ELSEVIER

Prevalence of Childhood Asthma in Urban Communities: The Impact of Ethnicity and Income

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PURPOSE: The goal of this study was to assess the relationship between hospitalization rates and asthma prevalence in New York City children and investigate the role that sociodemographic factors play in asthma.
METHODS: A parent-report questionnaire was distributed in 26 randomly selected New York City public elementary schools, stratified according to neighborhood hospitalization rates.
RESULTS: The overall student response rate was 76.9% (5250 students). Prevalence of current asthma was 17.9%, 9.59%, 6.39% ($p < .001$) in areas of high, median, and low asthma hospitalization rates, respectively. The overall prevalence of current asthma was 13.0%. Children living in predominantly low socioeconomic status (SES) communities had a 70% greater risk of current asthma, independent of their own ethnicity and income level. Asthma prevalence within different ethnic and income groups was consistently lower in neighborhoods of greater socioeconomic status, except among Puerto Rican children, who had high asthma prevalence, regardless of school attended or income.
CONCLUSIONS: Prevalence of current asthma is strongly associated with attending a school in a low-income neighborhood. Although hospitalization rates have been used as an indicator of the burden of asthma in a neighborhood, it alone does not reflect the level of disparities that exist among communities with different socioeconomic backgrounds.
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KEY WORDS: Asthma, Child, Urban Health, Prevalence, Ethnic Groups.

INTRODUCTION

Hospitalization rates are often used to measure the burden of asthma in a population because diagnoses are commonly reported to state databases by local hospitals. Studies have shown disparities in asthma hospitalizations, with low-income urban minority neighborhoods having the highest rates (1–7). Many factors may contribute to the correlation between proportion of low-income minority populations in a neighborhood and high rates of asthma hospitalizations. However, asthma hospitalization rates may not necessarily reflect asthma prevalence. For example, it is possible that higher rates of hospitalizations in neighborhoods of low socioeconomic status (SES) with predominantly low-income minority residents can result from a high proportion of individuals with severe disease, inadequate asthma self-management, and/or lack of access to preventive medical care.

The objectives of the present study were to assess the relationship between hospitalization rates and childhood asthma prevalence within the urban center of New York City and to determine the role of sociodemographic factors in precipitating asthma outcomes. New York City is a prototypical urban center, with a diverse ethnic and socioeconomic population. Asthma prevalence among elementary school children in neighborhoods with varying childhood hospitalization rates and sociodemographic risk factors were compared.

METHODS

A cross-sectional parent self-report study was conducted in randomly selected New York City public elementary schools during the 2002–2003 school year. The project was approved by the Mount Sinai Institutional Review Board, by the Mount Sinai Health Insurance Portability and Accountability Act (HIPAA) Privacy Office, and by the Proposal Review Committee of the New York City Department of Education's (DOEs) Division of Assessment and Accountability.

Study Design

Asthma hospitalization rates for children ages 5–12 were calculated and mapped for each of the residential ZIP Codes

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Selected Abbreviations and Acronyms

SES = socioeconomic status
SPARCS = Statistics Planning and Area-wide Research Council
ISAAC = Study of Asthma and Allergies in Childhood
DOE = Department of Education

in New York City, using data from year 2000 and methodology described previously (2). Briefly, population and hospital discharge data were obtained from New York State's Statistics Planning and Area-wide Research Council (SPARCS) database and National Census Data, using the INFOSHARE software program (Infoshare, Community Studies of New York, Inc., New York, NY). Asthma hospitalization rates were calculated as the ratio of the number of hospital discharge diagnoses of asthma (ICD-9 code = 493) per 10,000 children. Asthma hospitalization rates for children ages 5–12 were used to order and stratify New York City ZIP Codes into 15 approximately equally sized groups. The data were then imported into MAPINFO (MapInfo Corp., Troy, NY), a geographic information system software package, and a thematic map was constructed.

Three ZIP Code groups (highest, median, and lowest) were selected for inclusion in the study. Each of these groups contained eleven ZIP Codes. The high group contained ZIP Codes ranging in hospitalization rates from 86.3 to 163.2 per 10,000 children. The median group contained ZIP Codes with hospitalization rates of 28.9–35.7 per 10,000 and in the low group, rates were 0–4.99 hospitalizations per 10,000 children.

