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Research Article

Effect of Smoking on the Association Between Environmental Triggers and Asthma Severity Among Adults in New England

Kimberly Nguyen, MS, MPH, Justin Peng, MPH, and Eileen Boulay, RN, BSN

Abstract: *To identify environmental triggers associated with asthma severity and the potential modifying effect of cigarette smoke, the authors examined the relationship between sociodemographic characteristics, controller medication use, environmental triggers, and actions taken to reduce triggers on asthma severity among adults (≥18 years) residing in New England using the Behavior Risk Factor Surveillance Survey (BRFSS) Asthma Call-Back data. Asthma severity was categorized as intermittent, mild persistent, moderate persistent, and severe persistent according to the National Asthma Education and Prevention Program guidelines. In weighted logistic regression models, asthma severity was analyzed for 3075 adults with active asthma in Connecticut, Massachusetts, Maine, New Hampshire, and Vermont from 2006 to 2007. The odds of more severe asthma were 1.8 for smokers as compared with nonsmokers (95% confidence interval [CI] = 1.1, 3.1). Among current smokers, the odds of more severe asthma among those who were exposed to wood stoves was 2.4 (95% CI = 1.1, 5.7) as compared with those who were not exposed to wood stoves. Among nonsmokers, those who had a high school education or less (odds ratio [OR] = 2.0, 95% CI = 1.2, 3.3), had some college or technical school education (OR = 2.1, 95% CI = 1.2, 3.7), or had any comorbidity factors such as chronic obstructive pulmonary disease, emphysema, or bronchitis (OR = 2.5, 95% CI = 1.6, 3.8) were significantly associated with more severe asthma. Furthermore, the odds for more severe asthma were 2.1 (95% CI = 1.1, 4.0) among nonsmokers who were exposed to environmental tobacco smoke (ETS) as compared with those who were not exposed to ETS. The effect of environmental triggers on asthma severity differs among smokers and nonsmokers, even after controlling for sociodemographic factors, medication use, and actions taken to reduce triggers. Targeting smokers with asthma and making modifications to the environment may be important for reducing asthma severity among a high-risk population.*

Keywords: asthma; asthma education; environmental controls; self-management; asthma management

Asthma is a chronic respiratory disease that is characterized by symptoms of wheezing, coughing, chest tightness, and dyspnea. It is among the most common chronic diseases, affecting 22 million, or 7.2%, of Americans in 2005.[1] Asthma reduces quality of life as well as increases health care costs. Studies estimate that 4487 deaths, 1.8 million emergency department visits, and 10.4 million physician office visits were attributable to asthma in 2000.[2] Asthma accounts for approximately 2 million emergency department visits and 500 000 hospitalizations and at least $18 billion in health care costs each year. Data from the 2006 Behavior Risk Factor Surveillance Survey (BRFSS) showed that the asthma prevalence for New England adults (9.7%) was significantly higher than that for the rest of the United States (8.1%), even after controlling for age, gender, race/ethnicity, income, education, marital status, weight, and smoking status.[3] However, the reasons for the increased prevalence of asthma are not completely clear.

Asthma is an immunologically mediated disease that can be provoked by a variety of stimuli, including allergens. Exposure to indoor allergens is a potential environmental risk factor in the development of asthma and an important determinant of asthma severity.[4] The indoor environment contains environmental tobacco smoke (ETS), allergens from furred pets, dust mites, cockroaches, rodents, and molds, as well

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as particulate matter from cooking exhaust, wood-burning stoves, and fireplaces that could exacerbate asthma symptoms and lead to increased asthma hospitalizations and emergency department visits.[5-10] Because Americans spend nearly 90% of their time indoors, such as the home, workplace, and school,[11] it is hypothesized that indoor air irritants and allergens are a major determinant of asthma development and severity.

The effect of smoking and environmental triggers on the exacerbation of asthma is unknown. Studies have shown that cigarette smoke disrupts the normal lung homeostatic tolerance to inhaled allergens, which may enhance allergic sensitization.[12,13] It is hypothesized that smokers who are exposed to environmental triggers have worse asthma severity than nonsmokers exposed to the same triggers.

