

Stressful life events and asthma in adolescents

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Recent studies suggest that psychosocial factors may contribute to asthma. We examined associations of stressful life events with asthma prevalence and morbidity among Chicago adolescents. Self-reported asthma, measures of asthma morbidity, and 15 life events were collected from 2026 seventh to ninth grade students from 34 Chicago Catholic schools as part of the International Study of Allergies and Asthma in Childhood in 1994–95. Life events were reported by 77% of adolescents and overall asthma prevalence was 15.5%. Stressful life events in adolescents were significantly related to both asthma and asthma morbidity. Odds of asthma was 1.44 (95% confidence interval [CI] = 1.07, 1.95) for those reporting two to three stressful events and 1.92 (95% CI = 1.41, 2.62) for subjects endorsing more than three stressful events. In adolescents with asthma, number of asthma symptoms (odds ratio [OR] for increase in one event = 1.16, 95% CI = 1.07, 1.27), asthma-related school absenteeism (OR = 1.17, 95% CI = 1.04, 1.32), physician visits for asthma (OR = 1.16, 95% CI = 1.04, 1.29), and hospitalization for asthma (OR = 1.20, 95% CI = 1.001, 1.44) were significantly associated with the number of stressful events, independent of home exposure to cigarette smoke and dampness, use of inhaled substances, and sociodemographic factors. While these results are not sufficient to assign causality in the relationship between stress and asthma, they are supported by a number of other studies and by plausible biologic mechanisms. Assessing and addressing the effects of stressful life events may be helpful in managing asthma in inner city adolescents.

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Asthma morbidity and mortality rates are generally highest in low-income, minority urban populations (1). Asthma morbidity has been related to a number of exposures, including allergens and environmental tobacco smoke (2–4). Recent investigations have suggested that psychosocial factors relating to the child or the child's caretakers, such as mental health conditions, stressful life events, and living in a violent environment, can also affect asthma prevalence and morbidity (5–11).

Psychosocial stress has been linked to a number of factors that influence health outcomes in adolescents, including asthma. For example, within adolescent populations, stress has been associated with increased rates of smoking (12) and other substance abuse (13), reduced

adherence to medications (14), and more adverse psychological symptomatology (e.g., depression, anxiety) (5) which have, in turn, been linked to asthma morbidity. Others have demonstrated altered immune expression in adolescent asthmatics related to increased stress (15), which invokes the possibility of more direct pathways linking stress to asthma expression in this age group similar to what has been shown in younger children (16). Psychological stress increases with decreasing socioeconomic status (SES) and thus can be concurrently associated with increased exposures to other factors identified in lower SES populations (e.g., allergens, tobacco smoke, air pollutants) (17). Data on factors, especially stress-related factors, associated with asthma prevalence and morbidity in adolescents are

sparse, as many investigations have focused on either preadolescent children or adults. This study examines the relationship of stressful life events with asthma prevalence and morbidity in Chicago adolescents surveyed in the Chicago Asthma Prevalence study, a population-based survey of asthma prevalence and morbidity in adolescents for the International Study of Allergies and Asthma in Childhood (ISAAC) in 1994–95 (18).

Methods

Survey

Prior to initiation of this study protocol, it was reviewed and approved by the University of Illinois at Chicago Office for the Protection of Research Subjects. The study used a stratified cluster random sample design to survey Chicago Catholic and public school adolescents during the 1994–95 school year, with strata being public and Catholic schools and clusters being the 7th and 8th grades (generally age 12–14 yr) within those schools (18). The proportion of students from public/Catholic schools was roughly equal to the overall proportion in Chicago (72%/28%). Because only the Catholic schools would allow us to ask questions about risk factors and ethnicity, a random second sample of Catholic school children was also surveyed, and included students in the 9th grade from two schools. Data used in this report are from all Catholic schools surveyed, 21 schools from the basic sample and 13 schools from the over sample, for a total of 2273 of a possible 2487 (91%) surveys. A total of 2026 participants were included in the analysis after exclusion of surveys with missing data on crucial variables. Briefly, students self-administered the surveys anonymously in the classroom. The study staff checked each form and asked students whether they wanted to complete any unanswered questions. Staff members returned at a later date to administer the survey to absent students.

