The protective effect of community factors on childhood asthma

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Background: Asthma burden in the US is not evenly distributed. Although asthma prevalence varies widely across urban neighborhoods, little attention has been paid to the community as a key contributor.

Objective: To determine the effect of positive socio-environmental community factors on childhood asthma prevalence in Chicago.

Methods: From 2003 to 2005, an asthma screening survey was conducted among children attending Chicago Public/Catholic schools from kindergarten through eighth grade. One hundred five schools participated, yielding a stratified representation of 4 race-income groups. Positive community factors, such as social capital, economic potential, and community amenities, were assessed by using the Metro Chicago Information Center's Community Vitality Index.

Results: Of the surveys returned, 45,177 (92%) were geocoded into 287 neighborhoods. Neighborhoods were divided into quartile groups by asthma prevalence (mean, 8%, 12%, 17%, 25%). Community vitality (54% vs 44%; $P < .0001$) and economic potential (64% vs 38%; $P < .0001$) were significantly higher in neighborhoods with low asthma prevalence. Neighborhood interaction (36% vs 73%; $P < .0001$) and stability (40% vs 53%; $P < .0001$) were significantly higher in neighborhoods with high asthma prevalence. Overall, positive factors explained 21% of asthma variation. Childhood asthma increased as the black population increased in a community ($P < .0001$). Accordingly, race/ethnicity was controlled. In black neighborhoods, these factors remained significantly higher in neighborhoods with low asthma prevalence. When considered alongside socio-demographic/individual characteristics, overall community vitality as well as social capital continued to contribute significantly to asthma variation.

Conclusion: Asthma prevalence in Chicago is strongly associated with socio-environmental factors thought to enrich a community. A deeper understanding of this impact may lend insight into interventions to reduce childhood asthma. (J Allergy Clin Immunol 2009;123:1297-304.)

Key words: *Asthma, prevalence, community, neighborhood, childhood, environment, social capital, disparity*

Asthma is the leading chronic illness of childhood, affecting over 9 million children; however, the burden is not equally distributed in the United States.[1] Racial differences in prevalence have been identified as an important public health concern,[2] as has the problem of increased asthma prevalence in certain US urban populations.[3-5]

Chicago, a city with one of the highest asthma rates in the country, has asthma mortality twice the national average.[6-8] Chicago hospitalization rates have also been shown to be twice as high as suburban Chicago and overall US rates.[8] However, research demonstrates that childhood asthma rates in Chicago vary widely based on the neighborhood in which a child lives.[9]

Researchers exploring the causes of the asthma burden in Chicago and other high-risk urban areas have demonstrated that mortality rates are associated with individual factors such as race and community social economic status.[5,10] Some negative community-level physical environment factors, such as neighborhood violence, air pollution, and housing conditions, have also been implicated in affecting childhood asthma prevalence and morbidity.[11-15] To our knowledge, the effect of social and environmental factors thought to enrich a community, ie *positive community factors*, has not been fully characterized. In a study limited to a comparison of 3268 adults in Chicago, it was suggested that collective efficacy, a measure of residents' trust, attachment, and capacity for mutually beneficial action, was protective against asthma and breathing problems.[16]

The Chicago Initiative to Raise Asthma Health Equity (CHIRAH) study was designed to better characterize the factors associated with asthma burden. Initial findings have suggested a wide variation in childhood asthma prevalence.[9] Therefore, the purpose of this study was to determine the effect of positive community factors such as social capital, economic potential, and community amenities on childhood asthma prevalence in Chicago neighborhoods.

METHODS

Overview of study design

This report is based on a cross-sectional survey screening for asthma that was conducted as part of the CHIRAH study. This study consisted of a large

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Abbreviations used
CHIRAH: Chicago Initiative to Raise Asthma Health Equity
CPS: Chicago Public School
CVI: Community Vitality Index
MCIC: Metro Chicago Information Center
PHDCN: Project on Human Development in Chicago Neighborhoods

sample of children attending Chicago public and Catholic elementary and middle schools during the 2003 to 2004 and 2004 to 2005 school years. An overview of the study methods follow; for further details on study methods, refer to Shalowitz et al.[17]

School sample

In 2004, Chicago Public Schools (CPS) had 320,557 students in 486 elementary schools. CPS students were 50% black, 38% Hispanic, and 9% white. Eighty-five percent of CPS students were considered low-income, defined as coming from families who are receiving public aid, living in institutions for neglected or delinquent children, being supported in foster homes with public funds, or being eligible to receive free or reduced-price lunches. In 2004, the Archdiocese of Chicago had 37,333 students in 126 elementary schools. Archdiocese students were 14% black, 17% Hispanic, and 62% white. Twenty-four percent of Archdiocese students were low-income (includes Chicago and suburbs; Chicago-only estimates are higher).

