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## Beliefs About the Health Effects of “Thirdhand” Smoke and Home Smoking Bans

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### Abstract

**OBJECTIVE**—There is no safe level of exposure to tobacco smoke. Thirdhand smoke is residual tobacco smoke contamination that remains after the cigarette is extinguished. Children are uniquely susceptible to thirdhand smoke exposure. The objective of this study was to assess health beliefs of adults regarding thirdhand smoke exposure of children and whether smokers and nonsmokers differ in those beliefs. We hypothesized that beliefs about thirdhand smoke would be associated with household smoking bans.

**METHODS**—Data were collected by a national random-digit-dial telephone survey from September to November 2005. The sample was weighted by race and gender within Census region on the basis of US Census data. The study questions assessed the level of agreement with statements that breathing air in a room today where people smoked yesterday can harm the health of children.

**RESULTS**—Of 2000 eligible respondents contacted, 1510 (87%) completed surveys, 1478 (97.9%) answered all questions pertinent to this analysis, and 273 (18.9%) were smokers. Overall, 95.4% of nonsmokers versus 84.1% of smokers agreed that secondhand smoke harms the health of children, and 65.2% of nonsmokers versus 43.3% of smokers agreed that thirdhand smoke harms children. Strict rules prohibiting smoking in the home were more prevalent among nonsmokers: 88.4% vs 26.7%. In multivariate logistic regression, after controlling for certain variables, belief

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that thirdhand smoke harms the health of children remained independently associated with rules prohibiting smoking in the home. Belief that secondhand smoke harms the health of children was not independently associated with rules prohibiting smoking in the home and car.

**CONCLUSIONS**—This study demonstrates that beliefs about the health effects of thirdhand smoke are independently associated with home smoking bans. Emphasizing that thirdhand smoke harms the health of children may be an important element in encouraging home smoking bans.

### Keywords

smoking; tobacco; pediatrics; family practice; parent; smoking cessation; secondhand smoke; environmental tobacco smoke; tobacco control

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The 2006 surgeon General's report on involuntary smoking concluded that more than 126 million people are exposed to secondhand smoke (SHS), 50 000 deaths per year are caused by SHS, and there is no "safe" level of exposure.<sup>1</sup> An increasing number of states have created laws on smoking to protect employees in restaurants, bars, and workplaces, but the home remains a place of intense and consistent exposure for nonsmoking children and adults.<sup>2</sup> The home is the predominant location for exposure of children and adults to tobacco smoke.<sup>1</sup>

The majority of adults are aware that visible SHS is harmful to health, and some smokers take measures to protect nonsmokers from this widely recognized harm.<sup>3</sup> These measures of highly variable efficacy, include opening windows, smoking in other rooms, turning on fans, or simply waiting until the smoke dissipates to mitigate the harmful effects of their smoking on others. Research has documented the association between smoking in the home and persistently high levels of tobacco toxins well beyond the period of active smoking.<sup>1,4-6</sup> These toxins take the form of particulate matter deposited in a layer onto every surface within the home; in loose household dust; and as volatile toxic compounds that "off gas" into the air over days, weeks, and months.<sup>6,7</sup> Smoking indoors on 1 day thus exposes people to tobacco toxins within that space in the future. We use the new term "thirdhand" smoke to name this complex phenomenon and define it as residual tobacco smoke contamination that remains after the cigarette is extinguished. This study is the first to examine the thirdhand smoke concept and home smoking bans.

The toxicity of low levels of tobacco smoke constituents has been proved. According to the National Toxicology Program, these 250 poisonous gases, chemicals, and metals include hydrogen cyanide (used in chemical weapons), carbon monoxide (found in car exhaust), butane (used in lighter fluid), ammonia (used in household cleaners), toluene (found in paint thinners), arsenic (used in pesticides), lead (formerly found in paint), chromium (used to make steel), cadmium (used to make batteries), and polonium-210 (highly radioactive carcinogen).<sup>1</sup> Eleven of these compounds are group 1 carcinogens (most carcinogenic designation).<sup>1</sup> For some of these compounds, such as radioactive polonium-210, the cumulative dose is especially concerning, leading health professionals to call for immediate disclosure and warnings about exposure.<sup>8</sup>