Previous studies[5-10] on environmental risk factors for asthma have been mostly conducted among children, did not examine the effect of smoking status in combination with environmental factors on asthma severity, and were not generalizable to adults in the United States. While the associations between environmental factors and asthma found in children may exist in adults, studying the adult population is important because they may respond differently to environmental allergens or triggers than children. New England states have the highest asthma prevalence in the United States, suggesting the need to study asthma risk factors in this population. Identifying differences in the risk for asthma severity by smoking status is important in the overall prevention and management of asthma, especially among high-risk populations. The relationship between indoor environmental triggers and asthma severity and the potential modifying effects of cigarette smoke was examined in a representative sample of adults residing in New England using the 2006-2007 BRFSS Asthma Call-Back Survey (ACBS).

Methods

BRFSS Survey Design

The BRFSS is an annual, cross-sectional telephone survey conducted by the Centers for Disease Control and Prevention (CDC) and state health departments and is administered in all 50 states, the District of Columbia, and the territories. The survey collects information about modifiable risk factors for chronic diseases and other leading causes of death among the noninstitutionalized US population 18 years of age and older. It includes core questions administered to all respondents nationwide, as well as questions added by states on specific topics. A disproportionate, stratified sampling plan was used for selecting households.[14] Data are collected on an ongoing basis, and the survey is administered in several languages, including English, Spanish, and Portuguese.

Data Collection

Two weeks following the annual BRFSS survey, a follow-up survey, the ACBS, was administered for respondents who responded yes to the question, "Have you ever been told by a physician, nurse, or other health professional that you had asthma?" The ACBS contains questions that cover a wide range of topics related to asthma and asthma management, including environmental triggers, medication usage, symptom frequency, health care utilization, and patient knowledge about the disease. Five of the 6 New England states (all except Rhode Island) conducted the ACBS in 2006 and 2007. All BRFSS questionnaires, data, and reports are available at www.cdc.gov/brfss.

Following the National Asthma Education and Prevention Program (NAEPP): Expert Panel Report 3 guidelines, we classified asthma as either intermittent, mild persistent, moderate persistent, or severe persistent using 4 parameters, namely, symptoms, nighttime awakenings, interference with normal activity, and use of short-acting β_2-agonists (SABA).[15] Adults who have symptoms less than or equal to 2 days per week, nighttime awakenings less than or equal to 2 times per month, SABA use for symptoms less than or equal to 2 times per week, and no limitations with normal activity were categorized as having intermittent asthma. Adults who were categorized as having mild persistent asthma reported symptoms greater than 2 days per week (but not daily), nighttime awakenings 3 to 4 times per month, SABA use greater than 2 days per week (but not daily), and minor limitations with normal activity. In addition, adults with moderate persistent asthma were defined as having daily symptoms, more than 1 nighttime awakening per week (but not nightly), daily SABA use, and some limitations with normal activity. Finally, adults with severe persistent asthma were defined as having symptoms on a continuous basis, nighttime awakenings each night, SABA use several times per day, and extreme limitations with normal activity.

In addition to the asthma severity questions, the ACBS included questions on age, sex, race, Hispanic origin, body mass index (BMI), metropolitan area residence, educational level, employment status, smoking status, and health conditions (Table 1). BMI (kg/m^2) was categorized as less than 25.0 (underweight or normal), 25.0 to 29.9 (overweight), and 30.0 and greater (obese; http://www.cdc.gov/healthyweight/assessing/bmi/adult_BMI/index.html). A person was classified as living in an urban area if they lived in a metropolitan statistical area. Education was categorized as high school graduate or less, some college or technical school, or college graduate. Employment status was categorized as employed, homemaker/student, retired, or unable to work. Smoking status was classified into 2 groups: nonsmokers (persons who have smoked fewer than 100 cigarettes in their lifetime or do not currently smoke) and current smokers (persons who have smoked at least 100 cigarettes in their lifetime and currently smoke, either once in a while, or every day). Measured health conditions included physician-diagnosed emphysema, chronic obstructive pulmonary disease (COPD), bronchitis, and depression. Medications included any controller medication use as defined by the NAEPP in the past 3 months.

