Areas with High Rates of Police-Reported Violent Crime Have Higher Rates of Childhood Asthma Morbidity

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Objectives To assess whether population-level violent (and all) crime rates were associated with population-level child asthma utilization rates and predictive of patient-level risk of asthma reutilization after a hospitalization.

Study design A retrospective cohort study of 4638 pediatric asthma-related emergency department visits and hospitalizations between 2011 and 2013 was completed. For population-level analyses, census tract asthma utilization rates were calculated by dividing the number of utilization events within a tract by the child population. For patient-level analyses, hospitalized patients (n = 981) were followed until time of first asthma-related reutilization. The primary predictor was the census tract rate of violent crime as recorded by the police; the all crime (violent plus nonviolent) rate was also assessed.

Results Census tract-level violent and all crime rates were significantly correlated with asthma utilization rates (both $P < .0001$). The violent crime rate explained 35% of the population-level asthma utilization variance and remained associated with increased utilization after adjustment for census tract poverty, unemployment, substandard housing, and traffic exposure ($P = .002$). The all crime rate explained 28% of the variance and was similarly associated with increased utilization after adjustment ($P = .02$). Hospitalized children trended toward being more likely to reutilize if they lived in higher violent ($P = .1$) and all crime areas ($P = .01$). After adjustment, neither relationship was significant.

Conclusions Crime data could help facilitate early identification of potentially toxic stressors relevant to the control of asthma for populations and patients. *(J Pediatr 2016;173:175-82)*.

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Disparities mark how asthma is experienced across pediatric populations,[1-4] driven by social determinants that include socioeconomic hardship, substandard housing, and exposure to pollutants.[5-9] These factors, which are influenced by neighborhood context, cause stress that can result in or augment potentially preventable symptoms, emergency department (ED) visits, and hospitalizations. A stress response becomes toxic when it prompts strong, frequent, or prolonged activation of the body's stress-response systems in the absence of coping mechanisms.[10] There can also be disruptions to the hypothalamic-pituitary-adrenal axis, including for those frequently exposed to violence, resulting in elevated serum cortisol levels.[11,12] This may prompt asthma exacerbations via associated physiologic inflammation.[13-15] There can also be mental health ramifications (toxic stress has been linked to depressive symptoms[16]), which may affect treatment adherence and symptom control.[13]

Children are frequently exposed to criminal acts.[17] Crime, which "mirrors" stress present within a community, has been linked to health outcomes.[18,19] Exposure to violence has also been explicitly linked to asthma-related symptoms and exacerbations,[20-25] perhaps via provoked inflammatory responses. Studies describing this link, including the Inner City Asthma Study, generally rely on family- or self-report of exposures.[23] In practice, however, public health officials and physicians do not commonly screen for these exposures or experiences. Developing methods for identifying exposures to potentially toxic stress precipitants, such as crime, in an efficient and reliable manner would be a step forward in population- and patient-level risk assessment. The use of neighborhood crime data would be one way to evaluate the interplay of the social environment and asthma without relying on a social history or screen.[26-28] Moreover, evidence linking stressful exposures to health outcomes could facilitate a more informed, targeted approach to population- and patient-level intervention.

ACR	All crime rate
CCHMC	Cincinnati Children's Hospital Medical Center
ED	Emergency department
HCVD	Housing code violation density
VCR	Violent crime rate

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We recently defined "geomarkers" as "objective contextual or geographic measures that influence or predict incidence of outcome or disease,"[7] Here, we sought to determine whether geomarkers of violent crime and all crime (violent plus nonviolent), as reported and measured by the police, would be associated with population-level rates of asthma ED visits and hospitalizations. As a secondary objective, we sought to examine whether, among children already hospitalized for an asthma exacerbation, these crime measures would be predictive of asthma-related reutilization (ED revisit or rehospitalization).

