The Role of the Social Environment in Children and Adolescents with Asthma

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***Rationale*: Biopsychosocial models of asthma have been proposed in the literature, but few empirical tests of social factors at various levels of influence have been conducted.**

***Objectives*: To test associations of neighborhood, peer, and family factors with asthma outcomes in youth, and to determine the pathways through which these social factors operate.**

***Methods*: Observational study of youths with asthma (n = 78).**

***Measurements and Main Results*: Youths completed questionnaires about neighborhood problems, peer support, and family support. Biological (IgE, eosinophil count, production of IL-4) and behavioral (youth smoking, exposure to smoke, adherence to medications) pathways were measured. Asthma symptoms and pulmonary function were assessed in the laboratory and at home for 2 weeks. Lower levels of family support were associated with greater symptoms (β coefficients: −0.26 to −0.33, $P < 0.05$) and poorer pulmonary function (β: 0.30, $P < 0.05$) via biological pathways (Z statistics from 1.19 to 1.51, $P < 0.05$). Higher levels of neighborhood problems were associated with greater symptoms (β coefficients: 0.27–0.33, $P < 0.05$) via behavioral pathways related to smoking (Z statistics = 1.40, $P < 0.05$). Peer support was not associated with symptoms or pulmonary function.**

***Conclusions*: This study indicates that family factors may affect youths' asthma via physiologic changes, whereas community factors may help shape the health behaviors of youths with asthma.**

Keywords: support; behaviors; inflammatory markers; children; adolescents

The social environment has long been viewed as an important determinant of asthma outcomes in youth. Consistent with biopsychosocial approaches to conceptualizing the onset and course of asthma (1, 2), research indicates that factors such as exposure to violence (3), abrasive family relationships (4, 5), and psychological stress (6–8) all relate to adverse outcomes in youths with asthma.

However, most previous studies have focused on social factors at a single level (e.g., the family). At the broadest level of social influence, the neighborhood, factors such as greater violence in the neighborhood and lower socioeconomic status of neighborhoods have been associated with greater asthma morbidity and heightened allergic inflammatory responses (9–11). At a more circumscribed level of social influence, one's peers, high stress in combination with low levels of social support increases risk for asthma exacerbations (12). At the most proximal level of social influence, the family, parenting difficulties and parental stress have been associated with markers of inflammation and high risk for onset of childhood asthma (5, 6, 13).

By contrast, fewer studies have provided a more complete picture of the relative contributions of neighborhood, peer, and family factors, or asked whether they influence asthma through similar versus different mechanisms. Understanding these contributions has important implications for interventions. For example, associations between neighborhood factors and asthma may suggest the need for interventions aimed at making community-wide changes. In contrast, associations between family factors and asthma would suggest specific interventions targeted at the dynamics among family members. In addition, there is a need for research that situates individuals within the larger social context in which they live. The present study addresses this gap by investigating social connections at the family and peer level. The goals of the present study were as follows: (*1*) to examine how social factors at the neighborhood, peer, and family levels relate to morbidity in a sample of youths with asthma; and (*2*) to identify mechanisms linking social factors and disease outcomes by exploring both biological and behavioral pathways. We hypothesized that greater neighborhood problems, a lack of peer support, and a lack of family support would all relate to greater asthma morbidity, and that immune and behavioral variables would comprise pathways linking social factors to asthma (social factors → behavioral/biological → asthma clinical outcomes).

AT A GLANCE COMMENTARY

Scientific Knowledge on the Subject

Biopsychosocial models of asthma have been proposed in the literature, but few empirical tests of social factors at various levels of influence have been conducted.

What This Study Adds to the Field

This study indicates that family factors may affect youths' asthma via physiologic changes, whereas community factors may help shape the health behaviors of youths with asthma.

METHODS

Patients

Seventy-eight youths who were physician-diagnosed with asthma (70% allergic asthma) were recruited from Vancouver, BC, Canada, from asthma clinics, newspaper advertisements, and school and community center postings. The youths ranged in age from 9 to 18 years, were fluent in English, free of acute respiratory illness at the time of their visit (by parent and youth report), had not had a prednisone course for at least 2 weeks, and had no chronic illnesses other than asthma. The protocol was approved by the University of British Columbia Research Ethics Board.