Strict no-smoking policies in the home have been associated with significantly lower levels of biochemical markers of tobacco exposure and lower health risks in nonsmokers.<sup>3,9-12</sup> Individual adult smokers who are not yet prepared to quit can therefore provide some relative protection to others by setting strict "no smoking" policies in their homes. The pressures of strict rules also may be important for encouraging smoking cessation among household members,<sup>13-19</sup> discouraging smoking initiation in youth,<sup>20-26</sup> and decreasing the risk for house fires.<sup>27</sup> Previous work showed that having children in the home, other nonsmoking adults in the home, and presence of smoke-free public places are associated

with having smoking bans.<sup>28</sup> Among smokers, longer time to first cigarette and being in the preparation stage of change are associated with home smoking bans.<sup>19</sup>

This study uses a nationally representative sample of adults to determine the prevalence of recognizing the dangers associated with thirdhand smoke and the association with household smoking bans. We hypothesized that belief about the harmful health effects of thirdhand smoke would be associated with higher rates of strict no-smoking policies within the home.

## METHODS

This study reports data from the Social Climate Survey of Tobacco Control (SCS-TC), an annual cross-sectional survey that was designed to operationalize the concept of the social climate on tobacco into a comprehensive set of quantifiable social and environmental indicators across social institutions that characterize society: (1) family and friendship groups; (2) education; (3) work-place; (4) government and political order; (5) health and medical care; (6) recreation, leisure, and sports; and (7) mass culture and communication. Survey items were developed and selected on the basis of an extensive review of extant tobacco control surveys and then reviewed by a panel of tobacco control researchers.

The SCS-TC was administered to a representative sample of US adults in September to November of 2005. Households were selected by using random-digit-dialing procedures. Once a household was reached, the adult to be interviewed was selected by the interviewer's asking to speak with the person in the household who was 18 years of age and would have the next birthday. When not at home, 5 attempts were made to contact the selected adult. The sample was weighted by race and gender within each census region, on the basis of 2005 US Census estimates. The institutional review board at Mississippi State University reviewed and approved this project. Informed consent was obtained orally as part of the introduction to the telephone interview by trained interviewers. No compensation was given to study participants. A detailed description of the survey method can be found on the SCS-TC Web site.<sup>29</sup>

### Measures

Two questions from the Behavior Risk Factor Surveillance System and the National Health Interview Survey were used to assess the current smoking status of respondents. Respondents were asked, "Have you smoked at least 100 cigarettes in your entire life?" Respondents who reported that they had were then asked, "Do you now smoke cigarettes every day, some days, or not at all?" Respondents who reported that they now smoke every day or some days were categorized as current smokers.

### Home Smoking Policies

One question was used to assess the current household's rules about smoking. Respondents were asked which of the following best describes their household's rules about smoking: (1) smoking is allowed in all parts of the home; (2) smoking is allowed in some parts of the home; (3) smoking is not allowed in any part of the home; or (4) don't know/not sure. Respondents who reported that they did not allow smoking in any part of the home were categorized as having strict rules prohibiting smoking in the home. Respondents who reported that they allowed smoking in all parts of the home or some parts of the home or did not know/were not sure were categorized as not having strict rules prohibiting smoking in the home.

### Health Beliefs About SHS and Thirdhand Smoke

One question was asked to assess health belief about SHS. Respondents were asked whether they strongly agreed, agreed, disagreed, or strongly disagreed with the following statement: “Inhaling smoke from a parent’s cigarette can harm the health of infants and children.” Respondents who strongly agreed and agreed with this statement were categorized as holding the belief that SHS harms the health of children. Respondents who disagreed or strongly disagreed with these statements were categorized as not holding the belief that SHS in the home harms the health of children.

One question was asked to assess health belief about thirdhand smoke. Respondents were asked whether they strongly agreed, agreed, disagreed, or strongly disagreed with the following statement: “Breathing air in a room today where people smoked yesterday can harm the health of infants and children.” Respondents who strongly agreed and agreed with this statement were categorized as holding the belief that thirdhand smoke harms the health of children. Respondents who disagreed or strongly disagreed with these statements were categorized as not holding the belief that thirdhand smoke harms the health of children. The “don’t know” category was handled consistently for both the SHS and thirdhand smoke variables as a third level.