Listings and enrollments of all public elementary schools within each three ZIP Code-defined groups were obtained from the New York City DOE. Magnet schools and other schools of choice were not included, as children attending these schools often do not live in the same neighborhood as the school. From these listings, one school from each ZIP Code contained in the selected groups was randomly selected with probability proportional to size using SAS Surveyselect Procedure (SAS Institute, Cary, NC). A total of 26 schools were selected, 8 each from the high group and the median group, and 10 from the low group. Oversampling in the low group was conducted to compensate for the expected lower asthma prevalence in these neighborhoods. All of the selected schools agreed to participate.

To control for seasonality of asthma symptoms, schools from each of the three groups were assessed during overlapping 2-week periods. This allowed for symptom frequency comparison between the groups in later analysis. Within each school, two classrooms at each grade level, kindergarten through fifth grade, were randomly selected to participate in the study. In each classroom, students were given questionnaires to be brought home and completed by a parent/guardian. Children and teachers were given nominal incentives, consisting of school supplies, to encourage participation.

Questionnaire Content

The questionnaire was adapted from a previous study of asthma prevalence used in a New York City public elementary school (8). It contains standardized questions on demographics, household environment, and asthma symptoms from the International Study of Asthma and Allergies in Childhood (ISAAC) (9). Parents/guardians of asthmatic children also completed questions on symptom frequency during the previous two-week period, use of medical services and medications, school absences, insurance status, and environmental exposures.

Children's ethnicity was reported based on the parents' classification using the following categories: Asian, African-American non-Hispanic, Dominican, Mexican, Puerto Rican, Other Hispanic, White non-Hispanic, and Other. If more than one Hispanic category was checked, children were classified as "Other Hispanic." If more than one category was selected, children were classified as "Other."

Questionnaires were available in English, Spanish, and Chinese. All three language options were pilot-tested among a group of respective native speakers prior to the study to ensure clarity and accuracy.

Ever having asthma was defined as a "yes" response to the following question: "Have you or your child ever been told by a doctor or a nurse that he/she has asthma?" A child was identified has having *current asthma* if a "yes" response was given to both the previous question and "In the last 12 months, has your child had wheezing in the chest?"

Data Analysis

To determine if the sampled schools were representative of their corresponding ZIP Codes, the ethnic breakdown of each school's enrollment was compared to the overall public school population within each ZIP Code, based upon school enrollment data from the DOE during the previous school year, which was the most recent enrollment data available. The reported ZIP Code of residence for each student was compared to the school ZIP Code in order to verify that the school enrollment was primarily from the surrounding ZIP Code.

All data were weighted to represent the number of children attending public elementary schools within each selected ZIP Code, adjusting for nonresponse as well as differential selection probabilities. Population proportions of baseline characteristics, prevalence estimates, and corresponding 95% confidence intervals were calculated in SAS, (SAS Institute, Cary, NC) using the Surveymeans and Surveyfreq procedures to perform descriptive statistics and account for the sampling design of stratification by

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neighborhood asthma hospitalization rate and clustering by school (10). Using the school as the unit of analysis, the relationship between the resulting estimates of current asthma prevalence and the local childhood asthma hospitalization rates was examined by performing a correlation calculation. To make comparisons between the ZIP-Code defined groups and to determine univariate associations between current asthma and demographic factors, a chi-squared statistic for categorical variables and the Wald test for continuous variables, corrected for the study design, were calculated in STATA (STATA Corporation, College Station, TX) using svy- procedures (11). Adjusted odds ratios were calculated using the survey logistic regression procedure in STATA. The model was constructed by manual backward elimination. All factors associated with current asthma in univariate analysis were entered as indicator variables in the initial model, except age, which was entered as a continuous variable. Significance was determined at the $p < .05$ level. Responders with missing data were excluded from the model.

