The effect of geographic access on severe health outcomes for pediatric asthma

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Background: Access to medical care and severe pediatric asthma outcomes vary with geography, but the relationship between them has not been studied.
Objective: We sought to evaluate the relationship between geographic access and health outcomes for pediatric asthma.
Methods: The severe outcome measures include emergency department (ED) visits and hospitalizations for children with an asthma diagnosis in Georgia and North Carolina. We quantify asthma prevalence, outcome measures, and factors included in the statistical model using multiple data sources. We calculate geographic access to primary and asthma specialist care using optimization models. We estimate the association between outcomes and geographic access in the presence of other factors using logistic regression. The model is used to project the reduction in severe outcomes with improvement in access.
Results: The association between access and outcomes for pediatric asthma depends on the type of outcome measure, type of care, and variations in other factors. The expression of this association is also different for the 2 states. Access to primary care plays a larger role than access to specialist care in explaining Georgia ED visits, whereas the reverse applies for hospitalizations. In North Carolina access to both primary and specialist care are statistically significant in explaining the variability in ED visits.
Conclusions: The variation in the association between estimated access and outcomes affects the projected reductions of severe outcomes with access improvement. Thus applying one intervention would not have the same level of improvement across geography. Interventions must be tailored to target regions with the potential to deliver the highest effect to gain maximum benefit. (J Allergy Clin Immunol 2015;136:610-8.)

***Key words:** Geographic access, pediatric asthma, severe health outcomes*

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Abbreviation used
ED: Emergency department

Asthma is a common chronic childhood condition, with more than 7.1 million American children having a current asthma diagnosis.[1] In addition to impairing quality of life, asthma contributes significant costs to the health care system, particularly for emergency department (ED) visits and hospitalizations, which in many cases could be prevented. The prevalence and cost of pediatric asthma demonstrate great disparities. In general, both minority populations and economically disadvantaged areas have lower access to asthma-related health care.[2] In 2006, the asthma hospitalization rate for children living in a ZIP code with a median income of less than $37,000 was 76% higher than for other children.[3] African American and Hispanic children are more likely to have asthma and experience a severe asthma outcome than white children.[4-8]

A key contributor to health and health care disparities for chronic conditions, particularly pediatric asthma, is insufficient access to health care services. Appropriate access is important for managing asthma because regular care visits can reduce severe outcomes, controlling asthma is at least as important as its severity, and severity and control of the disease are not always correlated.[9-13] In this study we focus specifically on geographic access. Although financial access is at the forefront of the current health policy agenda, it is only salient if care is made accessible and available. Even though asthma is a common disease among children, geographic access to care for asthma is insufficient and exhibits great disparities.

Although it is well understood that geographic access can affect health care use and health outcomes,[14-16] there is little research that addresses whether this relationship varies across states, whether it behaves uniformly across geography within a state, and how it differs across different forms of health outcomes. This is particularly important for pediatric asthma, which is the cause of approximately 170,000 childhood hospitalizations each year.[17] Understanding the extent of this relationship will suggest interventions targeted to reduce severe outcomes.

Potential access is commonly used in place of realized access.[18-28] In this article we study the link between potential geographic access and severe outcomes for pediatric asthma while controlling for other potentially contributing factors in Georgia and North Carolina. Improving asthma outcomes is a priority for the Georgia Department of Public Health, which leads the Georgia Asthma Control Program. Data availability, geographic proximity to Georgia, and a different distribution of distance to receive asthma specialist care contributed to choosing North Carolina as the second state for analysis. We use mathematic modeling to estimate geographic access and apply logistic regression to quantify the relationship between access and outcomes. We also investigate the potential reduction in severe outcomes with access improvement.

METHODS

Study population

The population under consideration consists of children aged 5 to 17 years who were estimated to have a current diagnosis of asthma in Georgia and North Carolina. The age group of 0 to 4 years is excluded because of the difficulty of diagnosing asthma in this age group. The percentage of children who had a current diagnosis of asthma is reported by age group in Table C3 of the 2010 BRFSS survey for Georgia[29] and by the 2011 National Survey of Children's Health for North Carolina.[30] The census tract population counts of children for each age group were obtained from the 2010 Census data Table B09001.[31] It is assumed that prevalence for each age group is uniform across each state. The number of asthmatic children in each census tract is estimated by multiplying the population with the percentage of children in each age group in each state with an asthma diagnosis. Census tract estimates are computed for use in the assignment model, and estimates are aggregated at the county level, as shown in Fig E1 in this article's Online Repository at www.jacionline.org, for the regression analysis.

