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Smoke-Free Air Laws and Asthma Prevalence, Symptoms, and Severity Among Nonsmoking Youth

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WHAT'S KNOWN ON THIS SUBJECT: Smoke-free laws reduce exposure to secondhand smoke, as measured by cotinine, in both adults and children. In adults, smoke-free laws have been associated with reductions in health outcomes such as respiratory symptoms and acute myocardial infarctions, as well.

WHAT THIS STUDY ADDS: This study examined the association between smoke-free laws and health in children and adolescents. Health outcomes that have been associated with exposure to secondhand smoke in children include prevalence of asthma, asthmatic symptoms, asthma severity, and ear infection.

abstract

OBJECTIVE: We investigated the association between smoke-free laws and asthma prevalence, symptoms, and severity among nonsmoking youth (aged 3–15 years).

METHODS: We examined data from the 1999–2006 National Health and Nutrition Examination Survey, a cross-sectional survey designed to monitor the health and nutritional status of the US population. Survey locations were dichotomized as having or not having at least 1 smoke-free workplace, restaurant, or bar law at the county or state level that covered the entire county population. Asthma prevalence was assessed as self-reported current asthma and as ever having asthma with current symptoms. Asthmatic symptoms included persistent wheeze, chronic night cough, and wheeze-medication use. We also examined asthma severity (asthma attack or emergency-department visit for asthma) and persistent ear infection.

RESULTS: Smoke-free laws were not associated with current asthma but were significantly associated with lower odds of asthmatic symptoms (odds ratio [OR]: 0.67 [95% confidence interval (CI): 0.48–0.93]) among nonsmoking youth. The association between smoke-free laws and ever having asthma with current symptoms approached significance (OR: 0.74 [95% CI: 0.53–1.03]). Smoke-free laws were associated with lower odds of asthma attacks (OR: 0.66 [95% CI: 0.28–1.56]) and emergency-department visits for asthma (OR: 0.55 [95% CI: 0.27–1.13]), although these results were not statistically significant.

CONCLUSIONS: Our results suggest that smoke-free laws reduce asthmatic symptoms, including persistent wheeze, chronic night cough, and wheeze-medication use in nonsmoking youth. *Pediatrics* 2011;127:102–109

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KEY WORDS
asthma, tobacco control policy, children, adolescents, National Health and Nutrition Examination Survey

ABBREVIATIONS
NHANES—National Health and Nutrition Examination Survey
OR—odds ratio
CI—confidence interval

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Secondhand smoke has been associated with a number of respiratory conditions in children and adolescents. In the 2006 Surgeon General's report,[1] it was concluded that there was sufficient evidence that parental smoking causes lower-respiratory illnesses, middle-ear disease, cough, phlegm, wheeze, breathlessness, and prevalent asthma.

Among children with asthma, exposure to secondhand smoke can trigger an asthma attack.[1] It has been estimated that exposure to secondhand smoke worsens the condition of 400 000 to 1 million children with asthma.[2] Common symptoms of an asthma attack include coughing, wheezing, and shortness of breath.

It is well established that smoke-free laws reduce exposure to secondhand smoke in adults.[3–17] Evidence shows that smoke-free laws also reduce exposure to secondhand smoke in children and adolescents[18,19] by reducing the overall amount of secondhand smoke in a community and by reducing the amount of smoking in the home,[20,21] the primary source of secondhand smoke exposure for children.[22–25] Although smoke-free laws have been shown to be associated with a number of respiratory illnesses[13–17] and acute myocardial infarction[26–28] in adults, the evidence for the effects of smoke-free laws on the health of children is limited.[29]

We previously showed that smoke-free laws were associated with lower cotinine levels in children and adolescents.[19] In the current study, we examined the association between smoke-free laws and health outcomes, including prevalence of asthma, asthma-related symptoms, and asthma severity among children and adolescents using data from the 1999–2006 National Health and Nutrition Examination Survey (NHANES).

METHODS

Data Source

The NHANES, conducted by the National Center for Health Statistics, is a series of cross-sectional surveys designed to monitor the health and nutrition status of the US population. Participants are selected through a complex, multistage, probability-cluster design. From 1999–2006, adolescents aged 12–19 years, adults aged 60 years or older, low-income subjects, Mexican American people, and non-Hispanic black people were oversampled to improve the reliability and precision of estimates for these groups.[30] Public-use data files were released in 2-year cycles (1999–2000, 2001–2002, 2003–2004, and 2005–2006).