(*Received in original form November 13, 2006; accepted in final form June 7, 2007*)

Supported by National Institutes of Health grant HL073975 and the Canadian Institutes of Health Research.

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This article has an online supplement, which is accessible from this issue's table of contents at www.atsjournals.org

Am J Respir Crit Care Med Vol 176. pp 644–649, 2007
Originally Published in Press as DOI: 10.1164/rccm.200610-1473OC on June 7, 2007
Internet address: www.atsjournals.org

Measures

Please refer to the online supplement for additional information.

Social environment measures. LACK OF FAMILY SUPPORT. The Social Support Scale for Children assesses the degree to which youths lack a parent who understands, values, or cares about them (14).

LACK OF PEER SUPPORT. The Social Support Scale for Children also assesses the degree to which youths do not have at least one close friend who they can talk to and who understands them (14).

NEIGHBORHOOD PROBLEMS. The Chicago Youth Development Study (CYDS) Community and Neighborhood measure assesses the degree to which youths perceive problems in their neighborhood, such as crime, gangs, drugs, and graffiti (15).

Behavioral measures. SMOKING. Youths were asked the number of days over the past 6 months that they had smoked cigarettes. Youths were also asked the number of days over the past 6 months that they had been exposed to smoke. These variables were log-transformed in analyses because of their nonnormal distribution.

ADHERENCE TO MEDICATIONS. Families brought their youths' medications to the research center, and each drug's name and dose was recorded from the label. Adherence was determined with respect to daily prescribed medications, and defined as the number of days youths had taken an inhaled corticosteroid during the past 14 days.

Biological measures. A complete blood count with five-part differential (Bayer Advia 70 hematology system; Diamond Diagnostics, Holiston, MA) was performed to obtain eosinophil counts. Total serum IgE was measured using an automated fluorescence immunoassay (Pharmacia CAP system; Phadia, Inc. Portage, MI), and was log-transformed because of its nonnormal distribution. Production of the Th2 cytokine IL-4 by peripheral blood mononuclear cells stimulated for 48 hours with phorbol myristate acetate (25 ng/ml) and ionomycin (1 μg/ml) was measured as described previously and as described in the online supplement (7).

Clinical measures. PULMONARY FUNCTION. Pulmonary function was evaluated through spirometry according to American Thoracic Society guidelines (16). FEV_1 was derived and calculated as a percentage of predicted values, based on age, sex, ethnicity, and height (17). Measures were taken at least 4 hours after the last use of a short-acting bronchodilator, and at least 24 hours after the use of a long-acting bronchodilator, following the protocol of a multisite clinical asthma trial (18). Youths also monitored PEF at home using an electronic monitor (Quadromed, Hoechberg, Germany). Three peak flow readings were taken upon awakening each day for 2 weeks. Morning PEF% was calculated as a percentage of each youth's laboratory best result, and averaged across the 2 weeks. Youths who did not complete at least 10 to 14 days of measurements were excluded from peak flow analyses.

ASTHMA SYMPTOMS. In the lab, youths were interviewed about symptoms during the previous 2 weeks. The frequency of daytime, nighttime, and exertional symptoms were probed as per the National Asthma Education and Prevention Program, Expert Panel Report 2, (NAEPP/EPR2) guidelines (19). After the lab visit, youths kept a diary of the intensity of their symptoms every day for 2 weeks. Diary symptoms were averaged across the 2-week home monitoring period.

Potential confounds. Variables that could provide alternative explanations for the above relationships were included as covariates in statistical analyses. This included demographic characteristics (age, sex, ethnicity), and asthma severity, determined from the NAEPP/EPR2 guidelines based on the higher of symptom frequency and medication use, paralleling the approach of previous researchers (20).