RESULTS

Areas of highest childhood hospitalization rates were clustered in the South Bronx, Harlem, and Central Brooklyn, as seen previously (2) (Fig. 1). Overall, 5374 out of 7310 students returned a questionnaire. Of these, 5250 questionnaires were complete and usable. After adjusting for the

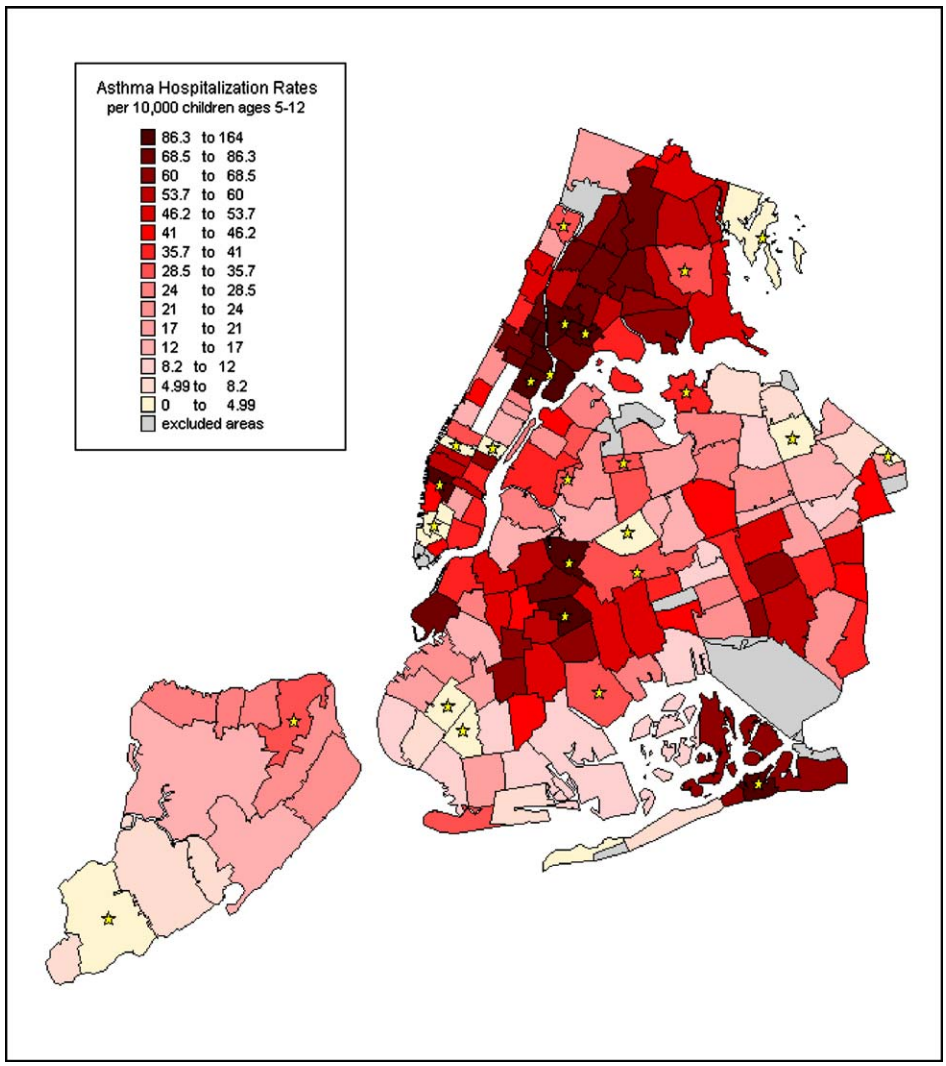

FIGURE 1. 2000 New York City Asthma Hospitalization Rates for Children Ages 5–12 by ZIP Code, with areas included in study marked with a star. Schools in areas with hospitalization rates from 86.3 to 163.2 were considered the high group, schools in areas with hospitalization rates ranging from 28.9 to 35.7 were considered the median group, Schools in areas with hospitalization rates ranging from 0 to 4.99 were designated as the low group (Nonresidential areas and areas with fewer than 200 children ages 5–12 were considered excluded areas).

average absence rate of each school (12), the response rate was 76.9%. Response rates were slightly higher in the second and third grades; however, all grades had a response rate greater than 70%. The individual adjusted response rates for the three ZIP Code-based areas were 70.8%, 74.9%, and 82.8% for the areas of high, median, and low asthma hospitalization rates, respectively. It was observed that approximately 70% of children live in the same ZIP Code where their school is located.