Outcomes – asthma and asthma severity

The questionnaire included core ISAAC questions, as well as more detailed questions about the student's symptoms and indices of severity (19). Asthma prevalence in the basic random sample, as well as symptom and severity frequency, has been previously reported (18). Adolescents with asthma were identified from the questions 'Have you ever had asthma?' and 'Has a doctor ever said you had asthma?' Questions

relating to asthma severity included: 'In the last 12 months, how many attacks or episodes of asthma did you have?' 'How many attacks of wheezing have you had in the last 12 months?' 'In the last 12 months, how often, on average, has your sleep been disturbed by wheezing?' 'In the last 12 months, has wheezing ever been severe enough to limit your speech to only one or two words at a time between breaths?' 'In the last 12 months, have you had a dry cough at night, apart from a cough associated with a cold or chest infection?' 'In the last 12 months, have you had a problem with sneezing or a runny, or blocked nose when you did not have a cold or the flu?' 'How many days of school have you missed because of your asthma or wheezing in the last 12 months?' 'How many times have you been to the doctor for asthma or wheezing during the past 12 months?' 'How many times have you gone to the emergency room (ER) for asthma or wheezing during the last 12 months?' 'How many times have you stayed in the hospital overnight for asthma or wheezing during the past 12 months?'

A summary measure of asthma symptoms was created. The sum of types of respiratory symptoms reported (asthma attacks, wheezing, sleep disturbed by wheezing, dry cough at night, speech limited by wheezing, and nasal symptoms without a cold) was indicated by an ordinal variable (0, 1–2, 3–4, or 5–6 symptoms).

Exposures – stressful life events

A 15-item stressful life events inventory (in the past 12 months) was administered to students. The life events survey consisted of both more traditional items included on established life event instruments (20) and additional events we thought would be more prevalent in inner city youths, such as gang violence and stabbings or shootings. These questions were added to the survey based on interactions with community members who identified life stressors in these categories as salient factors related to the well-being of Chicago youths. Indicators used in the analyses included a total stressful life events score obtained by summing all 15 items as well as subscale scores related to particular domains including family or relationship difficulties, school difficulties and experiencing violent events (Table 1).

Covariates – demographics and other exposures

Demographic information was collected, including gender, age, history of asthma in a parent or

Table 1. Stressful life events during the prior 12 months in 2026 Chicago adolescents

Self-reported events	Adolescents with asthma (n = 315)	Adolescents without asthma (n = 1711)	All adolescents (n = 2026)
Family/relationship events, mean (s.d.)	1.4 (1.3)*	1.1 (1.1)*	1.2 (1.2)
Job loss in your family, %	9.9	8.1	8.4
Divorce, separation or remarriage of parents, %	10.1†	6.5†	7.0
Birth of a brother or sister, %	11.7†	7.5†	8.2
Serious illness of a family member, %	35.1†	27.2†	28.4
Break up with a boy or girl friend, %	39.6	35.2	35.9
Death of a friend or family member, %	43.0†	32.6†	34.2
Any family event, %	72.4†	62.6†	64.1
School events, mean (s.d.)	0.6 (0.7)	0.5 (0.7)	0.5 (0.7)
Suspension or expulsion from school, %	6.7	7.0	6.9
Change of schools, %	22.7	19.5	20.0
Failing a class at school, %	33.5	28.8	29.5
Any school event, %	46.5	42.0	42.7
Violent events, mean (s.d.)	0.8 (1.2)*	0.5 (0.9)*	0.6 (0.9)
Sexual abuse, %	1.7	0.9	1.0
Stabbing or shooting, %	7.7†	2.1†	3.0
Stabbing or shooting of a family member, %	8.1†	3.9†	4.5
Problems related to gangs, %	16.6†	9.8†	10.8
Arrest or conflict with police, %	17.5†	10.1†	11.2
Physical fight, %	33.2†	26.5†	27.7
Any violent event, %	44.8†	33.9†	35.6
Total stressful events, mean (s.d.)	2.8 (2.4)*	2.2 (2.0)*	2.3 (2.1)
Any stressful event, %	81.3†	75.8†	76.7
Number of stressful events, %†			
0–1	32.4	46.2	44.0
2–3	36.2	32.0	32.7
>3	31.4	21.8	23.3

