Inequalities in Neighborhood Child Asthma Admission Rates and Underlying Community Characteristics in One US County

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Objectives To characterize variation and inequalities in neighborhood child asthma admission rates and to identify associated community factors within one US county.

Study design This population-based prospective, observational cohort study consisted of 862 sequential child asthma admissions among 167 653 eligible children ages 1-16 years in Hamilton County, Ohio. Admissions occurred at a tertiary-care pediatric hospital and accounted for nearly 95% of in-county asthma admissions. Neighborhood admission rates were assessed by geocoding addresses to city- and county-defined neighborhoods. The 2010 US Census provided denominator data. Neighborhood admission distribution inequality was assessed by the use of Gini and Robin Hood indices. Associations between neighborhood rates and socioeconomic and environmental factors were assessed using ANOVA and linear regression.

Results The county admission rate was 5.1 per 1000 children. Neighborhood rates varied significantly by quintile: 17.6, 7.7, 4.9, 2.2, and 0.2 admissions per 1000 children ($P < .0001$). Fifteen neighborhoods containing 8% of the population had zero admissions. The Gini index of 0.52 and Robin Hood index of 0.38 indicated significant inequality. Neighborhood-level educational attainment, car access, and population density best explained variation in neighborhood admission rates ($R^2 = 0.55$).

Conclusion In a single year, asthma admission rates varied 88-fold across neighborhood quintiles in one county; a reduction of the county-wide admission rate to that of the bottom quintile would decrease annual admissions from 862 to 34. A rate of zero was present in 15 neighborhoods, which is evidence of what may be attainable. *(J Pediatr 2013;163:574-80)*.

Although asthma is one of the most common chronic illnesses of childhood, morbidity is not equally shared across populations.[1,2] Deep, preventable disparities exist in the frequency of acute asthma exacerbations, with morbidity clustering within disadvantaged populations and communities.[3-6] Such high-risk populations often are concentrated within geographic areas affected by factors such as low household income, unemployment, limited access to transportation, poor-quality housing, and crowded conditions within the home.[7-15] Observed disparities have been explained, in part, by these socioeconomic and home environmental risk factors and by their interaction with an individual's atopic or genetic predisposition.[16]

Currently, researchers are focusing on the identification of disease "hot-spots" to inform targeted community-based interventions.[17-19] Considerably less attention has been paid to low-risk, "cold-spot" communities, even though they represent the health that could theoretically be obtained across a region. Similarly, medical research has rarely focused on objective measures of inequality across high- and low-risk areas. Inequality measures, including the Gini and Robin Hood indices, commonly are used to characterize income inequalities, but they have not been routinely used to capture inequalities in health outcomes.[20-22]

Understanding the drivers of health inequalities requires the identification and use of informative geographic boundaries.[23] The geographic distribution of childhood asthma has been studied with the use of zip codes as well as individual and spatially aggregated census tracts.[8-11,24] Zip codes, which were designed for efficient delivery of mail, are often heterogeneous with respect to social and environmental factors.[25] Census tracts, although smaller and more homogenous, do not always align with community-accepted neighborhood boundaries. Few studies have used boundaries defined by the community to define the distribution of asthma morbidity.[26]

CCHMC	Cincinnati Children's Hospital Medical Center
GCARS	Greater Cincinnati Asthma Risks Study
SES	Socioeconomic status

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In this study, we first sought to delineate variability in neighborhood asthma admission rates within a single Midwestern county that is characterized by geographic, socioeconomic, and demographic diversity. The identification of asthma morbidity "hot-" and "cold-" spots through the use of community-accepted neighborhood boundaries is new in the pediatric asthma literature, and we anticipated that it would frame neighborhood-based interventions in new, community-focused ways. Second, we sought to illustrate and calculate distribution inequalities in the admissions of children for asthma by using the Gini and Robin Hood indices in novel ways. Finally, we sought to identify neighborhood-level characteristics that may contribute to observable neighborhood variability in asthma admissions and may present targets for future intervention.

