabling services in a responsible, low-cost way to improve outcomes. Both the ACO concept and the demonstration pilot should theoretically provide the flexibility to consider how NEMT services are delivered to assist transportation disadvantaged families with children for purposes other than direct medical care services. Increasing personal mobility beyond medical appointments may have other significant benefits that could improve health outcomes. For example, proactively providing transit passes could help alleviate problematic federal Medicaid policies. Currently, NEMT programs can provide services only for a child with a Medicaid covered service. Among families with multiple children, the parent/guardian may have to find child care for siblings who do not need medical services. This policy has created hardships for families with multiple children for years. In addition, many mothers to newborns often lose Medicaid eligibility two months post-partum. Despite this fact, children and newborns remain eligible for Medicaid. Empowering transportation disadvantaged families with mobility would permit greater access to services for which the entire family is still eligible, but for which transportation services are not provided. These services often include such things as WIC and exercise and parenting classes. Federal and state initiatives in expanding health insurance to low income populations will only prove fruitful if those covered by health insurance have the ability to seek timely and appropriate preventive health care services. The pediatric ACO demonstration pilots may offer the opportunities to test these hypotheses.

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