Demographics

The demographics of the sample were comparable to the overall population of New York City children enrolled in public elementary schools, although both males and African Americans were underrepresented in the sample (Table 1). Additionally, for 24 of the 26 schools studied, the ethnic background of the student population was closely similar to their surrounding ZIP Code. Demographic characteristics of the overall sample and the three ZIP Code areas are shown in Table 2. The area with high asthma hospitalization rates had a significantly higher percentage of minority children and children living in low-income households than the areas of median and low asthma hospitalization rates. Exposure to environmental tobacco smoke in the household was also highest in the areas of high asthma hospitalization rates, although the trend was not significant. There was a slight, but significant, difference in the mean age of the children.

Asthma Prevalence

Prevalence is shown in Figure 2 for each of the three ZIP Code groupings. The prevalence of ever having been diagnosed with asthma was highest in the areas of high asthma hospitalization rates, reaching 27.6%, compared to 17.2% and 11.2% in the areas of median and low hospitalization rates respectively ($p < .001$). The same relationship held true for the prevalence of current asthma. Neighborhoods of high asthma hospitalization rates had almost double the prevalence found in median areas, and almost triple the asthma prevalence found in the areas of low asthma hospitalizations (17.9%, 9.59%, 6.39%, respectively, $p < .001$). There was no significant difference in the percentage of children with current wheezing without an asthma diagnosis, with measurements ranging from 2.38% to 2.81%. There was a significant correlation between the asthma prevalence of each individual school and its respective ZIP Code's childhood asthma hospitalization rate (Pearson correlation coefficient = 0.694, $p < .01$).

TABLE 1. Comparison between the study population and the general elementary public school population of New York City

	Study Data (n = 5,250)	New York City Department of Education Data* (n = 1,091,717)
Gender		
Male (%)†	46.8	51.30
Ethnicity		
Hispanic (%)	39.2	39.47
African-American (%)†	22.3	32.67
White (%)	15.2	14.99
Asian (%)	12.3	12.38
Other‡ (%)†	6.75	0.41
Did not specify (%)	4.05	–

*New York City Department of Education, Official Audited Register as of Oct. 31, 2002 J-Form.
†$p < .001$, Sample size of study data was adjusted to account for the design effect; design effects calculated in Stata to account for sampling design.
‡"Other" in Department of Education data refers only to American Indians. In our study, "Other" refers to members of any racial/ethnic group not included in the four listed, as well as multiracial/multiethnic children.

Sociodemographic Factors Associated with Prevalence of Asthma

The prevalence within demographic subgroups was compared among the three areas with different asthma hospitalization rates to determine if ZIP Code grouping of the schools had any effect on asthma prevalence. Asthma prevalence within the majority of demographic subgroups was greater in children that went to school in areas with high asthma hospitalizations (Table 3). For example, White children going to school in areas of high asthma hospitalizations had over four times the current asthma prevalence of White children living in the lowest asthma hospitalization areas. This relationship also was seen when examining asthma prevalence by age group, although there was no significant association between age group and current asthma in univariate analysis (11.4, 12.4, 12.6 $p = 0.1$ for age groups 4–6, 7–9, and 10–13, respectively). A notable exception was found among Puerto Ricans, who show consistently high prevalence (21.2% overall) regardless of where they live or go to school.

Multivariate Analysis

A logistic regression model was created to examine independent effects of demographic factors on current asthma (Table 4). Living in a low-income household, living in an area with high asthma hospitalization rates, and male gender were all independently associated with having current asthma. After controlling for ZIP Code grouping and income level, the relationship between race/ethnicity and current asthma disappeared, except in the case of Puerto Rican and Asian children. Regardless of where they lived or household income level, Puerto Ricans had the highest risk of current asthma, more than double that of White children. Conversely, Asians had almost a 40% lower risk of current asthma than did other ethnic groups.