The NHANES consisted of a household interview and a standardized physical examination conducted in a mobile examination center. The household interview included questions about demographic characteristics, health history, health-related behaviors, and medical conditions. In general, subjects aged 16 or older were interviewed directly. A responsible adult provided information for participants younger than age 16 years. Signed informed consent was obtained for all participants. For NHANES 1999–2006, there were 50 939 subjects selected for the sample, 41 474 subjects were interviewed (81.4%), and 39 352 (77.3%) were examined in the mobile examination center.

This analysis was restricted to nonsmoking participants (youths) aged 3–15 years. Nonsmokers were defined by both cotinine levels and self-reported smoking status. Youth with missing cotinine levels ($n = 2091$) were excluded. Participants with cotinine levels less than 15.0 ng/mL[31] were considered to be nonsmokers ($n = 9135$). Youth aged 12–19 years answered questions themselves (not using a proxy) about tobacco or nicotine use in the 5 days before blood collection, using a computer-assisted personal interview. Youth who reported that they had used tobacco or nicotine in the previous 5 days or who were missing information on this variable were excluded ($n = 324$). Youth who were pregnant also were excluded ($n = 11$). This resulted in a final sample size of 8800 nonsmoking youth.

Outcomes

Four outcomes were examined: prevalence of asthma; asthmatic symptoms; ear infection; and asthma severity. Prevalence of asthma was first assessed as self-reported current asthma, defined as a positive answer to both of 2 questions: "Has a doctor or other health professional ever told you that you have asthma?" and "Do you still have asthma?"

Second, we defined ever having asthma with current symptoms as reporting ever having doctor-diagnosed asthma and at least 1 of the following self-reported symptoms in the previous year:

- a total of 3 or more episodes of wheezing or whistling in the chest (persistent wheeze);
- dry coughing at night that lasted 14 days or more, not counting a cough associated with a cold or chest infection (chronic night cough); or
- medication prescribed by a doctor for wheezing or whistling (wheeze-medication use).

Persistent ear infection was defined as having had 3 or more ear infections in the previous year. This question was only asked in 1999–2004. Only participants with self-reported current asthma ($n = 896$) were asked questions about asthma severity. Youth who reported having an asthma attack ("During the past 12 months, have you had an episode of asthma or an

asthma attack in the past year?") or an emergency-department visit ("During the past 12 months have you had to visit an emergency department or urgent care center because of asthma?") were considered to have severe asthma.

Exposure to Smoke-Free Laws

NHANES participants were classified into smoke-free law-coverage categories by their county and state of residence.[8,19] From 1999 to 2006, NHANES sampled youth from 117 survey locations or counties. Information on state and local smoke-free laws was obtained for each county from a database of local and state indoor-air ordinances maintained by the American Nonsmoker's Rights Foundation.[32] The American Nonsmoker's Rights Foundation list indicated smoke-free laws for workplaces, restaurants, and bars at the city, county, and state level. Locations classified as having a smoke-free law completely banned smoking and did not allow for separately ventilated smoking rooms, size exemptions, or allowed smoking in bars attached to restaurants. Laws only were included if they were enacted before the examination portion of the survey was administered.

Each county was categorized into 2 smoke-free law-coverage groups. Smoke-free counties ($n = 26$) had at least 1 smoke-free workplace, restaurant, or bar law at the county or state level that covered the entire county population. There were 91 counties without such a smoke-free law at the county or state level.

Covariates

Variables associated with smoke-free law enactment or asthma were included in each model, including age (3–5, 6–11, and 12–15 years), gender, race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican American, and other), ratio of family income to poverty (above versus below poverty threshold), 2-year survey cycle, and region (West, Northeast, and South/Midwest combined because of small sample sizes).

Additional risk factors for asthma included in the models were household size ($\geq$5 vs $<$5 residents), health insurance status in the previous year (yes or no), BMI (underweight/healthy, overweight, and obese on the basis of gender and age), mother's age at birth ($<$20, 20–24, 25–29, and $\geq$30 years), mother's smoking status during pregnancy (no, yes, yes but quit), and low birth weight ($\leq$5.5 lb). Daycare or preschool attendance (ever) was collected in 1999–2004 and was used to adjust the ear infection analysis, which also was collected in 1999–2004.