To gain a representative sample of students, schools were stratified first by race and then income. Schools were identified by population proportionate and cluster sampling methods within each of the 4 race-income sampling groups (high black/mid-income; high black/low-income; low black/mid-income; low black/low-income), resulting in a final sample of 105 schools. For each school, all children in kindergarten through eighth grade were eligible to be surveyed and asked to participate. A total of 48,917 (79%) completed surveys were returned. For further details on school sample, see this article's Supplemental text in the Online Repository at www.jacionline.org.

Survey instrument

The screening survey was distributed at the schools and taken home by the students for an adult caregiver to complete in English or Spanish. It consisted of questions including the child's birth date, height, weight, sex, report of physician-diagnosed or nurse-diagnosed asthma, age at diagnosis, race/ethnicity of the child, current asthma status, relationship to the child of the person completing the survey, names and ages of others living in the same household with asthma, the child's home address, and a short asthma symptom screening tool: the Brief Pediatric Asthma Screen Plus.[18,19] Our analyses included only children with physician-diagnosed or nurse-diagnosed asthma as reported by an adult caregiver. The sampled subjects were geocoded by using ArcGIS US Streetmap and linked with neighborhoods (ESRI GIS and Mapping Software; Redlands, Calif).

Neighborhood selection criteria

To study the possible community-level factors, all children were assigned to a neighborhood. The Chicago neighborhoods used in this analysis represent neighborhoods as defined by the Project on Human Development in Chicago Neighborhoods (PHDCN).[20] The PHDCN Scientific Directors defined *neighborhoods* spatially, as a collection of people and institutions occupying a contiguous subsection of a larger community. The project collapsed 847 census tracts in the city of Chicago to form 343 neighborhoods. The predominant guideline in formation of the neighborhoods was that they should be as ecologically meaningful as possible, composed of geographically contiguous census tracts, and internally homogenous on key census indicators. The project settled on an ecological unit of about 8000 people, which is smaller than the 77 established community areas in Chicago (of which the average size is almost 40,000 people), but large enough to approximate local communities. Geographic boundaries (eg, railroad tracks, parks, and freeways) and knowledge of Chicago's community areas guided this process. Our sample consisted of children from 287 of the 342 PHDCN neighborhoods; 56 neighborhoods had fewer than 15 children from our sample and were not included in the study.

Community Vitality Index

Community-level socio-environmental characteristics were assigned to each neighborhood and were part of the Community Vitality Index (CVI). The census-tract level CVI was developed by and obtained from the Metro Chicago Information Center (MCIC), an official Census Information Center. The MCIC CVI provides a composite score with 3 components: Social Capital (33.3%), Economic Potential (33.3%) and Community Amenities (33.3%). Each of these components consists of 4 subindices. For further details on CVI components, see this article's Table E1 in the Online Repository at www.jacionline.org. Subindex scores range from 1 (lowest observed value) to 100 (highest observed value). The values are averaged and then ranked together to produce the overall CVI and CVI component scores for each census tract.

The MCIC CVI generates a score from 1 to 100 for every census tract in the 6-county Chicago metropolitan region. The score is a way to grade each census tract in relation to the region as a whole. For example, if a tract has a CVI score of 87, it means that 87% of the tracts in the region have lower CVI scores. Indicators in this index model were determined through a review of the literature and current practices, small area data availability, and stakeholder input. All data indicators are normalized to account for population density differences. A neighborhood's community indices are the averages of its corresponding census-tract level indices. (For detailed CVI methodology, see http://info.mcfol.org/www/datainfo/cvi/tech_methodology.asp.)

Statistical analysis

Neighborhoods were assigned to a quartile group according to childhood asthma prevalence. The multiple t test was performed to evaluate the CVI across each quartile group. This method allowed us to test the null hypothesis of no difference in the mean among 3 or more groups simultaneously and produces an accurate assessment of the effects of community factors on asthma prevalence.[21,22] Proc Multtest (Bonferroni option) in SAS was used for this analysis (SAS Institute, Inc, Cary, NC).

To accommodate the significant effects of neighborhood racial/ethnic composition on asthma prevalence, we grouped neighborhoods with greater than two thirds of a specific race: white, black, and Hispanic. We then applied multiple group analysis to evaluate further the effects of community factors on asthma prevalence specific to neighborhoods categorized by race. Mplus3.0 was used to implement the multiple group analysis (Muthén & Muthén, Los Angeles, Calif).

Multilevel logistic regression analysis was performed for 45,309 individuals nested within 287 neighborhoods to estimate the effect of the 12 CVI subindices on childhood asthma neighborhood variance. A similar analysis was conducted looking at individual and neighborhood factors alongside CVI to assess the impact of each subindex and subindex item on childhood asthma neighborhood variance. SAS GLIMMIX was used for multilevel analysis (SAS Institute, Inc). For further details on the multilevel logistic regression analysis, see this article's Supplemental text in the Online Repository at www.jacionline.org.