The ACBS asked questions about participants' exposure to mold, pets, rodents, ETS, and air pollutants from gas and

Table 1. Socioeconomic and Demographic Characteristics by Categories of Asthma Severity Among Adults With Active Asthma in New England, Asthma Call-Back Survey, 2006-2007

		Level of Asthma Severity			
Characteristics	Number (%)[a]	Intermittent	Mild Persistent	Moderate Persistent	Severe Persistent
Total	3075 (100.0)	29.5	28.3	18.9	23.2
Age, y					
18-24	102 (12.3)	25.1	29.4	26.5	18.9
25-34	279 (20.8)	30.9	33.9	17.0	18.2
35-44	483 (16.4)	33.8	30.6	19.3	16.3
45-54	746 (21.3)	30.6	27.4	17.6	24.5
55-64	754 (14.9)	31.0	22.9	15.6	30.5
65+	711 (14.3)	25.6	22.5	20.1	31.8
Sex[b]					
Male	813 (34.7)	33.2	26.9	14.6	25.3
Female	2262 (65.3)	28.1	28.8	21.2	21.9
Race/ethnicity[c]					
Non-Hispanic white	2734 (85.7)	31.9	27.5	18.4	22.3
Non-Hispanic black	52 (2.0)	11.2	17.5	55.5	15.8
Hispanic	135 (8.5)	18.0	27.0	23.3	31.7
Other	121 (3.8)	20.2	50.8	4.7	24.3
Employment[d]					
Employed for wages/self-employed	1607 (58.5)	35.5	29.2	17.5	17.9
Homemaker/student	223 (11.4)	30.9	35.9	25.5	7.7
Retired	639 (13.0)	28.3	18.4	20.9	32.4
Unemployed/unable to work	602 (17.0)	11.8	25.1	18.2	44.8
Education[d]					
High school graduate or less	1032 (31.7)	17.4	28.0	20.2	34.4
Some college or technical school	787 (24.9)	25.0	28.3	22.8	23.9
College graduate	1255 (43.4)	41.8	28.2	15.7	14.4
Metropolitan area	590 (21.6)	24.6	26.4	28.6	20.5
Body mass index, kg/m^2					
<25	905 (34.8)	30.1	30.5	19.2	20.2
25 to <30	916 (31.1)	35.9	26.8	16.2	21.1
≥30	1106 (34.2)	25.3	25.8	21.6	27.3
Any comorbidity factors (chronic obstructive pulmonary disease, emphysema, or bronchitis)[d]	541 (15.9)	15.1	22.0	19.2	43.7
Depression	1118 (33.8)	23.4	31.8	17.6	27.1
Controller medication use[d]	1429 (39.9)	19.3	27.8	20.7	32.2

[a]Weighted percentage.
[b]$P < .05$.
[c]$P < .01$.
[d]$P < .0001$.

Table 2. Environmental Triggers and Actions Taken to Prevent Triggers by Categories of Asthma Severity Among Adults With Active Asthma in New England, Asthma Call-Back Survey, 2006-2007

		Level of Asthma Severity			
	Number (%)[b]	Intermittent	Mild Persistent	Moderate Persistent	Severe Persistent
Environmental trigger[a]					
Gas for cooking	1142 (36.6)	32.0	29.3	17.9	20.8
Mold	496 (15.6)	20.0	36.7	16.8	26.5
Pets	1864 (61.5)	30.2	30.3	18.8	20.8
Rodents	285 (8.2)	33.4	23.9	13.4	29.3
Cockroach[c]	58 (2.9)	4.3	31.6	18.8	50.3
Wood stove	767 (26.9)	36.4	26.6	17.7	19.3
Gas stove	180 (4.8)	36.3	31.4	11.7	20.5
Environmental tobacco smoke[d]	530 (16.5)	11.3	31.5	15.8	41.4
Carpet	1857 (60.5)	28.8	27.3	21.1	22.8
Current smoking[e]	541 (15.9)	13.9	32.2	17.1	36.8
Action taken to reduce triggers					
Air cleaner	775 (25.1)	29.2	29.1	18.9	22.9
Dehumidifier	959 (35.0)	29.0	30.8	20.4	19.8
Kitchen fan	1619 (54.0)	28.6	28.5	19.1	23.8
Bathroom fan	1756 (58.7)	31.3	27.5	18.4	22.8
Dust mite–controlling mattress cover	912 (30.2)	29.0	27.5	18.0	25.5
Dust mite–controlling pillow cover	916 (28.1)	27.4	29.3	18.3	25.0
Hot water when washing laundry	1101 (40.7)	28.2	30.9	19.0	21.8

[a]Mold is defined as any sight or smell of mold (or a musty odor) inside the home, not including mold on food, in the past 30 days. Pets are defined as any pet such as dogs, cats, hamsters, birds, or other feathered or furry pets that spend time indoors. Rodents are defined as any sight of mice or rats inside the home, not including mice or rats kept as pets, in the past 30 days. Wood stove is defined as a wood-burning fireplace or wood-burning stove used in the home. Gas stove is defined as unvented gas logs, unvented gas fireplaces, or unvented gas stoves used in the home.
[b]Weighted percentage.
[c]$P < .05$.
[d]$P < .01$.
[e]$P < .0001$.

wood stoves (Table 2). Actions taken to reduce environmental triggers, such as the use of an air cleaner, dehumidifier, kitchen fan or a bathroom fan that vents to the outside, dust mite–controlling mattress or pillow cover, and hot water when washing laundry, were also collected.