We examined the association between smoke-free laws and respiratory outcomes stratified by exposure to secondhand smoke in the home. One member of each household was asked "Does anyone who lives here smoke cigarettes, cigars, or pipes anywhere inside this home?" If at least 1 person smoked inside the home, all members of that house were classified as having home secondhand smoke exposure.

Statistical Analysis

Data management was conducted by using SAS 9.1 (SAS Institute Inc, Cary, NC) and data analysis in SUDAAN 9.0 (Research Triangle Institute, Research Triangle Park, NC), which accounted for the multistage, probability-cluster design. Examination sample weights were used to account for differential probabilities of selection and for nonresponse. Variance estimates were calculated by using the Taylor linearization-with-replacement method. Differences in proportions were evaluated with a t test using a significance level of $P < .05$.

Publicly released data files provided masked variance units to estimate sampling errors.[30] Masked variance units were created to comply with disclosure-avoidance principals that prohibit the public release of the primary sampling units. The exposure of interest, the smoke-free law-coverage category, was based on the true primary sampling units, and we used these strata variables, which are available through the National Center for Health Statistics Research Data Center (available at: www.cdc.gov/rdc), for calculating SEs for all estimates.

Weighted logistic regression was used to calculate unadjusted and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for the association between smoke-free laws and prevalent asthma, asthmatic symptoms, ear infection, and asthma severity. Effect modification by home secondhand smoke exposure and age was assessed by including an interaction term in the adjusted model.

RESULTS

A total of 2227 (21%) of 8800 participants lived in a smoke-free county. There was a higher percentage of certain demographic groups in smoke-free counties, including youth from the later survey cycles, Mexican American youth, youth from the West or Northeast, and youth who lived without a smoker in the home (Table 1).

Self-reported Current Asthma and Severity

Self-reported current asthma was reported by 9.8% of youth. There was a similar percentage of youth living in smoke-free counties who self-reported having current asthma as those not living in smoke-free counties (10.0% and 9.7%, respectively) (Table 2). The unadjusted ORs for the association between smoke-free laws and self-reported current asthma were close to 1 (OR:

TABLE 1 Weighted Percentage (SE) of Nonsmoking Youth Living in a County With a Smoke-Free Law, According to Covariates: Ages 3 to 15 Years, NHANES 1999–2006