The institutional review boards of Northwestern University and the Cook County Bureau of Health Services approved the school screening protocol. The CPS board and the Archdiocese of Chicago approved the asthma screening protocol in their respective schools.

RESULTS

Study population

A total of 48,917 children were screened and 45,177 (92%) were successfully geocoded and resided in 1 of the 287 Chicago neighborhoods. Among these children, 11% were age 3 to 5 years, 34% were age 6 to 8 years, 33% were age 9 to 11 years, and 22%

TABLE I. Demographic characteristics of sample population (n = 45,177)

Subpopulation	Frequency (n)	Sample prevalence (%)	Cases of asthma in subpopulation (n)	Asthma prevalence in subpopulation (%)
Reported asthma diagnosis				
Yes	5,874	13		
No	39,303	87		
Race/ethnicity				
White	12,915	29	1,227	10
Black	12,998	29	2,534	20
Hispanic	19,264	43	2,113	11
Sex				
Male	22,230	49	3,356	15
Female	22,947	51	2,518	11
Household member with asthma				
Yes	4,114	9	1,493	36
No	41,063	91	4,381	11
Age group (y)				
3-5	5,073	11	599	12
6-8	15,273	34	1,907	13
9-11	14,910	33	2,010	14
12 and older	9,921	22	1,358	14

were 12 years and older. Forty-nine percent were boys, and 29% self-identified as white, 29% as black, and 43% as Hispanic. The asthma prevalence of the overall study population was 13%. White and Hispanic children had a mean asthma prevalence of 10% and 11%, respectively, whereas black children had a mean asthma prevalence of 20% ($P < .0001$). Nine percent of children in the sample had a household member with asthma (Table I).

Positive community factors and asthma prevalence

To assess the effect of positive community factors on asthma prevalence, we categorized the 287 neighborhoods into quartile groups (Fig 1). Each neighborhood quartile group was characterized by its mean asthma prevalence: 8% in group 1, 12% in group 2, 17% in group 3, and 25% in group 4. As seen in Table II, the mean CVI score differed significantly across each neighborhood quartile group; as asthma prevalence decreased, the mean CVI percentile scores improved significantly ($P < .001$).

There were notable differences seen in the scores for each CVI component and the corresponding subindices. The overall social capital of a neighborhood did not reach statistical significance because the subindices measuring social capital were significant in opposite directions. Neighborhoods with more civic engagement ($P < .0001$) and community diversity ($P < .0001$) had lower childhood asthma rates. In contrast, neighborhoods with more interaction potential ($P < .0001$) and stability ($P < .05$) had higher asthma prevalence (Table II).

Neighborhoods with evidence of economic vigor had lower asthma prevalence rates ($P < .0001$), ranging from 64% in the low prevalence neighborhoods to 38% in the high prevalence neighborhoods. Lower asthma rates were also seen in neighborhoods with greater commercial vitality ($P < .0001$), buying power ($P < .0001$), and workforce potential ($P < .0001$). Asthma prevalence was not associated with evidence of confidence and investment in a community (Table II).

Neighborhoods with more community amenities also had lower childhood asthma prevalence ($P < .05$). Lower asthma rates were particularly common in neighborhoods with many cultural/entertainment facilities and restaurants ($P < .0001$). However, there were more community institutions (eg, libraries, universities, and so forth) in neighborhoods with high asthma prevalence ($P < .05$). Health and human service facilities seemed to be distributed equally among all neighborhoods and were not significantly associated with asthma prevalence (Table II).

The relationship of race and CVI with neighborhood asthma prevalence

As the black population increased in a community, so did the childhood asthma prevalence ($P < .0001$). To investigate whether CVI indicators were still predictive of asthma prevalence when race/ethnicity was controlled, neighborhoods with $\geq$67% of their population classified as white or black were analyzed individually. Because only 32 neighborhoods had a greater than two thirds Hispanic population, analyses were not done on this group.

Predominantly black neighborhoods. The predominant population in 108 Chicago neighborhoods was black. As asthma prevalence increased in these primarily black neighborhoods, the overall CVI score significantly decreased ($P < .05$). None of the 3 CVI component scores reached statistical significance. However, commercial vitality, an indicator of economic potential, was statistically significant ($P < .05$), with higher commercial vitality predictive of lower asthma prevalence.

Predominantly white neighborhoods. The predominant population in 72 Chicago neighborhoods was white. In these neighborhoods, neither the total CVI score nor any of the component scores were significantly related to asthma prevalence. However, community diversity, an indicator of social capital, was nearly significant ($P < .1$), with greater diversity corresponding to higher asthma rates. Economic potential was nearly significant ($P < .1$), with more potential for community development associated with lower asthma prevalence.