Analytic Approach

Three sets of statistical analyses were conducted. In the first set, we tested associations of social factors with both asthma clinical outcomes and with proposed pathways (behavioral and biological variables). To do this, we conducted multiple regression analyses in which the outcome variable (asthma symptoms, pulmonary function) was regressed onto covariates (age, sex, ethnicity, asthma severity) in step 1 and then onto the predictor variable (social factor) in step 2. The same procedure was then followed using behavioral and biological mechanisms as the outcome variable. Standardized regression coefficients (β) are presented, as well as percentage of variance in the outcome variable that can be accounted for by the predictor variable (ΔR^2, an indicator of effect size). β coefficients indicate the number of standard deviations the dependent variable changes for each standard deviation increase in the independent variable. For example, a 0.5 coefficient between neighborhood problems and symptoms would indicate that one standard deviation increase in neighborhood problems is associated with half a standard deviation increase in symptoms. Conversely, a −0.5 coefficient between neighborhood problems and pulmonary function would indicate that a one standard deviation increase in neighborhood problems is associated with half a standard deviation decrease in pulmonary function.

The second set of analyses consisted of statistical mediational tests. We note that this study is cross-sectional and observational, and hence we cannot draw causal inferences about whether social factors influence behaviors/biology and in turn clinical outcomes. Nonetheless, statistical mediation tests provide a method whereby one can test whether data are consistent with our proposed model of social factors → behavioral/biological → clinical outcomes. To do this, we applied the Sobel test with the distributional properties recommended by MacKinnon and colleagues (21). This statistic tests the significance of an indirect pathway using a products of coefficient test that gives a *Z* statistic. *Z* scores greater than 0.97 indicate a statistically significant pathway. Although we propose an indirect pathway through behaviors/biology, it could be the case that social factors are associated with clinical outcomes for reasons that have nothing to do with behaviors or biology (e.g., environmental exposures, health care characteristics). If this were the case, we would observe nonsignificant *Z* statistics. Hence, what the Sobel test does is to evaluate whether each specific indirect pathway we have proposed (e.g., family support → inflammatory processes → clinical outcomes) is statistically significant. Another way that one can think of these analyses is as testing whether the overlap between social factors and clinical outcomes is also shared with behaviors or biology.

The Sobel test assesses the significance of the indirect pathway, αβ, by dividing the indirect pathway effect by its standard error [αβ/square root of $(\alpha^2 \times \sigma_\beta{}^2 + \beta^2 \times \sigma_\alpha{}^2)$], where α represents the relation between the independent variable (e.g., family support) and the proposed mediator (e.g., inflammatory processes), β represents the relation between the mediator and the dependent variable (e.g., clinical outcomes) adjusted for the independent variable, and σ represents standard error. MacKinnon and colleagues have argued that the traditional Sobel test has low power because the αβ product is often not normally distributed, and based on extensive simulation studies, they recommend a critical value of 0.97 for the 0.05 significance level.

For statistical mediation analyses, we created composite scores of behavioral, biological, and clinical variables to reduce the number of statistical analyses and minimize the probability of type I error. This was done after conducting factor analyses to ensure that this approach was empirically justified. For behaviors, we created a composite smoking variable by standardizing and summing responses to youth smoking and exposure to smoke. For biological variables, we standardized each variable (because of the vastly different ranges) and then summed values (IgE, eosinophil count, IL-4). For clinical variables, we created a composite symptom score by averaging responses to each of the three symptom questions asked during the lab visit as well as symptoms reported on daily diary cards at home. We also created a composite pulmonary function variable by averaging values for FEV_1% and home PEF%. However, because some youths were missing peak flow data ($n = 26$), we also tested mediation using just the FEV_1% variable (hence with the full sample). Similar patterns emerged with both approaches, and are reported for the full sample below.

The third set of analyses tested whether family, peer, or neighborhood factors were more strongly related to asthma outcomes by conducting simultaneous regression analyses in which covariates of age, sex, ethnicity, and asthma severity were entered in the first step, and then the three social factors (neighborhood, peer, family) were entered simultaneously in the second step to determine which social factor had the strongest independent relationship with asthma clinical outcomes.

RESULTS

Social Environment and Clinical Outcomes

Descriptive information about the sample is presented in Table 1. *See* Figure 1 for a depiction of some of the findings below.