	Sample Size, *n*	Total Percentage (SE)	Percentage (SE) With a Smoke-Free Law	*P*[a]
Total	8800		20.9 (3.2)	
Year				
1999–2000	2112	21.8 (1.6)	11.8 (3.6)[b]	Reference
2001–2002	2407	28.0 (2.1)	20.4 (8.5)[b]	.40
2003–2004	2130	25.2 (1.5)	24.3 (7.7)[b]	.15
2005–2006	2151	25.0 (1.9)	26.2 (6.0)	.04
Gender				
Male	4407	52.3 (0.78)	21.1 (3.2)	Reference
Female	4393	47.7 (0.78)	20.8 (3.5)	.83
Age, y				
3–5	1582	18.8 (0.48)	21.0 (4.1)	Reference
6–11	3575	49.3 (0.78)	20.3 (3.0)	.66
12–15	3643	31.9 (0.77)	22.0 (3.4)	.53
Household size				
≥5	4863	46.9 (1.1)	24.6 (4.5)	Reference
<5	3937	53.1 (1.1)	17.7 (2.6)	.05
Race/ethnicity				
Non-Hispanic black	2776	15.0 (1.2)	10.6 (2.6)	.09
Non-Hispanic white	2248	59.0 (1.8)	17.6 (3.9)	Reference
Mexican American	3018	13.4 (0.9)	38.7 (4.4)	<.001
Other	758	12.6 (1.1)	30.2 (5.5)	.004
Ratio of income to poverty				
Below poverty level	2747	23.3 (1.2)	20.5 (3.3)	Reference
Above poverty level	5520	76.7 (1.2)	21.1 (3.4)	.74
Region				
South/Midwest	5019	58.9 (3.4)	3.1 (2.3)[b]	<.001
Northeast	1191	15.6 (1.2)	29.6 (8.5)[b]	.06
West	2590	25.5 (3.1)	56.8 (11.0)	Reference
Health insurance				
Yes	7264	87.4 (1.0)	21.3 (3.3)	Reference
No	1451	12.6 (1.0)	19.0 (3.5)	.32
BMI				
Underweight/healthy weight	5464	65.8 (1.1)	21.4 (3.8)	Reference
Overweight	1445	16.1 (0.5)	21.9 (3.2)	.76
Obese	1818	18.1 (0.9)	19.1 (2.3)	.45
Mother's age at birth, y				
<20	1559	13.6 (0.6)	14.7 (2.3)	Reference
20–24	2562	26.3 (0.9)	18.2 (2.8)	.03
25–29	2296	28.6 (0.9)	20.1 (3.4)	.008
>30	2275	31.5 (1.2)	26.7 (3.9)	<.001
Mother smoked during pregnancy				
Yes	780	11.3 (0.8)	13.6 (2.6)	.001
Yes but quit	459	6.7 (0.3)	17.4 (3.6)	.06
No	7421	82.1 (0.9)	22.4 (3.4)	Reference
Low birth weight, lb				
<5.5	1089	11.2 (0.6)	22.2 (3.4)	Reference
≥5.5	7621	88.8 (0.6)	20.7 (3.3)	.53
Ever attend day care (1999–2004)				
Yes	4406	72.1 (1.2)	18.5 (4.0)	Reference
No	2230	27.9 (1.2)	21.1 (4.7)	.30
Home secondhand smoke exposure				
Yes	1769	21.9 (1.2)	10.9 (2.3)	Reference
No	6956	78.1 (1.2)	23.8 (3.7)	<.001

[a] *P* value (*t* test) to test the null hypothesis of no differences in the percentage with a smoke-free law.
[b] Does not meet the standard of statistical reliability and precision (relative SE [SE/percent]) > 30%).

1.03 [95% CI: 0.81–1.30]). This association was not modified by secondhand smoke exposure at home or age.

Among youth with self-reported current asthma, 66% reported having an asthma attack and 20% reported going to the emergency department for their asthma attack. Adjusted for covariates, youth living in a smoke-free county had 0.66 (95% CI: 0.28–1.56) times the odds of having an asthma attack and 0.55 (95% CI: 0.27–1.13) times the odds of going to the emergency department for asthma (Table 2).

Ever Having Asthma With Current Symptoms and Asthmatic Symptoms

The percentage of youth reported as ever having asthma with current symptoms (7.2%) was slightly lower than the percentage of youth with self-reported current asthma (9.8%). Adjusted for covariates, youth living in smoke-free counties had 0.74 (95% CI: 0.53–1.03) times the odds of ever having asthma with current symptoms compared with youth living in counties without smoke-free laws (Table 3).

An estimated 11.4% of youth reported having asthmatic symptoms in the previous year, including persistent wheeze, chronic night cough, or wheeze-medication use. Youth living in smoke-free counties had fewer asthmatic symptoms (8.4%) compared with youth living in counties without smoke-free laws (12.1%) (Table 3), with an adjusted OR of 0.67 (95% CI: 0.48–0.93). Examining these symptoms individually, persistent wheeze and chronic night cough had slightly lower adjusted ORs than wheeze-medication use (Table 3). The association between smoke-free laws and asthmatic symptoms was similar for youth with current, previous, and no asthma (data not presented).

We found a difference in the association between smoke-free laws and ever having asthma with symptoms by home secondhand smoke exposure, although the difference was not statistically significant (*P* value for interaction = .36) (Fig 1A). Youth who did not experience home secondhand smoke

TABLE 2 Prevalence of Self-reported Current Asthma and Asthma Severity in the Previous Year and Association With Smoke-Free Laws Among Nonsmoking Youth Aged 3 to 15 Years, NHANES 1999–2006