Positive community factors and neighborhood asthma variance

Eleven of the 12 CVI subindices, with the exception of the degree of confidence and investment in a community, were

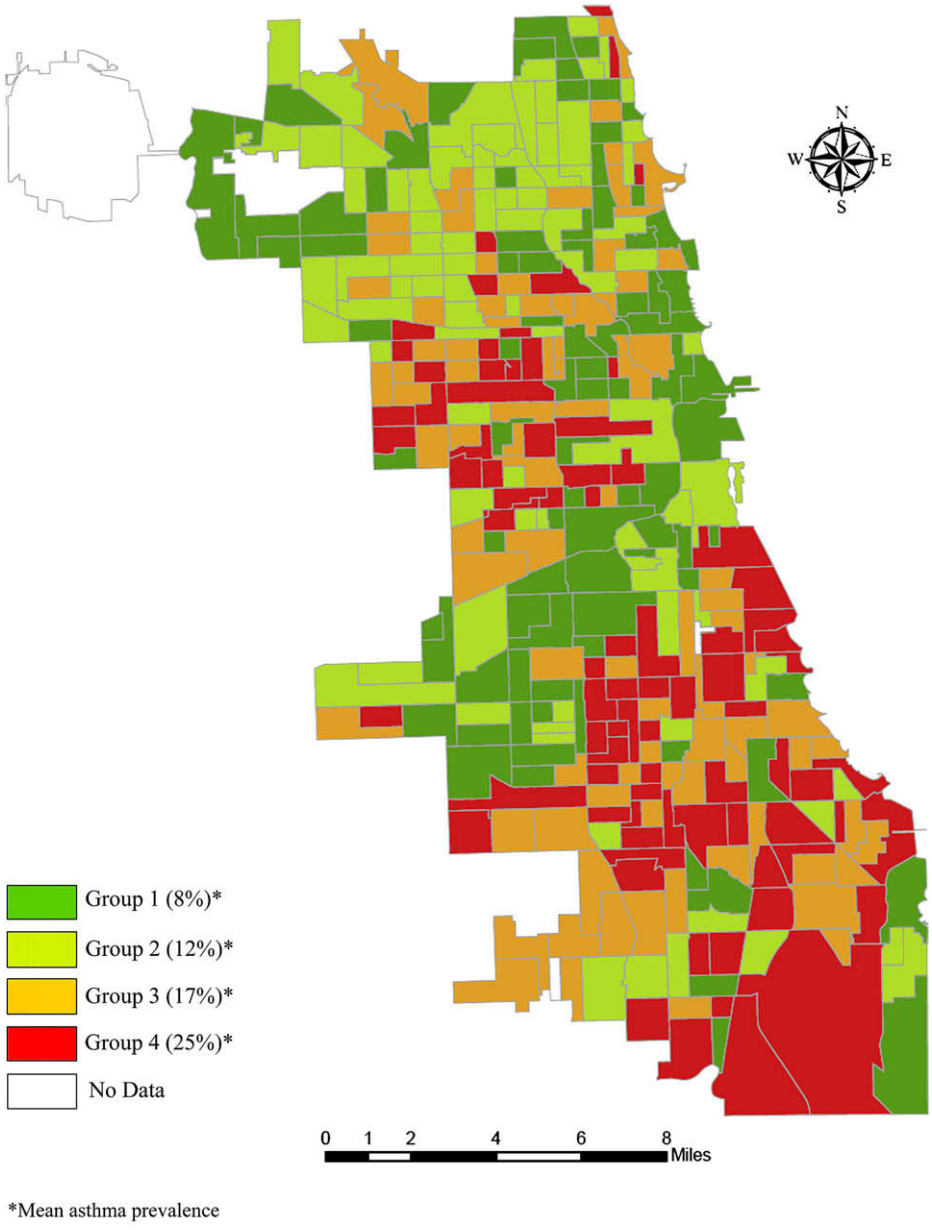

FIG 1. Asthma prevalence in Chicago arranged in quartile groups by neighborhood asthma prevalence.

significantly associated with the neighborhood asthma variation (Table III). That being said, each subindex had a small individual impact on the variation seen. Together, indicators of social capital explained 43% of the neighborhood variation seen (from values for neighborhood variance: [Model I - Model VI]/Model I, Table III). Indicators of economic potential explained 29% of the variation, whereas indicators of community amenities explained 50%.

In Table IV, individual characteristics as well as community race and socioeconomic status were added into the models. A child's age, sex, household asthma history, and community racial composition were all significant factors associated with the variation in neighborhood asthma prevalence. A community's socioeconomic status, however, was not significantly associated when modeled with CVI/CVI components and individual characteristics of the child. The CVI continued to contribute significantly when community race was added to the model. The social capital component played a significant role in explaining a degree of the variation seen in asthma prevalence by neighborhood in spite of the inclusion of a community's racial/ethnic composition. Absent race, overall CVI accounted for 50% of the variation in neighborhood asthma; with the inclusion of race, CVI continued to explain 21% of the variance (from values for neighborhood variance: [Model III - Model IV]/Model I, Table IV).