TABLE 1. DESCRIPTIVE INFORMATION OF SAMPLE

	%	Mean	SD
Age, yr		12.77	2.76
Sex, % male	68		
Ethnicity			
White	64		
Asian	26		
Other	10		
Severity			
Mild intermittent	16		
Mild persistent	39		
Moderate	31		
Severe	14		
Medications*			
Inhaled corticosteroids	74		
Leukotriene receptor antagonist	8		
Long-acting β-agonist	34		
Short-acting β-agonist	84		
Adherence†		6.89	6.19
No. days smoking‡§		0.08	0.04
No. days exposed to smoke‡§		0.65	0.08
IgE, kU/L§		2.16	0.10
Eosinophil count, $\times 10^9$cells/L		0.37	0.28
IL-4 production, pg/ml		19.74	27.40
FEV_1%		98.05	14.59
PEF%‖		96.43	14.22
Daytime symptoms (past 2 wk)¶		2.76	3.70
Nighttime symptoms (past 2 wk)¶		0.81	2.16
Exertional symptoms (past 2 wk)¶		2.75	3.94
Diary symptoms (2 wk monitoring period)**		3.45	3.83

* Medications = percentage of youth on each type of medication.

† Adherence = average number of days youth took inhaled corticosteroids during the past 2 weeks.

‡ No. days smoking/exposed to smoke = number of days youth reported smoking/being exposed to smoke in the past 6 months.

§ Log-transformed values. Mean untransformed values are as follows: 6.46 days smoking, 22.23 days exposed to smoke, and 526.06 kU/l IgE.

‖ PEF% = average morning peak flow across 2 weeks of home monitoring, expressed as a percentage of laboratory best results.

¶ Daytime, nighttime, and exertional symptoms = average number of days symptoms were reported in past 2 weeks.

** Diary symptoms = average daily symptom score from the 2-week home monitoring.

Family level. After controlling for age, sex, ethnicity, and severity, multiple regression analyses revealed that lower levels of family support were associated with marginally lower laboratory FEV_1% ($\beta = 0.20$, $\Delta R^2 = 3.9\%$, $P = 0.098$), and significantly lower at-home morning PEF % ($\beta = 0.30$, $\Delta R^2 = 8.0\%$, $P = 0.046$). In addition, lower levels of family support were associated with marginally greater daytime symptoms during the past 2 weeks ($\beta = -0.19$, $\Delta R^2 = 3.5\%$, $P = 0.09$), greater nighttime symptoms during the past 2 weeks ($\beta = -0.26$, $\Delta R^2 = 6.7\%$, $P = 0.027$), and greater exertional symptoms during the past 2 weeks ($\beta = -0.33$, $\Delta R^2 = 10.2\%$, $P = 0.005$).

Peer level. In contrast, friend support was not associated with any pulmonary function or symptom variables (all $P > 0.2$).

Neighborhood level. After controlling for age, sex, ethnicity, and severity, greater neighborhood problems were associated with greater daytime symptoms during the past 2 weeks ($\beta = 0.33$, $\Delta R^2 = 9.8\%$, $P = 0.004$), as well as with greater symptoms reported during the 2-week home monitoring period ($\beta = 0.27$, $\Delta R^2 = 6.2\%$, $P = 0.029$). Neighborhood problems were not associated with pulmonary function variables.

Social Environment and Behavioral/Biological Pathways

Table 2 contains standardized coefficients for analyses reported below.

Family level. After controlling for age, sex, ethnicity, and severity, multiple regression analyses revealed that lower levels of family support were associated with biological measures in a direction detrimental to asthma, including higher levels of total IgE ($\beta = -0.27$, $\Delta R^2 = 6.8\%$, $P = 0.043$), higher eosinophil counts ($\beta = -0.31$, $\Delta R^2 = 9.1\%$, $P = 0.009$), and greater production of IL-4 ($\beta = -0.44$, $\Delta R^2 = 18.6\%$, $P = 0.0004$). In contrast, family support was not associated with any behavioral measures, including youth smoking, exposure to smoke, or adherence to medications.

Peer level. Friend support was not associated with any biological variables or with youth smoking or exposure to smoke (all $P > 0.15$). There was an unexpected negative association of high friend support with low adherence to medications ($\beta = -0.40$, $\Delta R^2 = 12.8\%$, $P = 0.012$).