	Living in a County		OR (95% CI)	
	Without a Smoke-Free Law	With a Smoke-Free Law	Unadjusted	Adjusted[a]
Self-reported current asthma, *n*	6573	2227	—	—
Weighted % (SE)	9.7 (0.5)	10.0 (0.9)	1.03 (0.81–1.30)	1.08 (0.85–1.37)
Among self-reported current asthmatic subjects, *n*	682	215	—	—
Asthma attack, weighted % (SE)	66.5 (3.5)	63.5 (4.4)	0.86 (0.51–1.45)	0.66 (0.28–1.56)
Emergency-room visit, weighted % (SE)	20.3 (1.9)	17.7 (3.4)	0.77 (0.43–1.39)	0.55 (0.27–1.13)

[a] Adjusted for survey cycle, gender, age, race, ratio of income to poverty, region, health insurance, mother's age at birth, mother's smoking status during pregnancy, low birth weight, BMI, and household size.

TABLE 3 Prevalence of Ever Having Asthma With Symptoms in the Previous Year and Association With Smoke-Free Laws Among Nonsmoking Youth Aged 3 to 15 Years, NHANES 1999–2006

	Weighted Percentage (SE) Living in a County		OR (95% CI)	
	Without a Smoke-Free Law (*n* = 6573)	With a Smoke-Free Law (*n* = 2227)	Unadjusted	Adjusted[a]
Ever asthma with current symptoms[b]	7.5 (0.5)	5.9 (0.7)	0.79 (0.58–1.07)	0.74 (0.53–1.03)
Asthmatic symptoms[b]	12.1 (0.6)	8.4 (1.1)	0.69 (0.50–0.95)[c]	0.67 (0.48–0.93)[c]
Persistent wheeze	6.4 (0.4)	3.9 (0.7)	0.57 (0.36–0.92)[c]	0.58 (0.37–0.89)[c]
Chronic night cough	3.1 (0.4)	1.6 (0.4)	0.57 (0.35–0.95)[c]	0.43 (0.24–0.76)[c]
Wheeze-medication use	9.3 (0.5)	7.2 (0.9)	0.76 (0.56–1.05)	0.79 (0.58–1.05)
Persistent ear infections (≥3) (1999–2004)	6.1 (0.5)	3.4 (0.7)	0.57 (0.33–0.98)[c]	1.01 (0.50–2.05)

[a] Adjusted for survey cycle, gender, age, race, ratio of income to poverty, region, health insurance, mother's age at birth, mother's smoking status during pregnancy, low birth weight, BMI, and household size.
[b] Persistent wheeze, chronic night cough, or wheeze-medication use.
[c] Adjusted OR was additionally adjusted for ever attending daycare.

exposure had a stronger association between smoke-free laws and ever having asthma with current symptoms (OR: 0.67 [95% CI: 0.47–0.94]) compared with youth who did experience home secondhand smoke exposure (OR: 1.25 [95% CI: 0.50–3.16]). We found no difference in the association between smoke-free laws and asthmatic symptoms by home secondhand smoke exposure (Fig 1A).

We found a stronger association between smoke-free laws and ever having asthma with current symptoms in children aged 5 to 12 years compared with children aged 3 to 4 and 13 to 15 years (Fig 1B), with adjusted ORs of 1.11 (95% CI: 0.49–2.52), 0.57 (95% CI: 0.35–0.91), and 1.34 (95% CI: 0.79–2.28) for ages 3 to 4, 5 to 12, and 13 to 15 years, respectively (*P* value for interaction = .16). A similar pattern was seen for the association between smoke-free laws and asthmatic symptoms, with adjusted ORs of 0.93 (95% CI: 0.44–1.94), 0.55 (95% CI: 0.37–0.81), and 1.08 (95% CI: 0.67–1.74) (*P* value for interaction = .05). Examining asthmatic symptoms individually, the associations between smoke-free laws and chronic night cough and wheeze-medication use followed a similar age pattern. However, the association between smoke-free laws and persistent wheeze was stronger for children aged 3 to 4 and 5 to 12 years compared with those who were aged 13 to 15 years. None of these interaction terms were statistically significant.

Persistent Ear Infection

Youth living in smoke-free counties had approximately half the prevalence of persistent ear infections in the previous year (3.4%) compared with youth living in counties without a smoke-free law (6.1%) (Table 3). However, after adjustment for covariates, this difference no longer persisted (adjusted OR: 1.01 [95% CI: 0.50–2.05]). Region accounted for the majority of this attenuation. Youth living in the South and Midwest were more likely to have persistent ear infection and were less likely to live in a smoke-free county. The OR adjusted for all covariates except region was 0.64 (95% CI: 0.37–1.10).