Statistical Analysis

Weighted analyses were conducted using statistical methods to account for the complex sampling design in SAS version 9.2 (SAS Institute, Inc, Cary, North Carolina) to represent the adult population in the corresponding states in New England. More information on weight calculation can be found at http://www.cdc.gov/brfss/technical_infodata/weighting.htm. Descriptive statistics (eg, means and percentages) were performed with PROC SURVEYMEANS and PROC SURVEYFREQ.

The analysis was limited to adults with active asthma, defined as individuals with some level of asthma activities in the previous 12 months. These activities included seeing a physician about asthma, taking asthma medication, and showing symptoms of asthma within the past year.

For examining bivariate associations, we used χ^2 tests to evaluate any differences in demographic characteristics, comorbidities, environmental triggers, and actions taken to reduce environmental triggers by asthma severity. We used

univariate logistic regression to identify the factors that were significantly associated with asthma severity to be used as independent variables in multivariate logistic regression.

Asthma severity was dichotomized into more severe (combining moderate persistent and severe persistent asthma) and less severe (combining intermittent and mild persistent asthma) in logistic regression models, with less severe asthma as the reference category. The NAEPP guidelines make a fundamental distinction between persistent and intermittent asthma, with airway inflammation as the contributing factor in the difference between persistent and intermittent asthma. Furthermore, the rationale for categorizing asthma severity is to identify patients with more severe asthma.[16] By having 2 distinct asthma severity groups (less severe and more severe), adults with more severe asthma can be identified so that appropriate treatment and medications can be targeted to that group. The model was run separately for current smokers and nonsmokers. Although sex and race/ethnicity were not significant predictors of asthma severity in univariate analyses, we included those variables in the model because they are known confounders. Because the sample was predominantly non-Hispanic white, race/ethnicity was dichotomized into non-Hispanic white and other. Rodents and cockroaches were combined into a pest variable because of low numbers in each cell.

Results

Sample Population Characteristics

Among respondents, 30% met the criteria for intermittent asthma, 28% for mild persistent asthma, 19% for moderate persistent asthma, and 23% for severe persistent asthma (Table 1). The population of 3075 adults in New England represents a predominantly non-Hispanic white population (86%); 43% were college graduates, and 59% were employed. Sixty-five percent of the respondents were female, and the average age of the participants was 45 years (Table 1). The population was almost equally distributed among the 3 BMI categories: underweight or normal (35%), overweight (31%), and obese (34%). Twenty-two percent reported living in the center of a metropolitan area. Sixteen percent reported having a comorbid condition (eg, COPD, emphysema, or bronchitis), and more than one-third (34%) suffered from depression. Nearly 20% of adults with active asthma reported taking controller medications in the past 3 months (Table 1). Furthermore, 16% of adults were current smokers (Table 2).

Bivariate Results

Respondents' sex, race/ethnicity, education, employment status, smoking status, comorbid conditions (eg, COPD, emphysema, bronchitis), and controller medication use were all significantly associated with level of asthma severity (Table 1). Sex was significantly associated with asthma severity, with women being more likely to have worse asthma severity than men. Non-Hispanic whites were significantly less likely to have severe asthma than non-Hispanic blacks, Hispanics, and other races. Adults who were unemployed or unable to work were significantly more likely to have worse asthma severity than those who were employed. Asthma severity was inversely associated with education, with the highest level of asthma severity seen among those with the lowest educational level. In addition, those who had comorbid conditions (eg, COPD, emphysema, bronchitis) or depression were significantly more likely to have more severe asthma than those who did not. Furthermore, use of controller medications was significantly associated with more severe asthma (Table 1).