s.d., standard deviation.

Data were missing for: total family events (n = 16), job loss in your family (n = 93), divorce, separation, or remarriage of parents (n = 89), birth of a brother or sister (n = 95), serious illness of a family member (n = 88), break up with a boyfriend or girlfriend (n = 71), death of a friend or family member (n = 77), total school events (n = 40), suspension or expulsion from school (n = 92), change of schools (n = 77), failing a class at school (n = 135), total violent events (n = 41), sexual abuse (n = 89), stabbing or shooting (n = 92), stabbing or shooting of a family member (n = 93), problems related to gangs (n = 96), arrest or conflict with police (n = 89), and physical fight (n = 83).

*p < 0.05 for comparison of adolescents with and without asthma by Student's *t*-test.

†p < 0.05 for comparison of adolescents with and without asthma by chi-squared test.

sibling, number of siblings, and racial/ethnic background. Race/ethnicity was recoded as black, Mexican, Puerto Rican, mixed race, or other race, with white race as contrast category. The 'other' category included Native American, Asian, other Hispanic without Mexican or Puerto Rican ethnicity, and other not specified. The 'mixed' category included adolescents who indicated more than one racial/ethnic group in their response. As family income was not assessed in the survey, median family income in each school's census tract was estimated from the 1996 Claritas data set (University of Illinois at Chicago Center for Urban Education and Development).

Personal and home exposures during the prior year were also assessed. Personal exposures included: frequency of cigarette smoking; marijuana use; crack or cocaine use; sniffing or inhaling of glue, gasoline, paint, correction fluid; and alcohol use. Cigarette, crack or cocaine, or inhalant (glue, gasoline, paint, correction fluid) use was combined to create a variable for inhaled

substance use. Marijuana smoking was not included in this composite variable because of its acute bronchodilator effect (21). Home exposures included: pets; mold or dampness; cockroaches; rats/mice; insecticide use; and number of residents other than the child who smoke cigarettes.

Statistical analysis

For demographic and exposure variables, differences in medians or proportions between adolescents with and without asthma were evaluated using chi-squared or Student's *t*-tests, as appropriate. Associations of stressful life events with demographic and exposure variables were modeled using linear regression with a random intercept for school (PROC GENMOD, SAS version 9.1; SAS Institute Inc., Cary, NC, USA) (22); associations of stressful events with exposures were further adjusted for age, gender, ethnicity, and median family income in the school's census tract.

The risk of asthma or asthma morbidity with exposure to stressful events was analyzed using multivariable logistic models for binary outcomes (asthma prevalence, dry cough at night, sleep disturbed by wheezing, speech limited by wheezing, nasal symptoms without a cold, hospitalization) or proportional odds logistic models for ordinal outcomes (asthma attack, wheezing episodes, number of symptoms, missed school, physician visits, ER visits), with a random intercept to account for clustering of students within schools (SAS PROC GENMOD) (22). The number of stressful life events was used as a continuous variable to predict asthma outcomes, and, in addition, number of total life events was categorized (0–1, 2–3, >3) and dose–response models were estimated using two indicator variables or the ordinal variable to test for a trend over the categories. Covariates in models included age, gender, median family income in the school's census tract, and race/ethnicity. Home and personal exposure variables were considered potential confounding factors and were tested for associations with stressful events and asthma outcomes; dampness, number of smokers in the home and inhaled substance use were selected as covariates for the final models. In addition, synergistic effects of stress with other exposures on asthma and asthma morbidity were explored in models using multiplicative interaction terms for stressful events (<3 vs. ≥3 events) with dampness, smoking in the home and any inhaled substance use by the adolescent.