DISCUSSION

We examined the associations between smoke-free laws and prevalent asthma, asthmatic symptoms, asthma severity, and persistent ear infection among children and adolescents in the United States. We did not find an association between smoke-free laws and self-reported current asthma. However, smoke-free laws were associated with lower odds of ever having asthma with current symptoms (OR: 0.74 [95% CI: 53–1.03]) and asthmatic symptoms (OR: 0.67 [95% CI: 0.48–0.93]). In addition, smoke-free laws were associated with a lower odds of asthma attacks

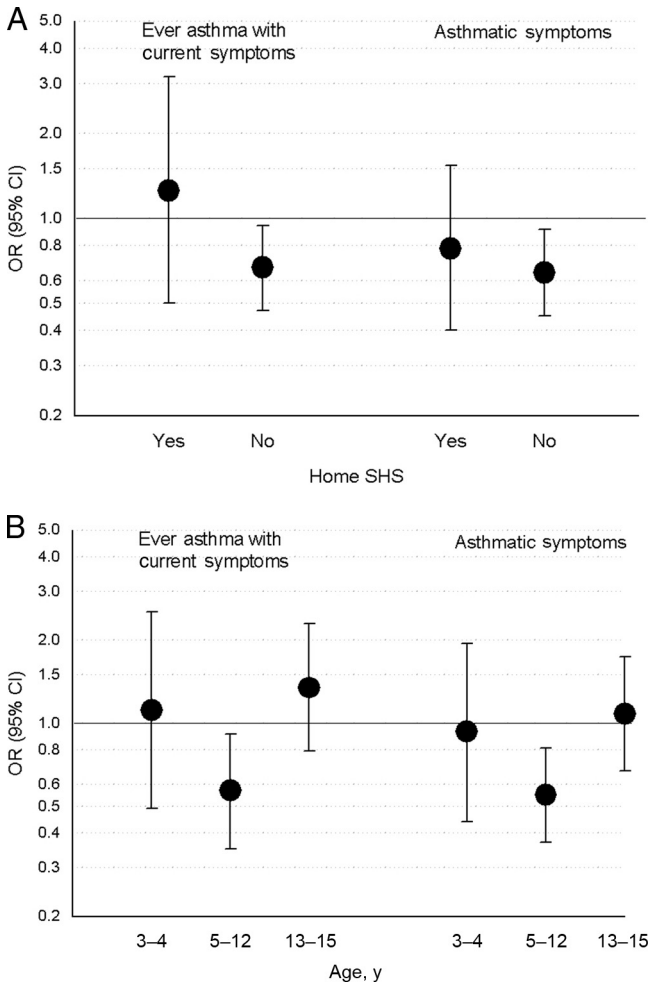

FIGURE 1
Association between smoke-free laws and ever having asthma with symptoms and asthmatic symptoms (persistent wheeze, chronic night cough, or wheeze-medication use) according to home secondhand smoke (SHS) exposure status (A) and age (B), NHANES 1999–2006. Data were adjusted for survey cycle, gender, age, race, ratio of income to poverty, region, health insurance, mother's age at birth, whether the mother smoked during pregnancy, low birth weight, BMI, and household size.

(OR: 0.66 [96% CI: 0.28–1.56]) and emergency department visits for asthma (OR: 0.55 [95% CI: 0.27–1.13]), although these results were not statistically significant. These results suggest that smoke-free laws primarily reduce the symptoms associated with asthma but not the prevalence of asthma.

The associations between smoke-free laws and ever having asthma with current symptoms and asthmatic symptoms seemed to be modified by home secondhand smoke exposure and age (although the interaction terms were not statistically significant). Youth living without a smoker in the home seemed to have a stronger association between smoke-free laws and ever having asthma with current symptoms. That is, smoke-free laws that targeted exposures to secondhand smoke outside the home had more effect on these children and adolescents without concomitant exposure at home.