### Self-report of Local Smoking Policies

Our expert panel hypothesized that knowledge of a local no-smoking policy in restaurants and bars would be associated with home smoking ban. Respondents were asked whether restaurants in their community are completely smoke-free, have designated smoking areas, or permit smoking anywhere. Similarly, respondents were asked whether bars and taverns in their community are completely smoke-free, have designated smoking areas, or permit smoking anywhere. Responses to these 2 questions were dichotomized as completely smoke-free or not.

### Statistical Analysis

We used  $\chi^2$  procedures to compare differences between age, gender, race, education, smoking status, smoking status of others in the home, rural/urban residence, health beliefs about smoking in bars, health beliefs about smoking in restaurants, and health beliefs toward SHS for the outcome variable of strict rules prohibiting smoking in the home. Associations were considered significant at the  $p < .05$  level. In our analyses, we treated “refused to answer the question” as missing data. The proportion of respondents who answered each question in each question set is reported in the footnotes of each data table. A multiple logistic regression model that controlled for demographic variables and known confounders was developed, with the dependent variable of having a strict rule prohibiting smoking in the home. All analyses were conducted by using SPSS 14 (SPSS, Inc, Chicago, IL).

## RESULTS

Table 1 shows the characteristics of the 1478 adults in the sample. Consistent with national smoking rates,<sup>30</sup> 18.9% of adults in this sample were current smokers. A total of 15.6% of the sample reported a smoker living in the home, and, among nonsmokers, 8.4% lived with a smoker. The total prevalence of homes with a smoker was 25.6%. A large majority (93%) of the respondents believed that SHS harms the health of children as opposed to only 61% of respondents who believed that thirdhand smoke harms the health of children. Significant numbers (22%) of respondents reported not knowing whether thirdhand smoke harms the health of children, whereas only 3.4% of respondents reported not knowing whether SHS harms the health of children. In bivariate analysis (Table 2), strict smoking rules were much more prevalent among nonsmokers than smokers (88.4% vs 26.7%;  $P < .001$ ).

In multivariate analysis (Table 3), controlling for sociodemographics and possible confounders, we found an independent association between belief that thirdhand smoke harms children and presence of a strict home smoking ban (adjusted odds ratio [aOR]: 2.19 [95% confidence interval (CI): 1.36–5.52]). In this multivariate analysis, belief that SHS harms children was not independently associated with a strict home smoking ban. When thirdhand smoke was removed from the model, SHS still did not achieve significance (aOR: 1.60 [95% CI: 0.69–3.60]). This lack of significance may reflect low SHS variability, with only 3.3% of the sample not believing that SHS harms the health of children. When the multivariate analysis was restricted to the 500 households that had children, SHS remained nonsignificant (aOR: 0.2 [95% CI: 0.0–1.6]).

Because current programs emphasize the harms of SHS, we wanted to explore the notion that increased strength of agreement with the SHS variable might be associated with strict home smoking ban. For the SHS variable, 38% of the sample strongly agreed and 55% agreed that SHS harms the health of children. Using disagree as the reference group for SHS, we found a positive but nonsignificant relationship between strong agreement that SHS harms the health of children and strict home smoking ban (aOR: 1.53 [95% CI: 0.58–4.00]). When we recoded the SHS reference group as agree, we found a significant relationship between strong agreement that SHS harms the health of children and strict home smoking ban (aOR: 1.87 [95% CI: 1.24–2.81]). In both cases, the OR for thirdhand smoke remained independently associated with strict home smoking ban (aOR: 2.07 [95% CI: 1.28–3.35]).

## DISCUSSION

In this large nationally representative sample, we identified an independent association between the health belief that thirdhand smoke harms children and strict no-smoking policies in the home. This novel finding is important because the thirdhand smoke concept could easily be incorporated into current and future tobacco counseling messages, tobacco control programs, policy initiatives, and guidelines. To date, programs have emphasized the harmful effects of visible SHS, a health belief that a large majority of adults already endorse. We were unable to find an association between simple belief that SHS harms children and strict home smoking ban. Our exploratory results do suggest a difference in protective home rules between those who simply agree that SHS is harmful to children and those who strongly agree that SHS is harmful to children. Emphasizing a high degree of harm caused by visible SHS may still have activity for encouraging home smoking bans. The SHS health message dates back to the 1986 Surgeon General's report, a transformative report that is now more than 20 years old.<sup>31</sup> The 2006 Surgeon General's Report summarized the intervening years of research, concluding that there is no safe level of tobacco smoke.<sup>1</sup> Meanwhile, an expanding body of evidence demonstrates that indoor spaces become contaminated with tobacco toxins after the visible smoke dissipates.<sup>4,6,7</sup>