Results

Demographic characteristics, home exposures, and personal substance use for the study population are presented in Table 2. Adolescents with asthma were more likely to be Puerto Rican, not to be Mexican, to have a family history of asthma, to be exposed to dampness, and to be exposed to home tobacco smoke (Table 2). Home exposure to a dog (43%), cat (18%), cockroaches (16%), rats or mice (17%), and insecticides (42%), as well as use of alcohol (26%), cigarettes (19%), sniffing glue, gasoline, paint or correction fluid (16%), marijuana (10%), and crack or cocaine (2%) did not differ significantly in adolescents with and without asthma ($p > 0.05$, data not shown).

Stressful events

Overall, 77% of adolescents reported one or more stressful event during the past year

Table 2. Demographics, home exposures and personal exposures reported by 2026 Chicago adolescents

Characteristic	Adolescents with asthma (n = 315)	Adolescents without asthma (n = 1711)
Male gender, %	53.3	51.1
Age in years, mean (s.d.)	13.1 (0.8)	13.1 (0.8)
Race/ethnicity, %*		
White	36.5	38.5
African-American	20.3	16.4
Mexican	11.8†	18.2†
Puerto Rican	7.0†	3.7†
Other race	11.4	12.4
Mixed race	13.0	10.8
Family income in school census tract, mean (s.d.)	40,505 (15,803)	42,171 (19,060)
Family history of asthma, %	49.2*	20.1*
Exposures during the last 12 months:		
Dampness or mold in home, %	31.4*	23.6*
Number of smokers in home, mean (s.d.)	0.9 (0.9)‡	0.8 (0.9)‡
Inhaled substance use by child§, %		
None	70.5	69.1
Low	13.7	15.0
Moderate to high	15.9	16.0

Family history of asthma was missing for 166 participants. s.d., standard deviation.

* $p < 0.05$ for comparison of adolescents with and without asthma using the chi-squared test.

† $p < 0.05$ for *post hoc* comparison of individual race/ethnic group in adolescents with and without asthma using the chi-squared test.

‡ $p < 0.05$ for comparison of adolescents with and without asthma by Student's *t*-test.

§Used cigarettes, crack or cocaine, or inhalant (glue, gasoline, paint, correction fluid).

(Table 1). Family-related stressful events were reported by 64% of adolescents and were more prevalent than violent or school events, which were reported by 36% and 43% of adolescents, respectively. Adolescents with asthma were significantly more likely to report a wide variety of stressful events.

Stressful events were positively associated with age and number of siblings and were reported more frequently by adolescents with African-American, Mexican, or mixed ethnicity ($p < 0.05$, data not shown). Family events were more frequent in females, while more violent events were reported by males ($p < 0.0001$, data not shown). Total stressful events were higher in adolescents who had residential exposure to cockroaches, insecticides, dampness, and smoking, or who used cigarettes, marijuana, alcohol, and inhalants, after adjustment for age, gender, median family income in school's census tract, and ethnicity ($p < 0.05$, data not shown).

History of asthma and stressful events

Family history of asthma was the strongest predictor of asthma (OR = 3.8, 95% CI = 3.1, 4.7, data not shown). The relationship of stressful events with asthma was studied in 1860 students, after excluding 166 students without data on family history of asthma. Asthma was reported by 295 of the 1860 participants (15.9%). Asthma was significantly associated with number of total, family and violent events, but not with school events, and these associations were only slightly attenuated after adjustment for family history of asthma, dampness, home smoking, inhaled substance use, age, gender, ethnicity, and family income (Table 3). A dose-response relationship was found for odds of asthma with category of increasing total stressful events (Table 3). In models testing for synergistic effects of stress with home and personal exposures, dampness, home smoking and inhaled substance use did not modify the effect of stressful events on asthma (data not shown).