Among environmental triggers, exposures to cockroaches and ETS as well as current smoking status were statistically associated with more severe asthma (Table 2). Those who reported seeing a cockroach inside their home in the past 30 days were significantly more likely to have more severe asthma than those who did not report seeing cockroaches in the home. In addition, adults who were exposed to ETS in the past week were significantly more likely to have worse asthma severity as compared with those who were not exposed to ETS. Finally, smokers were significantly more likely to have worse asthma severity than nonsmokers.

Univariate and Multivariate Regression Analyses

In univariate analyses, employment, education, comorbid factors (eg, COPD, emphysema, and bronchitis), ETS, smoking status, and controller medication use were independent factors significantly associated with level of asthma severity (Table 3). The odds of severe asthma were 2.1 (95% confidence interval [CI] = 1.4, 3.0) and 3.1 (95% CI = 1.7, 5.8) among adults who were retired and unemployed or unable to work, respectively, as compared with those who were employed. Furthermore, the odds of severe asthma for adults with a high school education or less was 2.8 (95% CI = 1.9, 4.2) and for adults with some college or technical school was 2.0 (95% CI = 2.3, 4.6) as compared with those with a college education. Those who were exposed to ETS were 2.1 times (95% CI = 1.7, 3.8) as likely to have more severe asthma as compared with those not exposed to ETS. Smokers were 1.8 times as likely to have more severe asthma as compared with nonsmokers (95% CI = 1.1, 3.1). Finally, controller medication use was significantly associated with more severe asthma (odds ratio [OR] = 2.1, 95% CI = 1.5, 3.0).

In multivariate analyses, sociodemographic factors, environmental triggers, and medication use were found to be significantly associated with asthma severity, and these effects were modified by smoking status, after controlling for all other factors in the model (eg, sex, race/ethnicity, and actions taken to reduce triggers; Table 4). Among current smokers, the odds of more severe asthma were 2.6 (95% CI = 1.2, 5.5) for adults who were unemployed or unable to work as compared with employed adults. Smokers who had wood stoves were significantly more likely to have more severe asthma as compared with smokers who did not have wood stoves (OR = 2.4, 95% CI = 1.1, 5.7). Among current smokers, using gas for cooking was inversely associated with more severe asthma

Table 3. Univariate Analyses of Demographic and Environmental Factors Associated With Asthma Severity, Asthma Call-Back Survey, 2006-2007

Demographics	Odds Ratio (95% Confidence Interval)
Male	0.9 (0.6, 1.3)
Race/ethnicity	
Non-Hispanic white	1.0
Other	1.5 (0.8, 2.7)
Employment	
Employed for wages/self-employed	1.0
Homemaker/student	0.9 (0.4,1.9)
Retired	2.1 (1.4, 3.0)
Unemployed/unable to work	3.1 (1.7, 5.8)
Education	
High school graduate or less	2.8 (1.9, 4.2)
Some college or technical school	2.0 (1.3, 3.3)
College graduate	1.0
Any comorbidity factors (chronic obstructive pulmonary disease, emphysema, or bronchitis; Y/N)	3.2 (2.3, 4.6)
Environmental triggers	
Gas for cooking	0.8 (0.6, 1.1)
Mold	1.1 (0.6, 1.8)
Pets	0.8 (0.5, 1.1)
Pest	1.3 (0.7, 2.4)
Wood stove	0.7 (0.5, 1.2)
Gas stove	0.6 (0.4, 1.1)
Environmental tobacco smoke	2.1 (1.7, 3.8)
Carpet	1.2 (0.9, 1.7)
Current smoking	1.8 (1.1, 3.1)
Actions taken to reduce triggers	
Air cleaner (Y/N)	1.0 (0.7, 1.5)
Dehumidifier (Y/N)	0.9 (0.6, 1.3)
Kitchen fan (Y/N)	0.6 (0.3, 1.3)
Bathroom fan (Y/N)	1.1 (0.8, 1.5)
Dust mite–controlling mattress cover (Y/N)	1.1 (0.8, 1.5)
Dust mite–controlling pillow cover (Y/N)	1.1 (0.8, 1.5)
Hot water when washing laundry (Y/N)	0.9 (0.6, 1.3)
Medication use (Y/N)	
Controller medication use	2.1 (1.5, 3.0)

The “no” category is the reference group for all Y/N variables.