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TABLE 2. Demographic Characteristics of the Study Population*

	ZIP Code Grouping by Childhood Asthma Hospitalization Rates			
	Overall (n = 5250)	High (n = 1370)	Median (n = 1641)	Low (n = 2239)
Gender				
Male (%)	46.8	46.5	47.1	46.5
Mean Age† (sd) [range], years	8.11 (1.81) [4–13]	8.3 (1.81) [4–13]	7.91 (1.83) [4–13]	8.16 (1.78) [5–12]
Ethnicity‡				
Hispanic (%)	39.2	54.5	37.0	15.3
Dominican (%)	6.87	7.42	9.44	1.01
Mexican (%)	8.03	15.6	3.19	3.27
Puerto Rican (%)	12.8	21.0	9.26	4.35
Other Hispanic (%)	11.8	10.5	15.20	6.71
African-American (%)	22.3	33.8	21.4	2.74
White (%)	15.2	1.11	18.6	34.5
Asian (%)	12.3	0.30	9.80	38.4
Other (%)	6.76	6.26	8.44	5.87
Income‡				
<$20,000 (%)	41.1	51.1	35.1	34.1
$20,001–$39,999 (%)	25.2	22.0	29.8	22.6
$40,000–$74,999 (%)	13.1	7.51	16.9	16.3
$75,000 or more (%)	5.31	1.43	4.77	13.4
Cigarette Smoking Present in the Household (%)	22.2	26.4	19.6	19.2
Language of completed survey‡				
English (%)	82.7	76.3	86.6	87.4
Spanish (%)	15.3	23.6	13.4	3.20
Chinese (%)	2.00	0.00	0.00	9.40
Mean Size of Household (sd), # of adults and children	4.59 (1.47)	4.69 (1.71)	4.50 (1.45)	4.58 (1.32)

*Nonresponders were included in the denominators of all calculated percentages. Thus, some categories do not equal 100%.
†$p < .002$, p-value from corrected F-test comparing ZIP Code groupings.
‡$p < .01$, p-value from corrected χ^2 test comparing ZIP Code groupings.

DISCUSSION

Prevalence of current asthma ranged from 6.39% to 17.9%, with an overall prevalence of 13.0%, more than twice recent estimates of national prevalence of 6.3% (13). In areas with the highest asthma hospitalization rates, more than one quarter of the children had ever received an asthma diagnosis. These ZIP Code areas were predominantly low-income minority communities. Even ZIP Code areas with very low asthma hospitalization rates and high numbers of nonminority residents had asthma prevalence at or above the national average. Therefore, although some neighborhoods bear a greater burden of disease than others, asthma is a critical health issue facing children throughout New York City.

Disparities in Asthma Prevalence Exist Among Urban Neighborhoods

Many studies have found higher-than-average childhood asthma prevalence in low-income minority communities, especially in urban settings (8, 14–19). However, it is not known what factors are the strongest contributors to the urban asthma epidemic. Certain race/ethnicity, income, and local environmental factors are considered culprits (18, 20–22). In the present study, asthma prevalence is three times higher than the national average in communities consisting primarily of low-income minorities. These communities are not exclusively comprised of low-income minorities. Higher income and White residents of these areas are also at high risk of asthma. Conversely, except in the case of Puerto

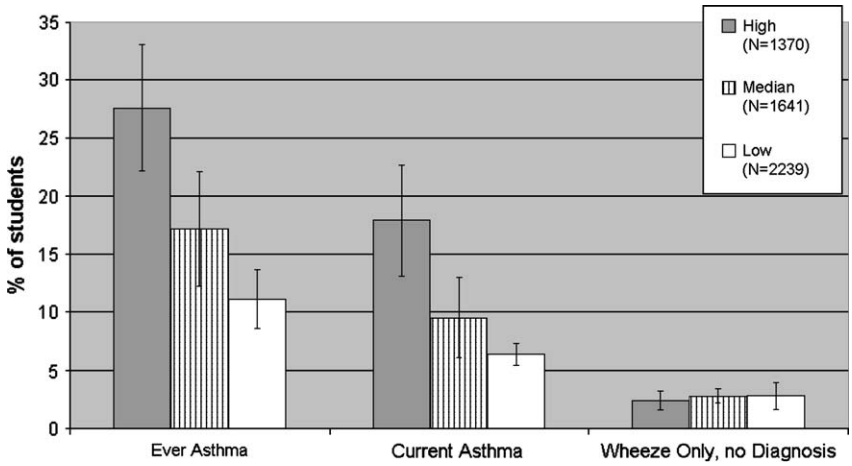

FIGURE 2. Asthma prevalence for asthma hospitalization rate ZIP Code groupings. *$p < .001$, p value from corrected χ^2 test comparing ZIP Code groupings.