DISCUSSION

To our knowledge, this study is the first to show the influence of positive community factors on childhood asthma prevalence. The overall CVI was significantly associated with asthma prevalence, with higher CVI scores in neighborhoods with low asthma rates. Specifically, communities with low childhood asthma rates had

TABLE II. Asthma prevalence, race/ethnicity distribution, and mean CVI scores arranged in quartile groups by neighborhood asthma prevalence

Variable	Percentage by neighborhood quartile group (%)			
	Group 1 (n = 72)	Group 2 (n = 72)	Group 3 (n = 72)	Group 4 (n = 71)
Mean asthma prevalence				
Total	8	12	17	25
Race/ethnicity				
White***	59	52	30	15
Black***	14	30	58	75
Hispanic***	32	33	14	12
CVI				
Total	54	55	50	44
Social capital component				
Total	44	53	51	49
Interaction potential***	36	42	59	73
Stability**	40	42	54	53
Community diversity***	52	63	42	31
Civic engagement***	62	61	52	43
Economic potential component				
Total***	64	61	51	38
Commercial vitality***	67	65	54	46
Buying power***	64	63	50	42
Confidence and investment	44	50	52	50
Workforce potential***	60	52	48	33
Community amenities component				
Total**	53	50	48	44
Arts, culture, and leisure***	47	43	34	26
Restaurants***	60	57	47	41
Health and human services	59	56	61	63
Community institutions**	45	45	54	54

**P value $<.05$.
***P value $<.001$.

greater potential for economic development and, from a social perspective, were more diverse and civically engaged. They also had more restaurants and cultural/entertainment facilities. Neighborhoods with high childhood asthma had more community institutions, such as libraries and universities, and more potential for community interaction; these communities also tended to be more stable. Health and human service agencies, including medical care facilities, were not significantly associated with asthma prevalence. After controlling for individual and community confounders, including race/ethnicity, a community's social capital continued to contribute significantly to neighborhood asthma variation. The overall CVI remained significant but contributed less to neighborhood asthma variation after the addition of community race. Accordingly, race may serve as a proxy for many socio-cultural and environmental risk factors for asthma in our study.

Under the social capital component, neighborhoods with more civic engagement (higher percentage of registered voters) and increased diversity (ethnicity, income, and age) were associated with low asthma prevalence. Interestingly, neighborhoods with high asthma had double the potential for community interaction. However, previous studies have shown that psychosocial factors, including lack of social support networks, led to increased asthma hospitalizations.[23,24] This apparent conflict may be explained by the measure with which interaction was evaluated. In this study, interaction was measured by the percent of households not linguistically isolated or composed of a single person living alone and having at least 1 household member not in the labor force. Although one can understand how these factors may lead to increased interaction, they may also signify crowding and poverty, which has been associated with increased indoor pollutants and asthma rates.[25,26] Future researchers may wish to question participants about personal social support and interaction networks to measure this variable accurately.

Neighborhoods with high asthma rates were also more stable, indicating that residents in the community were less likely to move. Previous studies have linked more residential stability both with higher[27] and lower[28] asthma rates based on cockroach allergen levels in the home. In the former study, higher asthma rates in more stable communities were attributed to less thorough and frequent maintenance cleaning in homes occupied for a longer period.[27] In the latter study, lower asthma rates in more stable communities were suggested to indicate a better built environment in these homes.[28]

If the measures used herein truly capture social support and stability, our findings are encouraging for the development of effective asthma interventions in communities with high asthma rates. Successful interventions are known to require an interactive and stable community in which individuals can develop shared commitments to desired outcomes.[29]

Poverty has been shown to be associated with asthma prevalence, hospitalizations, and mortality in multiple studies.[26,30,31] Likewise, we found a neighborhood's economic potential to be strongly associated with asthma prevalence. Specifically, the greater the number of businesses, number of business loans, aggregate income, degree of educational attainment, number of wage earners, and employment rate were all associated with lower asthma rates. In predominantly black neighborhoods, although