Although we did not have specific information on smoking policies within the home, research has shown that smoking only outside the home reduces, but does not eliminate, children's exposure to secondhand smoke.[33,34]

The association between smoke-free laws and ever having asthma with current symptoms and asthmatic symptoms was stronger among children ages 5 to 12 years compared with children ages 3 to 4 and 13 to 15 years. The interactions between smoke-free laws and age may be because of differences in the association between secondhand smoke exposure and asthmatic symptoms because we did not find a difference in the association between smoke-free laws and secondhand smoke exposure by age (results not shown). For example, the association between smoke-free laws and persistent wheeze was stronger among children aged 3 to 4 and 5 to 12 years compared with those aged 13 to 15 years. Using data from NHANES III, Mannino et al[35] also found a slightly stronger association between secondhand smoke exposure and persistent wheeze for children aged 4 to 6 and 7 to 11 years compared with children aged 12 to 16 years. An alternative explanation is that there is limited power to detect interactions by home secondhand smoke exposure and age. Although our sample included 8800 youth, it is effectively a comparison of 26 counties with a smoke-free law to 91 counties without a smoke-free law.

We did not find an association between smoke-free laws and persistent ear infection. This was surprising given the strong evidence in the literature for a positive association between secondhand smoke and ear infection.[1,36] The adjusted OR, not adjusting for region, approached significance (OR: 0.64 [95% CI: 0.37–1.10]).

LIMITATIONS

The county-specific definition of smoke-free laws is only an approximation of individual exposure to secondhand smoke outside the home. Misclassification of exposure to smoke-free laws was possible because county smoke-

free laws may not capture individual exposure to these laws. In particular, counties with a city with smoke-free laws but no county-wide smoke-free law were classified by our definition as having no smoke-free laws. Hence, youth may have lived in the city covered by the smoke-free law and thus actually were covered by a smoke-free law. This potential misclassification of smoke-free law coverage was likely not associated with respiratory outcomes, thus not producing the observed protective association.

Misclassification of current asthma was possible because self-reports were not validated by objective measures or clinical evaluations. Parental reports generally reflect physician diagnosis, but physician diagnosis of respiratory illnesses may not be consistent across the country because it depends on access and use of medical care and on physician diagnostic practices.[37,38] Examining asthma-related symptoms attempted to capture some of the undiagnosed cases of asthma.

Residual confounding is possible. Parental asthma is an important risk factor for asthma in children. NHANES 1999–2006 did not collect this information for children and adolescents aged younger than 20 years, so this risk factor could not be adjusted in our model. However, having a parent with asthma may be an intermediate on the pathway between smoke-free laws and asthma status in youth. In that case, we would not want to adjust for having a parent with asthma.

One other study examined the impact of smoke-free laws and health in children. After implementation of a smoke-free law in Lexington-Fayette County, Kentucky,[29] emergency-department visits for asthma declined by 18% (95% CI: 4–29) among children aged 19 years or younger. We found an adjusted 45% (95% CI: −13 to 73) decrease in odds of emergency-department visits among youth with asthma associated with a smoke-free law.

These results are consistent with other NHANES studies that have looked at cotinine and asthmatic symptoms in children.[35,39] In NHANES III (1988–1994), youth with high levels of cotinine (compared with youth with low levels of cotinine) were more likely to have persistent wheeze (adjusted OR: 1.3 [95% CI 0.8–2.1])[35] and moderate to severe asthma (adjusted OR: 2.7 [95% CI: 1.1–6.8]).[39] Our results also are consistent with reviews of the effect of secondhand smoke on children's health, where there is stronger evidence for an association with asthmatic symptoms and severity than the onset of asthma.[1,40]

CONCLUSIONS

Cotinine levels have decreased by almost 60% (from 0.12 ng/mL in 1988–1994 to 0.05 ng/mL in 2003–2006) among children without exposure to secondhand smoke in the home.[41] This reduction is likely because of the implementation of smoke-free laws. Currently, 74% of the population is covered by a smoke-free law.[42]

This study shows that not only are smoke-free laws associated with reduced exposure to secondhand smoke in children, but that they are associated with fewer respiratory symptoms as well. Youth living in a county with a smoke-free law had decreased odds of having respiratory symptoms (persistent wheeze, chronic night cough, or wheeze-mediation use) compared with youth living in a county without a smoke-free law. Eliminating exposure to secondhand smoke through the implementation of smoke-free laws may improve the respiratory health of children.

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