Neighborhood level. After controlling for age, sex, ethnicity, and severity, greater neighborhood problems were associated with detrimental behaviors, including greater amounts of youth smoking ($\beta = 0.44$, $\Delta R^2 = 17.0\%$, $P = 0.0001$), greater exposure to secondhand smoke ($\beta = 0.42$, $\Delta R^2 = 14.9\%$, $P = 0.001$), and less adherence to asthma medications ($\beta = -0.36$, $\Delta R^2 = 8.7\%$, $P = 0.039$). In contrast, neighborhood problems were not associated with biological variables.

Statistical Mediation Analyses

We next conducted statistical mediation tests, with $Z > 0.97$ indicating a statistically significant pathway. For family support, we tested biological and behavioral pathways to both symptoms and pulmonary function. We found that biological processes constituted a significant pathway linking family support to asthma symptoms ($Z = 1.51$), consistent with the idea that a lack of family support may result in increased allergic inflammation, which could then lead to an exacerbation of symptoms (*see* Figure 2). In contrast, the behavioral pathways of smoking ($Z = 0.33$) and adherence to medications ($Z = 0.58$) did not form significant pathways linking family support and asthma symptoms.

Second, we tested pathways between lack of family support and reduced pulmonary function. Biological processes also formed a significant pathway linking these variables ($Z = 1.19$), whereas the behaviors of smoking ($Z = 0.33$) and adherence to medications ($Z = 0.62$) did not. These data suggest that a lack of family support may increase inflammatory processes, and in turn reduce pulmonary function.

We then tested pathways between neighborhood problems and asthma symptoms. The behavioral measure of smoking formed a significant pathway linking neighborhood problems with asthma symptoms ($Z = 1.40$), whereas the behavioral measure of adherence to medications ($Z = 0.17$) did not. In addition, biological processes did not form a significant pathway linking neighborhood problems with asthma symptoms ($Z = 0.51$). Given that neighborhood problems were not associated with pulmonary function, we did not test pathways between these two variables. We also did not test pathways related to peer support, given that peer support was not associated with pulmonary function or asthma symptoms. *See* Figure 2 for a summary of pathways.

Simultaneous Analyses

Last, we tested whether family, peer, or neighborhood factors were more strongly related to asthma outcomes by conducting simultaneous regression analyses. With respect to pulmonary function, a lack of family support ($\beta = 0.29$, $\Delta R^2 = 6.0\%$, $P = 0.036$) but not peer support ($\beta = 0.04$, $\Delta R^2 = 0.1\%$, $P = 0.75$) or neighborhood problems ($\beta = -0.14$, $\Delta R^2 = 1.6\%$, $P = 0.27$) was associated with reduced pulmonary function. This suggests that, when compared against one other, family factors emerge