TABLE III. Significance of CVI components on neighborhood asthma prevalence†

Subindex	Model I (null model)	Model II OR (CI)	Model III OR (CI)	Model IV OR (CI)	Model V OR (CI)	Model VI OR (CI)
Analysis of social capital component						
Interaction potential		1.30*** (1.23- 1.36)				1.22*** (1.13-1.33)
Stability			1.12*** (1.06- 1.18)			1.00 (0.94-1.06)
Community diversity				0.81*** (0.77-0.86)		0.93** (0.86-0.99)
Civic engagement					0.86*** (0.82-0.91)	0.99 (0.93-1.05)
Neighborhood variance (SE)	0.14 (0.02)	0.09 (0.01)	0.13 (0.02)	0.1 (0.01)	0.12 (0.02)	0.08 (0.01)
Median odds ratio (CI)	1.42 (1.35- 1.49)	1.32 (1.26-1.38)	1.41 (1.34-1.47)	1.34 (1.28-1.4)	1.38 (1.32-1.44)	1.31 (1.25-1.37)
Analysis of economic potential component						
Commercial vitality		0.83*** (0.78-0.88)				0.89** (0.83-0.96)
Buying power			0.82*** (0.77-0.86)			0.83*** (0.77-0.91)
Confidence and investment				1.03 (0.98-1.09)		1.03 (0.97-1.09)
Workforce potential					0.84*** (0.79-0.88)	1.03 (0.94-1.13)
Neighborhood variance (SE)	0.14 (0.02)	0.12 (0.02)	0.11 (0.02)	0.14 (0.02)	0.12 (0.02)	0.1 (0.02)
Median OR (CI)	1.42 (1.35-1.49)	1.39 (1.32-1.45)	1.36 (1.3-1.42)	1.43 (1.35-1.49)	1.39 (1.32-1.45)	1.35 (1.29-1.41)
Analysis of community amenities component						
Arts, culture, and leisure		0.86*** (0.81-0.91)				0.84*** (0.77-0.93)
Restaurants			0.85*** (0.8-0.9)			0.87** (0.79-0.95)
Health and human services				1.09** (1.03-1.15)		1.13** (1.05-1.21)
Community institutions					1.11*** (1.05-1.18)	1.17*** (1.09-1.26)
Neighborhood variance (SE)	0.14 (0.02)	0.12 (0.02)	0.12 (0.02)	0.13 (0.02)	0.13 (0.02)	0.07 (0.01)
Median odds ratio (CI)	1.42 (1.35-1.49)	1.40 (1.33-1.46)	1.39 (1.32-1.45)	1.40 (1.33-1.47)	1.40 (1.33-1.47)	1.28 (1.22-1.34)

OR, Odds ratio.

**P value $<.05$.

***P value $<.001$.

†For each CVI component, models II through V incorporate a single subindex for the stated component and show the effect of that subindex on the likelihood of having asthma; Model VI incorporates all subindices for the stated component and shows the collective effect of subindices on the likelihood of having asthma.

the overall potential for economic growth was not associated with asthma prevalence, there were significantly more businesses in neighborhoods with lower asthma rates.

Surprisingly, the number of mortgages, home improvement loans, and occupied dwelling units—all representative of the degree of confidence and investment in a community—was not significantly different among neighborhoods. This may be because areas with higher asthma prevalence may also have a higher density of people, resulting in an illusory inflation in the number of mortgages and home improvement loans. Another possible explanation may be the unusually high real estate activity in Chicago in early 2000; many buildings in low income neighborhoods were sold and rehabbed for section 8 rentals, which may have disproportionately increased the number of occupied properties in neighborhoods with high asthma prevalence.

Community amenities may be a measure of socioeconomic status. It is likely that neighborhoods with low asthma rates had more restaurants and cultural/entertainment facilities because they had higher aggregate community income and, accordingly, were able to invest more in these facilities. Neighborhoods with high asthma had more libraries, houses of worship, and institutions of higher education. This too is understandable, because these facilities are typically not-for-profit and are often managed by the local government and religious organizations. Interestingly, the number of health and human services agencies was not related to asthma prevalence. However, previous studies have shown that poor children are less likely to use appropriate health services.[32-34] Although it seems health centers exist equally in neighborhoods regardless of asthma prevalence, a child in a community with high asthma rates may have difficulty accessing services because of insurance, knowledge, and other individual factors.

There are, as with all studies, limitations to the design that need to be highlighted. We obtained community data from the 2000 census and individual data was collected from 2003 to 2005. Because the community data are 3 to 5 years older than the individual data, there may be some discrepancy. Further, our study was based on school samples of children and a certain census per school. For this reason, we did not have an exact census of children from each neighborhood, and any neighborhood with less than 15 children was not included. Also, a small bias may exist for children not yet in school. However, our sample of children was large, and 84% of Chicago neighborhoods were represented.

We recognize that use of the CVI is relatively new to the field of medical research (we are aware of 1 study in progress using this measure), and, as such, the reliability of its measurement in the face of a counterintuitive finding is a potential limitation and open for further investigation. Our primary objective is to initiate an investigation into the impact of positive social and environmental community characteristics on childhood asthma prevalence. We encourage researchers to take note of these potentially mutable factors and further our work, through their own investigation, using a host of measures to validate (or challenge) our findings.