New information emerging about thirdhand smoke exposure may offer families needed additional information about sources of possible toxic exposure of their children and may enhance their motivation to alter home smoking practices to protect better the health of their children. Thirdhand smoke health education campaigns might be more powerful motivators for these families than simply reiterating information about visible SHS exposure that most families already know. It also seems plausible that clinicians' advice about third-hand smoke and toxic liabilities for children will enhance the motivation of parents to protect their children even when they already believe that thirdhand smoke exposure is harmful. These possibilities warrant formal experimental testing to inform public education, clinician services delivery, and improved environmental health strategies for single and multi-unit dwellings.

Children are especially susceptible to thirdhand smoke exposure because they breathe near, crawl and play on, touch, and mouth contaminated surfaces. At up to 0.25 g/day, the dust ingestion rate in infants is more than twice that of adults.<sup>32</sup> Urine cotinine levels of children in homes with strict no-smoking policies are 6 times lower than in homes without strict policies.<sup>6</sup> Third-hand smoke may remain inside even when smoking took place earlier.<sup>4-7,33,34</sup> Similar to low levels of lead exposure,<sup>35</sup> low levels of tobacco smoke markers have been associated with cognitive deficits among children.<sup>36</sup> The highest tobacco exposure levels were associated with the lowest reading scores; however, the lowest levels of exposure were associated with the steepest slope in the decrement in reading levels.<sup>36</sup> These facts underscore the possibility that compounds in tobacco smoke are neurotoxic at extremely low levels and the prudence of advocating for absolute restriction of all smoking in indoor areas that are inhabited by children.

Even when absolute bans are maintained, nonsmokers can be exposed to tobacco toxins by off-gasing from the smoker's clothing, through open windows and doors,<sup>3</sup> and from exhaled toxins for several minutes after the cigarette is extinguished.<sup>37</sup> Therefore, strict smoking restrictions should be encouraged as an adjunctive strategy as the smoker is treated for tobacco dependence and advances toward the goal of permanent abstinence.

Previous research showed that reported presence of smoking bans in public places was associated with a no-smoking policy in the home.<sup>28</sup> We found a nonsignificant positive trend for reported local smoking ban in bars being associated with a strict no-smoking policy in the home. This finding may indicate that a strong community social norm affects home policy. Conversely, reported local smoking bans in restaurants was associated with a lower likelihood of a no-smoking policy in the home. Having a restaurant but not a bar ban may represent a community social norm that actively chose to allow smoking in bars. Having no ban in bars or restaurants may reflect a community with a less permissive social norm that simply had not considered the local ordinance yet at the time of the survey.

This is the first study to examine the notion of third-hand smoke and its associations with health beliefs and home smoking policies. The sample is nationally representative (and items related to smoking status ascertainment have been validated with other national survey). Limitations of the study include that the data come from a cross-sectional survey and possible causal relationships cannot be assumed. In addition, there may be residual confounding by unmeasured or unknown confounders, although we have included the common known confounders in our analyses. Our logistic model included a number of theoretical and empirical correlates of home smoking bans and represents a severe test of an independent association when most theoretical models assume interactive relationships among variables such as these. Finally, this national survey cannot give definitive answers as to which types of specific messaging may have activity in prospectively establishing strict home smoking bans; however, we have created a possible messaging strategy for researchers who are interested in using the thirdhand smoke concept and posted it as part of a free programmatic tobacco control Web site ([www.ceasetobacco.org](http://www.ceasetobacco.org)).

## CONCLUSIONS

This study demonstrated that beliefs about the health effects of thirdhand smoke are independently associated with home smoking bans. Emphasizing that thirdhand smoke harms the health of children may be an important element in encouraging home smoking bans. Health messages about thirdhand smoke contamination could be easily incorporated into current tobacco control campaigns, programs, and routine clinical practice.