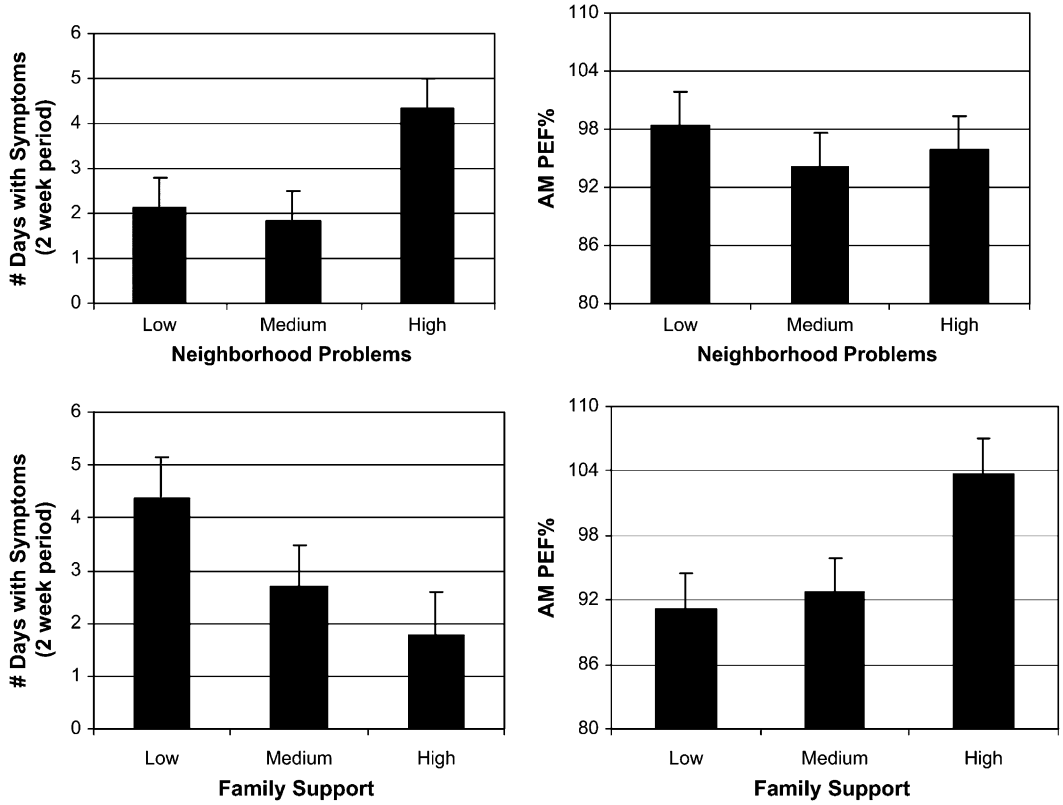

Figure 1. Association between social environment factors and clinical outcomes. For graphing purposes, each social factor was divided into tertiles. The *top panels* depict the association between neighborhood problems and symptoms (number of days of daytime symptoms in previous 2 wk) as well as pulmonary function (average morning PEF percentage over the 2-wk home monitoring period). The *bottom panels* depict the association between family support and symptoms (number of days of exertional symptoms in previous 2 wk) as well as pulmonary function (average morning PEF percentage over the 2-wk home monitoring period). Note that the relationship between neighborhood problems and peak flow is not significant.

as having a stronger relationship with pulmonary function than neighborhood or peer factors.

With respect to asthma symptoms, neighborhood problems were associated with greater symptoms ($\beta = 0.26$, $\Delta R^2 = 6.0\%$, $P = 0.023$), whereas there was only a marginal association for lack of family support ($\beta = -0.23$, $\Delta R^2 = 3.8\%$, $P = 0.067$). Peer support was not associated with symptoms ($\beta = 0.08$, $\Delta R^2 = 0.4\%$, $P = 0.55$). This suggests that, when the three are compared against one other, neighborhood factors have the strongest relationship with asthma symptoms, with family factors also contributing, but more modestly, to symptoms.

DISCUSSION

The present study tested the association of the social environment at multiple levels (neighborhood, peer, family) with asthma outcomes in youth. Although the study was cross-sectional and hence definitive conclusions cannot be drawn about directionality, evidence was consistent with the hypothesis that a lack of family support was related to increased asthma symptoms and poorer pulmonary function via allergic inflammation. In addition, evidence was consistent with the hypothesis that greater neighborhood problems were related to greater asthma symptoms via smoking behaviors. Peer support was unrelated to asthma outcomes. These findings suggest the possibility that, among youths with asthma, the family and the neighborhood play a more important role than peer support.

TABLE 2. REGRESSION COEFFICIENTS FOR ASSOCIATIONS OF NEIGHBORHOOD AND FAMILY FACTORS WITH BEHAVIORAL AND BIOLOGICAL PATHWAYS IN YOUTH WITH ASTHMA

	Neighborhood Problems		Family Support	
	β	*P*	β	*P*
Biological				
IgE	0.00	0.97	−0.27	0.043
Eosinophil count	−0.12	0.32	−0.31	0.009
IL-4	−0.02	0.86	−0.44	0.0004
Behavioral				
Youth smoking	0.44	0.0001	0.03	0.77
Exposure to smoke	0.42	0.001	0.08	0.53
Medication adherence	−0.36	0.039	−0.23	0.14

All analyses were controlled for youth, age, sex, ethnicity, and asthma severity. β = standardized regression coefficient. Coefficients indicate the number of standard deviations the dependent variable changes for each standard deviation increase in the independent variable.