Previous studies clearly identify the causes of pediatric asthma to be multifactorial. Negative community factors that have been associated with asthma prevalence include exposure to air pollution[4,35,36]; housing problems including sensitization to cockroach,[37-39] dust mite,[38,40] mouse,[41,42] and rat allergens[43]; decreased exposure to endotoxins (the hygiene hypothesis)[44-46]; community

TABLE IV. Significance of community and individual characteristics on neighborhood asthma prevalence†

Variable	Model I (null model)	Model II OR (CI)	Model III OR (CI)	Model IV OR (CI)	Model V OR (CI)	Model VI OR (CI)
Individual characteristics						
Age 6-8 vs age 3-5 y		1.05 (0.95-1.16)	1.05 (0.95-1.16)	1.05 (0.95-1.16)	1.05 (0.95-1.16)	1.05 (0.95-1.16)
Age 9-11 vs age 3-5 y		1.11** (1.00-1.23)	1.11** (1.00-1.22)	1.11** (1.00-1.22)	1.11** (1.00-1.23)	1.11** (1.00-1.23)
Age 12+ vs age 3-5 y		1.13** (1.02-1.26)	1.13** (1.01-1.25)	1.12** (1.01-1.25)	1.13** (1.01-1.25)	1.13** (1.01-1.25)
Male vs female		1.48*** (1.40-1.57)	1.48*** (1.40-1.57)	1.49*** (1.40-1.57)	1.49*** (1.40-1.57)	1.49*** (1.40-1.57)
Household member with asthma vs without		4.44*** (4.15-4.78)	4.47*** (4.15-4.81)	4.46*** (4.15-4.78)	4.46*** (4.15-4.81)	4.44*** (4.13-4.78)
Community race						
Black vs white‡		1.74*** (1.54-1.97)		1.74*** (1.45-2.08)		1.73*** (1.43-2.09)
Hispanic vs white§		1.06 (0.91-1.23)		1.10 (0.91-1.33)		1.11 (0.92-1.35)
Mixed vs white‖		1.10* (0.98-1.24)		1.20** (1.03-1.39)		1.25** (1.08-1.46)
Community socioeconomic status						
Low vs high¶			1.11 (0.95-1.31)	0.90 (0.76-1.06)	1.06 (0.90-1.25)	0.88 (0.74-1.04)
Moderate vs high#			0.97 (0.87-1.08)	0.89 (0.79-1.00)	0.98 (0.89-1.09)	0.89 (0.79-1.00)
CVI						
Total			0.84*** (0.79-0.90)	0.93** (0.87-0.99)		
Social capital component					0.84*** (0.77-0.91)	0.88** (0.81-0.96)
Economic potential component					1.00 (0.92-1.10)	1.06 (0.98-1.16)
Community amenities component					0.98 (0.93-1.03)	0.96 (0.91-1.01)
Neighborhood variance (SE)	0.14 (0.02)	0.04 (0.01)	0.07 (0.01)	0.04 (0.01)	0.06 (0.01)	0.04 (0.01)
Median OR (CI)	1.42 (1.35-1.49)	1.10 (1.16-1.27)	1.10 (1.23-1.35)	1.10 (1.16-1.27)	1.10 (1.21-1.33)	1.10 (1.16-1.26)

OR, Odds ratio.
*P value <.1.
**P value <.05.
***P value <.001.
†Models II through VI incorporate a collection of variables and show the collective effect of the variables on the likelihood of having asthma.
‡Where ≥2/3 population black vs ≥2/3 population white.
§Where ≥2/3 population Hispanic vs ≥2/3 population white.
‖Where <2/3 population black/Hispanic/white vs ≥2/3 population white.
¶Where average family income ≤$30,638.40 vs average family income >$51,632.25.
#Where average family income >$30,638.40 and ≤$51,632.25 vs average family income >$51,632.25.

income and education[26,47]; and exposure to violence.[15,48] Individual factors known to be associated with asthma include age, sex,[49,50] race,[30,51] family history,[52] smoking,[53,54] diet,[55,56] and stress.[57,58] Because asthma is such a complex disease, several of these factors may be related to the positive factors discussed. For example, in neighborhoods with more economic potential, there may be less indoor and outdoor pollutants and less indoor allergen exposure due to a better built environment.

Regardless, with childhood asthma prevalence at a historic high and disparities increasing among low-income and minority populations,[59] further insight is clearly needed to combat this growing problem. Positive community factors have rarely been examined as potential protective factors in childhood asthma even though asthma prevalence has been shown to vary widely by neighborhood.[9] Our results suggest that positive community factors are associated with childhood asthma prevalence, and further investigation is warranted. A deeper understanding of positive community factors and the interplay of these factors with individual and negative community factors is an essential step to determining the true causes of neighborhood variation in childhood asthma rates.

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Clinical implications: An understanding of the social and environmental community factors that may be protective against childhood asthma will lend insight into the allocation of public health resources.

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SCHOOL SAMPLE

Schools were eligible for asthma screening if: 1) greater than 50% of the enrolled students came from within the school district, 2) the school had not had on-site asthma screening within the previous 2 years, and 3) permission was obtained from the school principal. To gain a broad, largely representative sample, schools were stratified based upon both the percentage of African American students enrolled (>50% versus $\leq$50%, contingent on race/ethnicity reported by participant) and family income, where subsidized lunches served as a proxy for income (>70% versus $\leq$70% receiving subsidized or free lunches). This process resulted in four groups of schools, those with higher versus lower prevalence of African American (AA) students and those with middle versus lower income.