Asthma morbidity and stressful events

The relationship of stressful events with asthma morbidity was examined in the 315 adolescents with asthma. Asthma symptoms during the prior year were common in the adolescents with asthma, with almost 90% reporting at least one asthma symptom and at least 60% reporting asthma attacks, wheezing, dry cough at night, and nasal symptoms without a cold (Table 4). During the past year, 63% visited a physician,

Table 4. Respiratory symptoms, medical care for asthma, and missed school for asthma during the last 12 months in 315 Chicago adolescents with self-reported asthma

Asthma severity measure	n	%
Asthma attacks, %		
None	109	38.1
A few	112	39.2
Several/many/daily	65	22.7
Wheezing, %		
None	98	38.4
1-3	89	34.9
4-12	39	15.3
>12	29	11.4
Dry cough at night, %	180	62.9
Sleep disturbed by wheezing, %	97	38.4
Speech limited by wheezing, %	102	36.0
Nasal symptoms, %	196	69.0
Number of symptoms*, %		
0	33	10.5
1 or 2	103	32.7
3 or 4	110	34.9
5 or 6	69	21.9
Missed school days for asthma, %		
0	209	69.4
1-4	52	17.3
>4	40	23.3
Physician visit for asthma, %		
0	96	36.5
1-2	93	35.4
>2	74	28.1
ER visit for asthma, %		
0	225	78.7
1	29	10.1
>1	32	11.2
Hospitalization for asthma, %	43	15.0

Data were missing for: asthma attacks (n = 29), wheezing (n = 60), dry cough at night (n = 29), sleep disturbed by wheeze (n = 62), speech limited by wheeze (n = 32), nasal symptoms (n = 31), missed school (n = 14), physician visit (n = 52), ER visit (n = 29), and hospitalization (n = 29).

*Number of symptoms is the sum of types of respiratory symptoms reported (asthma attacks, wheezing, sleep disturbed by wheezing, dry cough at night, speech limited by wheezing, and nasal symptoms).

Table 3. Associations of asthma with total, family, school, and violent stressful life events in 1860 Chicago adolescents

Exposure	Odds of asthma (OR, 95% CI)*	
	Unadjusted	Adjusted†
Categorical variable		
0-1 total stressful events	1.00	1.00
2-3 total stressful events	1.65 (1.23, 2.20)	1.44 (1.07, 1.95)
>3 total stressful events	2.21 (1.61, 3.03)	1.92 (1.41, 2.62)
Continuous variable		
Number of total stressful events	1.16 (1.10, 1.23)	1.14 (1.07, 1.22)
Number of family events	1.28 (1.16, 1.42)	1.22 (1.11, 1.34)
Number of violent events	1.37 (1.21, 1.55)	1.37 (1.18, 1.60)
Number of school events	1.13 (0.99, 1.30)	1.10 (0.92, 1.31)

OR, odds ratio; CI, confidence interval.

*Odds of asthma from logistic regression models, with a random intercept for school. For models with continuous variable, odds ratios are the odds of asthma with increase in one stressful event.

†Adjusted for family history of asthma, age, gender, median family income in the school's census tract, race/ethnicity, dampness or mold in home, number of smokers in home, and inhaled drug use by adolescent.

21% visited an ER, 15% were hospitalized, and 31% missed school for asthma (Table 4).