Overall approach for understanding severe outcomes

To predict severe outcomes, we consider covariates that fall into 3 categories: age indicator; health access, which is of primary interest; and socioeconomics to control for other factors over the network. For consistency, the values for all covariates are collected or aggregated at the county level. Georgia has 159 counties, and North Carolina has 100.

In this study a severe outcome is defined as an ED visit or hospitalization caused by the child's asthma. The response variable is the outcome rate calculated as the ratio of ED visits or hospitalizations to the estimated number of children with asthma at the county level for each age group.

For Georgia, ED visits and hospitalizations in 2010 were obtained from the Online Analytical Statistical Information System database.[32] For North Carolina, ED visits and hospitalizations for 2009 were obtained from the Healthcare Cost and Utilization Project state databases, which contain deidentified individual records from community hospitals.[33,34] Institutional review board approval was obtained for this research. Severe outcomes were extracted by using the International Classification for Diseases, ninth edition, codes for asthma and the criterion that at least one of the first 2 diagnostic codes is for asthma.

Covariates of primary interest: Travel distances to asthma care providers

There are 3 variables for potential access in the model: the county-average distances to primary pediatric care ("PrimaryDistance"), the county-average distances to asthma specialist care ("SpecialistDistance"), and the intracounty variance of distance to specialist care ("VarSpecialistDistance"). We consider this third access measure because there can be a large variation across census tract distances to specialist care. The number of hospitals in each county is included as a potential predictor ("NumberHospitals") to control for mobility of the population across county lines for hospital care.[35]

We calculate potential geographic access to primary and asthma specialist care by using recent methodology to match supply and demand.[21] The approach accounts for constraints in the network (eg, mobility) along with potential barriers to care (eg, provider's willingness to accept patients with Medicaid). The approach uses an optimization model that matches patients to providers, mimicking the process through which patients or their parents choose physicians. Similar to Nobles et al,[21] we use distance as a primary criterion for choosing one physician over another. Using this patient-provider matching, we estimate the access measure for each census tract, which we aggregate at the county level for the regression.

For primary care, we consider physicians with a National Provider Identifier classification of pediatrics, nurse practitioner pediatrics, family medicine, and internal medicine and obtained travel distances for Georgia and North Carolina from the recent work of Gentilli et al.[36]

For specialist asthma care, we extracted the locations of asthma specialists from the National Provider Identifier Registry using the National Uniform Claim Committee's taxonomy codes.[37] Consistent with the identification of asthma specialists in analyses of the importance of specialist care in the literature, we considered allergists and pulmonologists to be asthma specialists.[38,39] The maximum caseload of visits for pediatric asthma care was adjusted depending on the specialty and whether the provider had a pediatric designation, and this is shown in Table E1 in this article's Online Repository at www.jacionline.org. We computed the street-network distance between specialist offices and centroids of the census tracts, representing the location for the entire population of the census tract, with ArcGIS software.[40]

In the optimization model for matching patients with providers, the utility function is the total statewide travel distance to access care for asthma subject to the following constraints:

- all patient appointments are fulfilled, if feasible;
- physician capacity cannot be exceeded;
- each specialist accepts a limited percentage of patients with Medicaid; and
- no patient can be assigned to a specialist with a travel distance greater than 50 miles.

The full optimization model is shown in Fig E2 in this article's Online Repository at www.jacionline.org, with additional details including parameter information.

We examine the distribution of distances to care for each state along with the Pearson correlation of distances. Similar to Nobles et al,[21] we estimate the spatial correlation on distance to care by using the Moran I measure, which was used to evaluated systematic disparities in geographic access.[41]

Other model covariates

All socioeconomic variables extracted from the 2010 Census data are restricted to data on households that have at least 1 child less than 18 years of age.[31] We include an indicator (0 or 1) variable ("AgeX-Y") for whether the response variable is for children in each of 3 age ranges (X to Y).[29,30] For income and education, we select among potential variables by investigating the strength of the association of these variables with the response variable, as plotted in Fig E3 in this article's Online Repository at www.jacionline.org. The variables selected are median family income ("MedianIncome") and percentage of adults with less than a high school diploma ("AdultEducation").

The final set of main effect covariates considered in the model is defined in Table I. The model selection procedure is outlined in the Methods section in this article's Online Repository at www.jacionline.org.

Statistical model

We quantify the effect of geographic access on severe outcomes by using logistic regression with replication (equivalent to binomial regression), and we generate separate models for hospitalizations and ED visits in each state. All of the numeric variables were scaled. To reduce the set of explanatory variables from all combinations of the variables shown in Table I, we applied stepwise model selection in which the models were compared based on the Akaike information criterion. The regression analysis was implemented with R statistical software. For model interpretation, we point