Methods

Data were analyzed as part of the population-based prospective, observational Greater Cincinnati Asthma Risks Study (GCARS) cohort. The GCARS enrolled children who were admitted for asthma or bronchodilator-responsive wheezing to Cincinnati Children's Hospital Medical Center (CCHMC), an urban, tertiary-care, stand-alone pediatric hospital. The cohort was limited to children between 1 and 16 years of age for several reasons. One, for children younger than 1 year of age, there is the potential for diagnostic overlap. Two, for older children, a greater proportion may obtain inpatient care at alternative institutions and therefore be lost to follow-up.

Between September 1, 2010, and August 31, 2011, eligible children were identified on the basis of admission diagnosis (*International Classification of Diseases*, 9th Revision, Clinical Modification, 493.XX) and use of the evidence-based clinical pathway for acute asthma care by the admitting physician. Children were excluded if they were removed from the asthma pathway after further diagnostic consideration or if they had significant respiratory or cardiovascular comorbidity (eg, cystic fibrosis, congenital heart disease). For this study, analysis was limited to patients from CCHMC's home county, Hamilton County, an area with nearly 170 000 children ages 1-16 years, so as to further limit admissions lost to other institutions.[27] Given data from the Ohio Hospital Association indicating that nearly 95% of all in-county asthma admissions for children ages 1-16 years occur at CCHMC facilities, our accrued admission sample was considered to be population-based.[28] Demographic data, including home address, were collected from the electronic health record. The CCHMC Institutional Review Board approved this study.

Calculation of Neighborhood Admission Rates

The home address for each admission event was geocoded with ArcGIS software (Version 10; Redlands, California). Greater than 99% of addresses were geocoded to the rooftop or street level and assigned to a locally defined neighborhood. In the City of Cincinnati, the Department of City Planning and Buildings defines "statistical neighborhood areas," composed of census tracts or parts of census tracts, to approximate local neighborhood boundaries accepted by citizens and community councils.[29] The Hamilton County Planning and Development Department oversees boundaries for municipalities and townships outside of city limits.[30] Such areas are used by city and county governments to guide planning activities and enforce regulations in ways that encourage participation from the communities involved.

We identified 93 neighborhoods primarily within Hamilton County. Three fell within a single census tract and were treated as a single neighborhood. Admission rates were calculated for Hamilton County as a whole and for each of the defined 91 in-county neighborhoods. The total number of admission events was then divided by the total number of children ages 1-16 years within the defined geographic area to calculate the neighborhood admission rate. Population denominators were calculated using values obtained from the 2010 US Census Summary File 1.[27] Neighborhoods were then sorted by their admission rate and grouped into admission rate quintiles such that each quintile included 20% of all neighborhoods. Quintiles were used to stabilize admission rate estimates, given the relatively small population sizes in certain neighborhoods.

Neighborhood-Level Measures

Neighborhood-level differences between admission rate quintiles were assessed by the use of neighborhood-level measures, chosen a priori to align with asthma-related socioeconomic and environmental factors, that were calculated from the 2006-2010 American Community Survey.[27] Measures for multiple census tracts, or parts of census tracts, were combined with weighted averaging.

Neighborhood-level markers of socioeconomic status (SES) included median household income and the percentage of individuals living below the poverty line[11,13,14,31]; neighborhood-level educational attainment was defined as the percentage of adults (≥25 years) with at least a college education.[32] Neighborhood-level unemployment[31] and the percentage of households without access to a car were also assessed.[5] Neighborhood-level home environmental markers were median home value, the percentage of renter-occupied and vacant homes, and population density, measured as the number of persons per square mile.[5,12,24]

Data Analyses

Descriptive statistics provided basic demographic information for individual children admitted to CCHMC facilities during the 1-year period. Neighborhood admission rate quintiles were compared with ANOVA.

Inequalities in admission distribution across Hamilton County were assessed with the use of inequality indices that can be calculated from the Lorenz curve. To construct the curve, neighborhoods were ordered by their admission rates from lowest to highest. Then, the cumulative proportion of all 167 653 children contributed by each neighborhood was measured on the x-axis and the cumulative proportion of