All asthma morbidity measures were significantly associated with the number of total stressful life events, adjusting for age, gender, income, and race (data not shown). Control for dampness, number of smokers in the home, and inhaled substance use only slightly attenuated the associations of asthma morbidity with stressful events, and all morbidity measures, with the exception of asthma attacks and ER visits, remained significantly associated with total number of stressful events after adjustment (Table 5). Significant dose-response relationships were found for odds of dry cough at night, nasal symptoms, number of symptoms, and physician visit for asthma with category of increasing total stressful life events (Table 6). In children who

Table 5. Associations of asthma severity with number of stressful life events in Chicago adolescents with self-reported asthma

	Odds of morbidity (OR, 95% CI) with increase in one stressful event*
Asthma attack	1.11 (0.99–1.24)
Wheezing	1.14 (1.04–1.25)
Dry cough at night	1.19 (1.03–1.39)
Sleep disturbed by wheezing	1.15 (1.01–1.32)
Speech limited by wheezing	1.13 (1.02–1.25)
Nasal symptoms	1.27 (1.10–1.47)
Number of asthma symptoms	1.16 (1.07–1.27)
Missed school for asthma	1.17 (1.04–1.32)
Physician visit for asthma	1.16 (1.04–1.29)
ER visit for asthma	1.16 (0.99–1.35)
Hospitalization for asthma	1.20 (1.001–1.44)

OR, odds ratio; CI, confidence interval.

*Odds of morbidity with increase in one stressful event from multivariable logistic models for binary outcomes (dry cough at night, sleep disturbed by wheezing, speech limited by wheezing, nasal symptoms without a cold, hospitalization) or proportional odds logistic models for ordinal outcomes (asthma attack, wheezing episodes, number of symptoms, missed school, physician visits, ER visits), adjusted for age, gender, median family income in the school's census tract, race/ethnicity, dampness or mold in home, number of smokers in home, inhaled drug use by adolescent, and clustering within schools.

used inhaled substances, the associations of total stressful events with nasal symptoms and physician visits for asthma were significantly stronger than the associations in children without substance use ($p < 0.05$ for interaction term in model, data not shown).

Relationships between asthma morbidity and family, violent and school-related stressful events were further explored, controlling for age, gender, income, and race as well as home and personal exposures. Significant associations with asthma morbidity were most often found for family events (data not shown). All three types of events were significantly associated with wheezing, nasal symptoms, number of symptoms and physician visit for asthma; family events were also associated with hospitalization, missed school, and most other symptoms, while school events were also associated with missed school for asthma (data not shown).

Discussion

In inner city adolescents, stressful life events were associated with asthma. Furthermore, in the students with asthma, stressful life events were associated with a number of measures of asthma morbidity. In general, the effects of stressful events on asthma morbidity remained significant after control for home dampness, smoking in the home, and inhaled substance use by the adolescent – factors which have been related to asthma

Table 6. Associations of asthma severity with stressful life event categories in Chicago adolescents with self-reported asthma

Asthma severity measure	Number of stressful events	Odds of morbidity* (OR, 95% CI)	p-Value for trend
Asthma attack	0 or 1	1.00	0.31
	2 or 3	1.41 (0.75, 2.62)	
	>3	1.42 (0.71, 2.85)	
Wheezing	0 or 1	1.00	0.07
	2 or 3	1.16 (0.69, 1.94)	
	>3	1.61 (0.95, 2.71)	
Dry cough at night	0 or 1	1.00	0.01
	2 or 3	1.53 (0.82, 2.85)	
	>3	2.63 (1.24, 5.57)	
Sleep disturbed by wheezing	0 or 1	1.00	0.051
	2 or 3	1.85 (0.98, 3.47)	
	>3	2.19 (0.98, 4.87)	
Speech limited by wheezing	0 or 1	1.00	0.40
	2 or 3	1.45 (0.91, 2.33)	
	>3	1.32 (0.67, 2.61)	
Nasal symptoms	0 or 1	1.00	<0.001
	2 or 3	1.45 (0.89, 2.38)	
	>3	3.73 (1.60, 8.73)	
Number of symptoms	0 or 1	1.00	0.02
	2 or 3	1.69 (1.14, 2.49)	
	>3	1.90 (1.11, 3.28)	
Missed school for asthma	0 or 1	1.00	0.07
	2 or 3	1.66 (0.89, 3.09)	
	>3	2.06 (0.95, 4.46)	
Physician visit for asthma	0 or 1	1.00	0.02
	2 or 3	1.53 (0.88, 2.65)	
	>3	1.98 (1.10, 3.55)	
ER visit for asthma	0 or 1	1.00	0.23
	2 or 3	1.72 (0.79, 3.74)	
	>3	1.85 (0.69, 4.99)	
Hospitalization for asthma	0 or 1	1.00	0.10
	2 or 3	1.19 (0.65, 2.21)	
	>3	2.36 (0.86, 6.49)	

OR, odds ratio; CI, confidence interval.