Ricans, prevalence within ethnic and income-defined subgroups was lower in areas of higher socioeconomic status. Overall, our study shows that children living in low-SES communities had greater than 70% increased risk of current asthma when compared to children of their same ethnicity and income level living in communities of greater economic affluence. These findings suggest that characteristics of the urban environment, apart from the ethnicity and income level of the residents, contribute to high asthma prevalence.

As seen in Figure 1, areas with high asthma hospitalization rates are geographically clustered in low SES areas that contain a number of potential pollution sources that could affect respiratory health, including designated truck routes and high traffic roads, waste transfer stations, and nearby power plants (23). In addition, Harlem houses six of the seven diesel bus depots located in Manhattan, while the South Bronx is in the takeoff and landing corridors of a major airport. Potential exposures in the urban

TABLE 3. Percentage of demographic subpopulations with current asthma by ZIP Code groupings

	ZIP Code Groupings by Hospitalization Rate		
Selected Demographic Groups	High %	Median %	Low %
Gender			
Male* (n = 637; 773; 1041)	22.2	11.2	8.13
Ethnicity			
Hispanic, overall (n = 741; 728; 310)	15.8	11.2	9.69
Dominican (n = 90; 225; 22)	12.66	13	10.63
Mexican* (n = 207; 65; 52)	8.93	2.66	0.277
Puerto Rican (n = 292; 127; 97)	22.87	16.13	23.96
Other Hispanic (n = 152; 311; 139)	14.3	8.4	4.87
African-American* (n = 404; 172; 80)	21.3	11.2	9.51
White† (n = 41; 324; 845)	23.99	6.85	5.37
Asian (n = 18; 236; 778)	9.09	6.10	3.91
Income			
< $20,000* ($n$ = 646; 625; 570)	19.93	9.51	5.95
$20,001–$39,999† (n = 309; 580; 492)	17.28	10.0	8.72
$40,000–$74,999* (n = 96; 244; 456)	21.1	7.13	6.69
>$75,000 ($n$ = 45; 80; 420)	10.7	4.54	4.06
Household smoking status			
Smoking* (n = 339; 324; 390)	19.1	12.8	7.50

*$p < .001$, p-value from corrected χ^2 test comparing ZIP Code groupings.
†$p < .05$, p-value from corrected χ^2 test comparing ZIP Code groupings.

TABLE 4. Independent effects associated with Current asthma*

	OR	95 CI
Gender		
Male	1.53	1.19–1.97
Female	Reference	–
Ethnicity		
Dominican	1.65	.888–3.06
Mexican	.701	.325–1.52
Puerto Rican	2.28	1.40–3.72
Other Hispanic	1.23	.751–2.00
African-American	1.78	.994–3.19
Asian	.604	.391–.933
Other	1.74	.969–3.13
White	Reference	–
Income		
<$20,000	2.10	1.25–3.52
$20,001–$39,999	1.83	1.05–3.18
$40,000–$74,999	1.66	.896–3.06
$75,000 or more	Reference	–
Neighborhood ZIP Codes		
High	1.73	1.20–2.49
Median	.890	.544–1.45
Low	Reference	–

*Adjusted for age of child, although not significantly associated with current asthma (OR = .990, p = .777).

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environment, such as ozone and particulate matter, have been found to be associated with asthma incidence (24, 25) and increased asthma exacerbations (26–28).

These neighborhoods also contain higher percentages of public housing and housing units with multiple maintenance deficiencies, while areas of low asthma hospitalization rates have been found to have few to none of these decrepit housing units (29–30). Poor housing conditions, rampant in low-income communities, increase early-life exposures to roaches, molds, and pesticides (30). These exposures have also been associated with childhood asthma (31–34).