Methods

This was a retrospective cohort study of children, aged 2-17 years, who visited the ED or were hospitalized for asthma at Cincinnati Children's Hospital Medical Center (CCHMC) between January 1, 2011 and December 31, 2013. This study was approved by the CCHMC Institutional Review Board. Subjects were identified using ED or hospital admission diagnosis (*International Classification of Diseases, Ninth Revision, Clinical Modification* code 493.XX). Street addresses were geocoded and linked to corresponding 2010 census tracts.[29] The population-level analysis focused on the cohort's 4638 total utilization events. The patient-level analysis used a subset of the cohort, those 981 patients who were hospitalized during the study period and followed for ≥12 months to assess time to first asthma-related ED revisit or rehospitalization.

Analyses were limited to children living within Cincinnati, the jurisdiction of the Cincinnati Police Department that oversees the data source for our predictors. Cincinnati is an urban area with 54 332 children aged 2-17 years. Cincinnati's poverty rate is 30.4%, and the child poverty rate is 44.9%, among the highest for US cities of its size.[29] There are 108 census tracts within Cincinnati. Four were excluded as <100 children lived within them. Locally, Ohio Hospital Association data suggest that CCHMC manages ~95% of all asthma hospitalizations. Although ED utilization data are less clear, the recent Greater Cincinnati Asthma Risks Study, a cohort study including regional patients hospitalized for asthma exacerbations suggested, via survey, that ~90% of reported ED visits occurred at CCHMC facilities.[30] As such, this was considered a population sample.

Outcomes and Predictors

The population-level asthma-related utilization rate outcome variable was calculated at the census tract level by dividing all ED and hospitalization events within a tract by the total number of children, aged 2-17 years, living within that tract. This was measured per 1000 children and annualized over the data collection period.

The patient-level reutilization outcome variable was assessed for the subset of children with an asthma hospitalization between 2011 and 2013. Each child was followed for ≥12 months to identify time to first reutilization, defined as the days between hospital discharge and the first asthma-related reutilization event. Those not experiencing a reutilization event were censored on December 31, 2014 (end of available follow-up data). Reutilization events were captured by *International Classification of Diseases, Ninth Revision, Clinical Modification* codes of discharge diagnoses within hospital billing data (493.XX).

Tract-level predictors were calculated from publicly available Cincinnati Police Department data. Data were obtained for the 104 included tracts for all criminal incidents between January 1, 2011 and December 31, 2013. To calculate the violent crime rate (VCR), we identified violent incidents, as defined by the Federal Bureau of Investigation's Uniform Crime Reporting Program, within the broader crime dataset (eg, homicide, rape, aggravated assault).[31] A VCR was calculated for each tract by dividing all in-tract violent incidents by the total in-tract population. This was measured per 1000 individuals of all ages living within the tract and annualized over the data collection period. We constructed an analogous measure, the all crime rate (ACR), using all criminal incidents, including violent as well as nonviolent and property crimes such as burglary, vandalism, and public indecency. Analyses used quartile cut points for both the VCR and ACR predictor variables: the 104 census tracts were placed in 1 of 4 risk groupings, each including 26 tracts (25% of all tracts), low, low medium, high medium, and high. This was done to simulate a use of the data that could be more easily implemented in public health, community, or clinical settings.

Covariates

Covariates for both population- and patient-level analyses were chosen given expected relationships with both the predictor (crime) and, potentially, the outcome (asthma utilization). At the population level, we identified census tract-level geomarkers of the economic environment using data from the US Census 2009-2013 American Community Survey: rates of poverty (percentage of individuals below the federal poverty level) and unemployment (percentage of unemployed adults).[29] We also included geomarkers of the physical environment, asthma-related housing code violation density (HCVD) and air pollution. HCVD, previously calculated using local health, property maintenance, and building department data, has been shown to be relevant to asthma utilization at both the population- and patient-levels.[7] The included measure of air pollution was derived using a validated land-use regression model that allows for the determination of traffic-related air pollution exposure at a specific latitude and longitude; it has also been associated with asthma outcomes.[32,33] Here, we used the median pollution value across each tract. Similar to VCR and ACR, variables were categorized, placing 25% of included tracts into 1 of 4 risk groups.

The covariates described above were also used in patient-level analyses by linking a patient's census tract to tract-level data. We also obtained data on patient age, sex, race, and insurance from the electronic health record. Age was treated as a continuous variable. Race was defined as white, black/African American, or multiracial/other; insurance as