*Odds of asthma morbidity from multivariable logistic models for binary outcomes (dry cough at night, sleep disturbed by wheezing, speech limited by wheezing, nasal symptoms, hospitalization) or proportional odds logistic models for ordinal outcomes (asthma attack, wheezing episodes, number of symptoms, missed school, physician visits, ER visits), adjusted for age, gender, median family income in the school's census tract, race/ethnicity, dampness or mold in home, number of smokers in home, inhaled drug use by adolescent and clustering within schools.

morbidity in other studies (2, 4, 21). We found that inhaled substance use modified the effect of associations of stressful events on nasal symptoms and physician visits for asthma, with stronger effects in adolescents with inhaled substance use.

Our finding of an association between asthma and stressful events is consistent with results from other investigations. A cross-sectional study of 15-yr-old Norwegian adolescents found asthma to be associated with exposure to violence and stressful events (5). A temporal relationship of personal or parental conflict with asthma diagnosis was found in a retrospective

study of Finnish university students (6). Stress in the caretakers of infants has been associated with the development of wheeze and an atopic immune profile during their first 14 months of life (7, 16), and with continuing atopic illness from 18 months to 3 yr (23).

Asthma morbidity has also been associated with stressors in the lives of children and/or their caregivers in other studies. In a longitudinal study of 1260 children with asthma aged 4–9 yr, Weil et al. (9) found associations of wheeze with mental health of the child, and of hospitalization for asthma with mental health of the child and parent, and with baseline stressful events. In a Chicago inner city and suburban population, the caregiver's life stressors and depression predicted asthma morbidity in children under 12, when adjusted for socioeconomic measures (10). A temporal relationship between stress and subsequent asthma morbidity was demonstrated in children aged 6–13 during an 18-month longitudinal study of daily symptom and peak flow measurements and repeated assessment of life events (11). An immediate effect of stress was noted in the first 2 days after an event (relative risk for asthma attack = 4.69). Thereafter, the risk decreased, but increased again 5–7 wk after the event (relative risk of asthma attack = 1.81), suggesting that two underlying mechanisms were responsible for the effects of stress.

Violent events were associated with some asthma symptoms and physician visits for asthma in the current study. Few studies have focused specifically on the effects of violence on asthma morbidity. Exposure to violence has been related to higher number of days with asthma symptoms and night caretakers lost sleep due to the child's asthma, although the effect was somewhat attenuated after controlling for other measures of stress (8).

Psychoneuroimmunology provides a plausible biologic pathway through which stress may affect asthma morbidity, primarily through dysregulation of the hypothalamic-pituitary-adrenal axis (24). Psychological stress causes the release of neuroendocrine hormones, which may influence the immune system, inducing a shift to a type 2 cytokine response associated with an allergic phenotype. Adolescents with asthma who experienced more stress have been shown to have higher levels of IL-5 and interferon- γ , cytokines associated with type 2 and type 1 immune responses, respectively (15). In a study of the effects of stress on the response of children with asthma and dust mite allergy to sublingual immunotherapy, children with higher psychological stress had decreased clinical responses to

therapy and increased neuroendocrine hormones compared with children with lower stress (25).