In all three ZIP Code areas studied, there was a small percentage of children with current wheezing and no diagnosis of asthma (2.33%–2.81%). This indicates that asthma does not often go undiagnosed (15–16). It is possible that public awareness campaigns and education on the issue of asthma in New York City has contributed to this relatively low figure (35).

Prevalence Is Not the Only Contributor to Hospitalization Rates

Hospitalization rates have been used to study the burden of asthma among populations (1–7). Our study suggests that although hospitalization rates are strongly associated to underlying prevalence, they do not reflect the distribution of asthma within an urban center. Prevalence of current asthma in areas of high asthma hospitalization rates were three times that of the areas with low hospitalization rates, but the difference in hospitalization rates is more than 30 fold.

This indicates that there are a number of factors, in addition to asthma prevalence, that contribute to the highly disparate asthma hospitalization rates seen in low-income, minority neighborhoods. In addition to possible environmental exposures found perhaps more frequently in low-SES communities, differences in health insurance status, in access to proper preventive care, and in medication utilization may contribute to increased asthma hospitalizations (8, 36–39). Prevention of attacks is a key component of successful asthma management. Previous research has shown that low-income minorities are more likely to obtain asthma care from emergency departments, a place where they are less likely to receive asthma education on prevention techniques (40–41). However, it remains unclear whether barriers related to insurance, severity of disease, or lack of primary care services are driving this disparity (37, 40, 42).

Puerto Rican and Asian Ethnicity Are Associated with Prevalence of Current Asthma, Regardless of Household Income Level

Another notable finding of this study was that the highest asthma prevalence was found among Puerto Rican children. Unlike for other race/ethnicity backgrounds, Puerto Rican ethnicity remained a significant risk factor for current asthma, even after adjusting for neighborhood and income level. Elevated asthma prevalence in Puerto Rican children and adults has been found in a number of studies, including those conducted on the island of Puerto Rico (14, 16, 43, 44). As seen in our results, there are differences in asthma prevalence between the different Hispanic ethnicities, especially between Puerto Ricans and Mexicans. It is interesting to note that even though Puerto Ricans and Mexicans living in New York City share similar demographics and geographic neighborhoods, the prevalence for Mexicans was the lowest of all ethnicities. It has been hypothesized that Puerto Ricans have a genetic susceptibility to asthma, although no specific gene has yet been identified (45).

Asian ethnicity was also found to have a protective effect. Much of the low-income Asian population in our sample was from the Chinatown sections of Lower Manhattan and Queens. Previous research conducted in an elementary school located near the Chinatown section of Boston found that children living in Chinatown had a significantly lower prevalence of asthma than did children living in other neighborhoods (46). The prevalence of asthma in a number of Asian nations is lower than national estimates for the United States (47). The design of this study did not allow for the identification of specific Asian ethnicity or immigration status, but the study showed that prevalence in the Asian population was consistently lower than for most other ethnic groups, even in Asians with low incomes.

Potential Limitations

New York City school enrollment data does not have a multiracial category, while 70% of the "Other" category in our sample consisted of multiracial children, one-third of whom are part African-American. This could well explain the apparent underrepresentation of African-Americans in our sample as compared to the New York City DOE data. It also may suggest that asthma prevalence in New York City may be even higher than what was reported here, as previous studies have shown African-Americans to have higher asthma prevalence, (13, 19, 21).

We found that the majority of the schools (24 of 26) included in our study had ethnic compositions similar to their surrounding ZIP Code. This suggests that ZIP Codes in our sample were relatively homogeneous for the relevant factors, such as ethnicity and income level, despite their arbitrary geographic boundaries. Finally, only public schools were included in this study. Private-school children are often wealthier and may have different asthma prevalence than their public-school counterparts.

CONCLUSIONS

The strengths of the study are that it presents high response rates in a large sample of urban children, and it provides details about their sociodemographic characteristics and asthma levels. We found that children living in predominantly low-SES communities have significantly high risk of current asthma, independent of their own ethnicity and household income level. Puerto Ricans, especially, have a high risk of asthma, regardless of socioeconomic status. Our data also show that although prevalence of current asthma is a strong contributor to the high asthma hospitalization rates, it alone does not explain the exuberantly high hospitalization rates that have been previously observed (2). These results provide a sociodemographic profile of asthma in urban populations.

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