Table 4. Multivariate Analyses of Demographic and Environmental Factors Associated With Asthma Severity, Stratified by Smoking Status, Asthma Call-Back Survey, 2006-2007

	Adjusted Odds Ratios (95% Confidence Interval)	
Demographics	**Current Smoker**	**Nonsmoker**
Male	0.8 (0.4, 1.9)	0.9 (0.5, 1.5)
Race/ethnicity		
Non-Hispanic white	1.0	1.0
Other	2.6 (0.9, 7.1)	1.4 (0.7, 2.9)
Employment		
Employed for wages/self-employed	1.0	1.0
Homemaker/student	0.5 (0.2, 1.7)	0.8 (0.4, 2.0)
Retired	1.4 (0.4, 4.7)	1.5 (0.9,2.3)
Unemployed/unable to work	2.6 (1.2, 5.5)	3.2 (2.0, 5.3)
Education		
High school graduate or less	1.3 (0.5, 3.1)	2.0 (1.2, 3.3)
Some college or technical school	3.3 (1.2, 8.7)	2.1 (1.2, 3.7)
College graduate	1.0	1.0
Any comorbidity factors (chronic obstructive pulmonary disease, emphysema, or bronchitis) (Y/N)	1.3 (0.7, 2.6)	2.5 (1.6, 3.8)
Environmental triggers		
Gas for cooking (Y/N)	0.4 (0.2, 0.7)	0.8 (0.6, 1.2)
Mold (Y/N)	1.6 (0.7, 3.6)	1.0 (0.6, 1.6)
Pets (Y/N)	0.7 (0.3, 1.5)	1.0 (0.7, 1.5)
Pests (rodents and cockroaches) (Y/N)	0.9 (0.4, 2.0)	1.2 (0.6, 2.7)
Wood stove (Y/N)	2.4 (1.1, 5.7)	0.9 (0.6, 1.5)
Gas stove (Y/N)	0.6 (0.2, 2.2)	0.5 (0.2, 1.1)
Environmental tobacco smoke (Y/N)	1.3 (0.7, 2.5)	2.1 (1.1, 4.0)
Carpet (Y/N)	1.0 (0.5, 2.1)	1.3 (0.9, 2.0)
Actions taken to reduce triggers		
Air cleaner (Y/N)	0.6 (0.3, 1.4)	0.9 (0.5, 1.6)
Dehumidifier (Y/N)	2.0 (0.8, 4.8)	1.0 (0.6, 1.5)
Kitchen fan (Y/N)	0.6 (0.3, 1.3)	1.0 (0.6, 1.5)
Bathroom fan (Y/N)	1.0 (0.5, 2.1)	0.9 (0.6, 1.4)
Dust mite–controlling mattress cover (Y/N)	0.8 (0.3, 2.0)	1.3 (0.7, 2.1)
Dust mite–controlling pillow cover (Y/N)	2.1 (0.8, 5.3)	0.9 (0.5, 1.6)
Hot water when washing laundry (Y/N)	0.6 (0.3, 1.2)	1.2 (0.8, 1.8)
Medication use (Y/N)		
Controller medication use	8.0 (3.9, 16.3)	1.7 (1.2, 2.4)

The “no” category is the reference group for all Y/N variables.

(OR = 0.4, 95% CI = 0.2, 0.7) as compared with those who do not use gas for cooking. In addition, the odds of severe asthma were 8.0 (95% CI = 3.9, 16.3) for smokers who used controller medications as compared with those who did not use controller medications.

Among nonsmokers, being unemployed or unable to work (OR = 3.2, 95% CI = 2.0, 5.3), having a high school education or less (OR = 2.0, 95% CI = 1.2, 3.3), or having some college or technical school education (OR = 2.1, 95% CI = 1.2, 3.7) were significant factors associated with more severe asthma. Nonsmokers who had any comorbid conditions (eg, COPD, emphysema, or bronchitis) were significantly associated with more severe asthma (OR = 2.5, 95% CI = 1.6, 3.8) as compared with those who did not have any comorbid conditions. In addition, nonsmokers who were exposed to ETS were 2.1 times (95% CI = 1.1, 4.0) as likely to have more severe asthma as compared with those who were not exposed. Finally, the odds of severe asthma was 1.7 (95% CI = 1.2, 2.4) for nonsmokers who used controller medications as compared with those who did not use controller medications.