In addition, the effects of psychological stress on asthma morbidity could be mediated through behavioral pathways that result in increased exposure to asthma triggers. Adoption of coping behaviors, such as cigarette smoking, may result from exposure to stress (12). Parents living in communities with high levels of violence may keep their children indoors, leading to increased exposure to indoor allergens. Stress can reduce resistance to respiratory infections (26), which are related to asthma morbidity (27). Life stress has been associated with symptoms of depression in adolescents (5), which could lead to noncompliance with asthma therapy (28). Asthma morbidity could also lead to increased stress. In young adults, diagnosed asthma has been related to an increased number of subsequent stressful life events (6). Dysfunctional family interactions may be the result of the development of asthma and wheeze in young children, particularly in the presence of stressful life events (29). Thus, life stress could both contribute to asthma morbidity and be a consequence of asthma morbidity. Due to the cross-sectional nature of this study, we are unable to establish the temporality of the relationship of stress to asthma morbidity.

The use of a self-administered anonymous survey in adolescents has both strengths and weaknesses. The anonymity of the survey method produced a substantial amount of missing data because we were unable to recontact children with deficient questionnaires. An anonymous questionnaire, however, may be a preferable method for collecting data on stressful life events, cigarette smoking, and drug use, as adolescents may be more likely to report such information when the possibility of disclosure to parents and teachers is reduced. Self-report rather than parental report may also be important in assessing stressful life events and asthma morbidity, with poor agreement between adolescents and their caretakers previously noted for reported exposure to negative events (30) and asthma symptoms (31). The lack of objective measures of asthma symptoms or medical care could potentially bias the results, with children experiencing more disruption in their lives, potentially reporting more symptoms, although medical care and missed school for asthma may be less affected by this reporting bias. Home environmental exposures by self-report are likely to be less accurate than measurement by an objective observer or quantification of allergen levels (32). Median family income in the school's census tract, which we used as a surrogate for household income,

may be a poor indicator of SES as many children attending a private school may live outside of the school's census tract. The lack of a variable measuring individual family income reduced our ability to adjust for variation in SES, which is associated with both psychological stress and exposure to asthma triggers, such as allergens and tobacco smoke (17). Our instrument for stressful events contained both frequently used life events and events likely to be important for inner city adolescents. Other investigations on the effects of stress on asthma morbidity have used a variety of instruments. While some of the other investigations on the effects of stress on asthma morbidity have suggested that mental health in children and their caregivers accounted in part for the effect of stress on asthma morbidity (8–10), we cannot determine whether this is a significant pathway in our population as we did not measure mental health status. The study results may be generalizable only to urban Catholic school children rather than the entire community. As income levels are likely to be higher in the families of Catholic compared with public school children, and low-income children may be exposed to greater life stressors (17), our results may underestimate the effects of stress on asthma in inner city adolescents.

The major strengths of this study are the use of a large survey in a random sample of Chicago Catholic schools, the high response rate, the robustness of the effect of stressful events on a variety of asthma morbidity measures, the increasing effect of stress on asthma and morbidity indicators at higher exposure doses, and the independence of the effects from race, as well as measured home and personal exposures. Our use of a statistical model that adjusted for clustering of students within schools may partially adjust for systematic interschool symptom variability, which in turn could be related to differences among schools in allergen exposure, respiratory virus infections, or other factors potentially related to asthma morbidity. The results are supported by a number of other studies in the literature and by plausible biologic mechanisms for the effects of stress on asthma.

In summary, asthma was associated with the number of stressful events experienced by inner city adolescents. In adolescents with asthma, respiratory symptoms as well as asthma-related school absenteeism, hospitalizations, and physician visits were associated with the total number of stressful events. These associations were independent of exposure to smoking in the home, home dampness or mold, personal use of inhaled substances and sociodemographic factors. Fur-

ther research is needed on the biologic and behavioral pathways through which stressful events affect asthma morbidity in adolescents and to investigate the potential role of interventions addressing community violence and individual stressors to reduce asthma incidence and morbidity, particularly in inner city populations. Assessing and addressing the effects of stressful life events and exposure to violence may be helpful in managing asthma in inner city children.

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