Ninety-two schools were identified by population proportionate sampling methods within each of the 4 race-income sampling groups (high AA/low income; high AA/mid-income; low AA/low income; low AA/mid-income). A population proportionate sampling method was used to adjust for school size, thereby providing an equal chance of a child being surveyed regardless of school size. In addition, five of the 92 schools were selected in each race-income sampling group to represent larger neighborhood areas. For each of the 5 schools in a given group, the 2 cluster schools in closest proximity were included for analysis, adding 40 additional schools to the 92 schools selected by population proportionate sampling.

Of these 132 schools, 27 refused to participate, and 1 of the selected cluster schools was a duplicate selection. The duplicate was replaced by the next closest school yielding a final sample of 105 schools (80%) that were widely dispersed throughout the city. Reasons for refusal generally related to other academic priorities competing for the principal's attention and an unwillingness to distract classes from daily lessons.

STATISTICAL ANALYSIS

In the multilevel logistic regression analysis, a non-conditional model (also called null model) was used to estimate the neighborhood level variance. This variance reflects the total neighborhood level variance, including all individual and neighborhood factors in our model. Under null hypothesis, the neighborhood level variance is expected to be zero because there is no between-neighborhood variability in the health outcomes of interest. The neighborhood level random variance was translated into a Median Odds Ratio (MOR) which can be compared with the intuitive odds ratios of individual variables.[16, 17] The MOR is interpreted as how much a child's probability of asthma would (in median) increase if this child moved to a neighborhood with a higher asthma risk due to the factors in our model. A MOR of 1 indicates that there are no differences between neighborhoods in the probability of the child having asthma. We first estimated the null model and then included neighborhood and individual variables. For example, neighborhood socioeconomic status measured by median family income was introduced into the models as a two-category variable. A series of multilevel models were developed to assess the relative effects of neighborhood income on child asthma as compared with the effects of individual factors. All individual and neighborhood variables were looked at in this manner.

TABLE E1. Explanation of CVI

Subindex	Variable	Definition
Social capital component (33%)		
Descriptor of connections between people that allow communities to work together		
Interaction potential (25%)	Neighborhood interaction*	% Households not linguistically isolated
	Social support*	% Households not composed of a single person living alone
	Availability*	% Households with at least 1 adult not in the labor force
Stability (25%)	Mobility*	% Households that resided in same home 5 y earlier
	Immigration*	Inversely ranked % foreign born residents who entered given tract within 5 y
Community diversity (25%)	Ethnic diversity*	Inversely ranked % tract population of largest single racial/ethnic group
	Age distribution*	Inversely ranked % tract population in any single age group (0-24, 25-44, 45+ y)
	Income mix*	% Households in any single income group ($0-34,999, $35,000-74,999, $75,000+)
Civic engagement (25%)	Voting rate†	% Registered voters who voted in November 2002 election
Economic potential component (33%)		
Descriptor of features considered important in community development and assets with potential leverage for community change		
Commercial vitality (25%)	Business density‡	No. of businesses per square mile
	Small business loans§	Aggregate amount of small business loans (<1 million)
Buying power (25%)	Aggregate income*	Total income for all people in given census tract
	Shelter cost burden*	Inversely ranked % households spending ≥30% monthly income on housing
Neighborhood confidence and investment (25%)	Home investment‖	No. of mortgages originated per dwelling unit
	Home improvement‖	No. of home improvement loans originated per occupied dwelling unit
	Owner occupancy*	% Occupied dwelling units
Workforce potential (25%)	Educational attainment*	% Population > 25 y old with at least some college education
	Wage earners*	No. of wage earners age 16-64 y per square mile
	Employment rate*	% Labor force employed
Community amenities component (33%)		
Descriptor of the impact of cultural and social amenities on the growth of social capital and community development		
Arts, culture, and leisure (25%)¶,#		No. of 3-mile buffers around each artistic, cultural and entertainment facility that include the center of each tract divided by the population density
Restaurants (25%)¶		No. of 1-mile buffers around each restaurant that include the center of each tract divided by the population density
Health and human services (25%)**		No. of 3-mile buffers around each agency that include the center of each tract divided by the population density
Community institutions (25%)††		No. of 2-mile buffers around each institution that include the center of each tract divided by the population density

*Data source: 2000 US Census.
†Data source: County Board of Elections, Chicago Board of Elections by precinct.
‡Data source: 2002 commercial listing of all businesses with telephones.
§Data source: 1999 Community Reinvestment Act data.
‖Data source: 1999 Home Mortgage Disclosure Act.
¶Data source: commercial database of businesses with telephones.
#Data source: database of nonprofit arts/culture organizations.
**Data source: 2001 United Way Blue Book.
††Data source: InfoUSA commercial business database.