Conclusion

More than two-thirds of adults with active asthma have asthma categorized as greater than intermittent asthma (28% for mild persistent, 19% for moderate persistent, and 23% for severe persistent asthma). The vast majority of asthmatic adults in New England have uncontrolled asthma, as evidenced by their repeated SABA use, limitations with normal activity, symptoms, and nighttime awakenings. Severe asthma not only decreases quality of life but also leads to increases in hospitalizations, emergency department visits, and health care costs. Yet little has been done to understand the causes of severe asthma in this population so that further asthma morbidity and mortality can be prevented.

These results demonstrate that more than any other environmental factor, cigarette smoke and ETS are significant contributors to asthma severity. In our population of adults with active asthma, 16% are current smokers and 17% are exposed to ETS within the past week. When the effects of environmental factors on asthma severity were analyzed separately for smokers and nonsmokers and adjusted for sociodemographic factors, we found differences in environmental factors associated with asthma severity among the 2 groups. For example, among current smokers, adults who have wood stoves in the home were more likely to have more severe asthma than those who do not have wood stoves; however, similar results were not found among nonsmokers, suggesting that cigarette smoke may increase sensitization to particulates released from wood-burning stoves. On the other hand, exposure to ETS increased the risk for more severe asthma among nonsmokers but not among smokers, suggesting that particulates from secondhand smoke may be more harmful among those who do not currently smoke. More studies need to be conducted to examine the relationship between active and passive smoking, and the combination of both, on asthma severity. The data imply that the effects of environmental triggers on asthma severity differ between smokers and nonsmokers, even after controlling for demographic characteristics and actions taken to reduce triggers.

In addition, the effect of sociodemographic factors and medication use on asthma severity also differs among smokers and nonsmokers. Employment status, educational level, comorbid conditions, and controller medication use were all significant factors associated with more severe asthma among nonsmokers. The results demonstrate that nonsmoking adults who are unemployed or unable to work are high-risk groups for worse severity of asthma as compared with nonsmoking adults who are employed. In addition, nonsmoking adults who had only a high school degree or some college or technical school are at greater risk for worse severity of asthma than nonsmoking adults with a college education. Nonsmoking adults with comorbid conditions (eg, COPD, emphysema, bronchitis) were also significantly more likely to have more severe asthma than adults without these conditions. These results suggest the need to target adults with comorbid conditions as well as lower socioeconomic status groups among nonsmokers.

To reduce the potential for bias resulting from modifications to the environment, we controlled for changes in the environment using the following variables from the ACBS: regular use of an air cleaner or purifier inside the home, regular use of a dehumidifier to reduce moisture inside the home, regular use of an exhaust fan that vents to the outside when cooking in the kitchen, and regular use of an exhaust fan in the bathroom that vents to the outside. Our results suggest that despite controlling for modification to the environment, significant associations between selected environmental risk factors and asthma severity exist.

One of the limitations of cross-sectional studies is the lack of causal inference, making it difficult to determine whether an environmental factor is the cause of the asthma or whether participants modified their environment in response to their asthma. For example, those who used gas for cooking were negatively associated with having more severe asthma. Those who have more severe asthma may have eliminated use of gas for cooking, which may lead to the protective effects found in this study. Because of the lack of causal inference, only associations can be determined.

A concern of this study is the relatively low response rates, ranging from 37% to 76% (J. Morman, unpublished data, 2009). The bias from nonresponse can change the OR in either direction, as it is not possible to know if those who refused to respond would have answered the questions in approximately the same ways as those who responded. Using a complex sampling scheme, however, the data were weighed to compensate for unequal probabilities of selection, to adjust for nonresponse and telephone noncoverage, and to ensure that results are consistent with population data and population estimates. While the weighed survey design attempts to ensure a representative sample, it is possible that the results may not

be truly generalizable to all noninstitutionalized adults in the United States.

The ACBS is the first study to evaluate indoor environmental risk factors and the potential interaction of environmental triggers and cigarette smoking on asthma severity among adults in New England. New England has the highest prevalence of asthma compared with other regions of the United States. Determining modifiable risk factors that may contribute to the increased severity is important for preventing and reducing morbidity and mortality caused by asthma in this population. The results suggest that factors associated with severe asthma differ among smokers and nonsmokers. Behavior change, whether through modifications in the home environment, smoking cessation, or both, may reduce asthma severity and lead to improved asthma management and control. Targeting smokers with asthma may be important for reducing risk factors among a high-risk population. Given the limitations of the study, more research is needed to understand environmental factors associated with severe asthma among smokers so that appropriate interventions can be implemented.

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