With respect to the family, our findings are consistent with previous observational studies documenting that dysfunctional family interactions predicted children with persistent atopic symptoms at age 3 (22). The experience of low levels of support from family may activate hormonal and inflammatory processes that contribute to asthma (23, 24). Our findings suggest the intriguing possibility that family factors may affect youths' asthma through direct biological mechanisms, such as allergic inflammation, rather than through medication adherence and other health behaviors, such as smoking.

Neighborhood factors were related to asthma outcomes through behavioral rather than biological pathways. This may be because neighborhoods set up norms for what types of behaviors are acceptable and because people have a tendency to copy the behaviors of those around them (25). For example, neighborhoods with higher rates of smoking would both expose youths to greater amounts of smoke and create social norms about the acceptability of smoking. Other researchers have suggested that community-level interventions could help change behavior at the individual level by providing informational networks that supplement gaps in individual patient knowledge (26). Such interventions, including providing community-wide asthma education and sponsoring health fairs, represent a recent trend with some promising initial results (27).

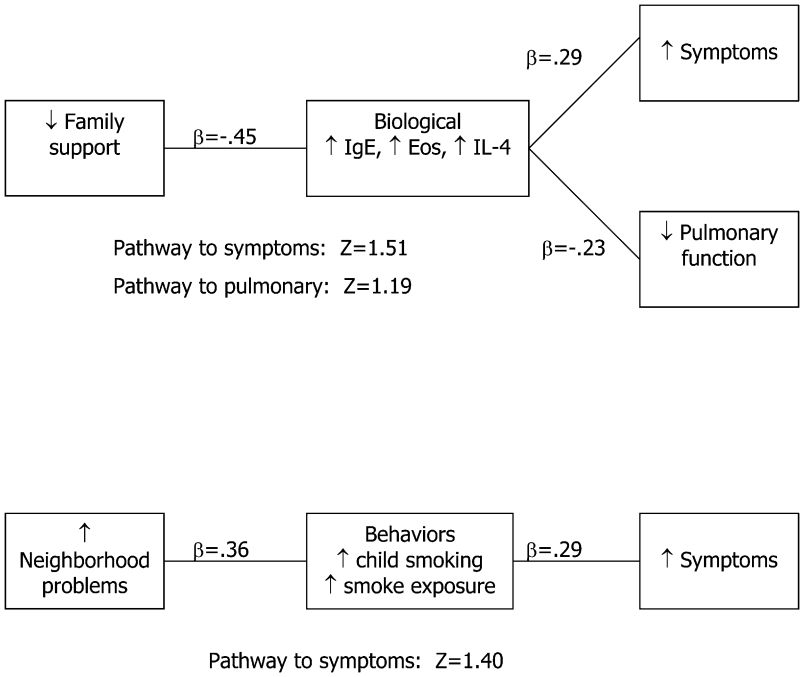

Figure 2. *Top*: Graphical depiction of pathways from family support to asthma symptoms and pulmonary function via biological processes. Note that the behavioral pathways of smoking and adherence to medications did not form significant pathways between family support and asthma symptoms or pulmonary function. *Bottom*: Graphical depiction of pathways from neighborhood problems to asthma symptoms via smoking behaviors. Note that neither biological processes nor adherence to medications formed significant pathways between neighborhood problems and asthma symptoms. Standardized regression coefficients are presented for composite variables (*see* text for description of calculations), as well as results of statistical mediational analyses. For mediational analyses, $Z > 0.97$ indicates a statistically significant pathway.

Unlike family and neighborhood factors, peer factors were not associated with asthma outcomes. It may be the case that social support networks are important for asthma among adults (28) but less so among youth. In particular, the influence of peers increases during adolescence, and thus the lack of peer findings in the present study may have been due to the broad age range of youths (9–18) in this sample.

The present study also provides evidence that is consistent with biopsychosocial models of asthma. For example, low levels of family support were associated with greater production of IL-4, higher levels of IgE, and more eosinophils. IL-4 induces B-cell production of IgE, which in turn activates cells to release histamines and leukotrienes, leading to airway constriction and edema (29). Eosinophils release inflammatory mediators, such as leukotrienes that contribute to airway injury and inflammation, and are associated with symptoms and severity level of asthma (30, 31). The present study also went beyond previous mechanistic research by including clinical outcomes and showing that low levels of family support were associated with heightened inflammatory markers, which in turn were associated with greater asthma symptoms and poorer pulmonary function. However, we acknowledge that this is merely one explanation for how social factors relate to asthma morbidity, and that there may be numerous other factors that also play into this relationship.

In simultaneous regression analyses, family factors were associated with pulmonary function more strongly than were peer or neighborhood variables. Given that measures of pulmonary function reflect airway obstruction, this suggests that family-level characteristics play an important role in youths' degree of airway obstruction, perhaps through effects on inflammation. In contrast, neighborhood factors were associated with asthma symptoms more strongly than were peer or family variables. To the extent that asthma symptoms reflect perceived disease burden, this suggests that neighborhood-level characteristics are important for how youths experience their asthma, perhaps in part due to environmental triggers such as smoke exposure. Overall, these patterns indicate that different components of asthma may be shaped by different social environment factors. As such, the most comprehensive picture of the determinants of asthma morbidity may come from situating an individual patient within the larger social context in which she/he exists.

In the present study, adherence to medications was not a significant pathway linking social factors to symptoms or pulmonary function. It could be that medication adherence is related to social variables other than family support or neighborhood problems, such as families' knowledge about asthma or the quality of physician–patient relationships. Alternatively, it is possible that some families inaccurately reported medication adherence, and that measurement error obscured relationships between adherence and asthma outcomes. Although adherence to medications is clearly an important determinant of asthma morbidity in youth (32), this study raises the possibility that links between adherence and symptoms may in part reflect the role of other health behaviors and biological processes.

Strengths of the present study include the assessment of social environmental factors at the neighborhood, peer, and family levels. In addition, the assessment of biological and behavioral pathways allowed us to develop models of how the larger social environment may get "under the skin" of an individual youth to influence disease.

Limitations of the present study include the sample size and the cross-sectional observational design. The cross-sectional nature of this study means that we cannot know for certain the directionality of effects. For example, although our proposed model is that neighborhood and family factors have effects on behaviors and inflammatory processes, which in turn affect morbidity, it is also possible that youths who experience more symptoms have more difficult family relationships, or that symptoms result in changes to inflammatory profiles, which can regulate central nervous system function in ways that affect social behaviors. To more clearly assess directionality, longitudinal studies are needed that repeatedly assess these factors over time. In addition, another limitation was the self-report nature of behavioral variables such as medication adherence and smoking. Self-reports may be biased because of a desire to present oneself in a positive light, or because of difficulties with recall about behaviors over extended periods of time, all of which may

have clouded associations with these variables. Future studies should use other approaches, such as electronic monitoring of medications. Medication regimens also differed across children, potentially complicating conclusions about links between the social environment and immune and clinical outcomes; however, asthma severity, which takes medication regimen into account, was controlled for in the present study. Finally, it should be noted that youths were recruited into this study on the basis of physician diagnosis of asthma and that physician diagnosis is not always accurate.

Future research is needed that places this study in a larger context by investigating the relative contributions of social versus other factors, such as genetics, allergen exposure, and viral infections in asthma, given that social factors in the present study accounted for only a modest percentage of the variance in clinical outcomes. Effect sizes in the present study were small, likely because asthma is a complex, multifactorial disease. Nonetheless, ascertaining the relative contribution of specific social environmental factors is important for gaining a more comprehensive understanding of childhood asthma. Future research is also needed to understand how relationships of social factors with asthma and the associated mechanisms change with age, pubertal status, and developmental milestones.

In sum, the present study provided evidence consistent with the hypothesis that poor family support is associated with decreased pulmonary function and greater asthma symptoms through biological mechanisms involving inflammation. In contrast, evidence suggests that neighborhood problems are associated with greater asthma symptoms via behavioral pathways related to smoking. Poor family relations may foster psychological experiences with direct physiologic consequences, whereas problematic neighborhoods may operate by providing role models for maladaptive health behaviors. Overall, these findings suggest that the larger social environment is linked to asthma, and that there are multiple pathways through which family and neighborhood factors may come to affect functioning in children with asthma.

Conflict of Interest Statement: None of the authors has a financial relationship with a commercial entity that has an interest in the subject of this manuscript.

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