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## Abbreviations

<b>SHS</b>	secondhand smoke
<b>SCS-TC</b>	Social Climate Survey of Tobacco Control
<b>aOR</b>	adjusted odds ratio
<b>CI</b>	confidence interval

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**What's Known on This Subject**

There is no safe level of exposure to tobacco smoke. Thirdhand smoke is residual tobacco smoke contamination that remains after the cigarette is extinguished. Children are uniquely susceptible to thirdhand smoke exposure.

**What This Study Adds**

No studies have explored whether beliefs toward thirdhand smoke are associated with behaviors that affect the health of children, such as setting strict no-smoking policies in the home.

TABLE 1

## Characteristics of National Survey Sample

Variable	Total Sample Valid (N =1478), % <sup>a</sup>
Age, y	
18–24	9.4
25–44	28.3
45–64	40.3
65	22.1
Gender	
Male	46.9
Female	53.1
Race	
Nonwhite	20.6
White	79.4
Education	
<12 y	6.4
High school graduate	29.2
Some college	25.8
College graduate	38.6
Residence	
Rural	25.0
Urban	75.0
Smoker status	
Current smoker	18.9
Not current smoker	81.1
Other smokers in the home	
Yes	15.6
No	84.4
Child in the home	
Yes	33.8
No	66.2
Reported presence of smoking bans in bars	
Local ban present	29.0
Local ban not present	71.0
Reported presence of smoking bans in restaurants	
Local ban present	45.0
Local ban not present	55.0
Believe that SHS harms children	
Agree	93.2
Disagree	3.3
Don't know	3.4
Believe that thirdhand smoke harms children	

<b>Variable</b>	<b>Total Sample Valid (N =1478), %<sup>a</sup></b>
Agree	61.0
Disagree	16.7
Don't know	22.3

<sup>a</sup>Percentage of respondents who answered each question in this question set ranged from 99% to 100%.

TABLE 2

Presence of Strict Home Smoking Ban According to Respondent Characteristic

Characteristic	Strict Home Smoking Ban Valid (N =1478), % <sup>a</sup>	P
Age, y		.407
18–24	81.2	
25–44	76.0	
45–64	75.2	
65	78.4	
Gender		.003
Male	73.3	
Female	79.9	
Race		.625
Nonwhite	75.7	
White	77.0	
Education		<.001
<12 y	58.7	
high school graduate	70.5	
Some college	74.1	
College graduate	86.4	
Residence		.318
Rural	74.8	
Urban	77.3	
Smoker status		<.001
Current smoker	26.7	
Not current smoker	88.4	
Other smokers in the home		<.001
Yes	43.1	
No	82.5	
Child in the home		<.001
Yes	83.5	
No	73.2	
Reported presence of smoking bans in bars		.712
Local ban present	76.4	
Local ban not present	77.2	
Reported presence of smoking bans in restaurants		.554
Local ban present	73.5	
Local ban not present	75.2	
Believe that SHS harms children		<.001
Agree	79.0	
Disagree	51.0	
Don't know	40.0	
Believe that thirdhand smoke harms children		<.001

Characteristic	Strict Home Smoking Ban Valid (N =1478), % <sup>a</sup>	P
Agree	82.1	
Disagree	57.5	
Don't know	76.2	

<sup>a</sup>Percentage of the 1478 respondents who answered each question in this question set ranged from 99% to 100%.

**TABLE 3**

Final Logistic Regression Model Showing Odds of Having a Strict Home Smoking Ban

Predictor	Strict Home Smoking Ban, aOR (95% CI)
Thirdhand smoke and SHS beliefs	
Believe that thirdhand smoke harms children	2.190 (1.360–3.520)
Don't know whether thirdhand smoke harms children	1.910 (1.100–3.320)
Believe that SHS harms children	0.980 (0.390–2.470)
Don't know whether SHS harms children	0.230 (0.070–0.830)
Smoking status	
Nonsmoker	12.830 (8.470–19.460)
No other smokers in home	2.900 (1.840–4.590)
Presence of child living in home	
Child in home	2.900 (1.860–4.520)
Community smoking bans	
Reported local ban in bars	1.630 (0.995–2.680)
Reported local ban in restaurants	0.580 (0.370–0.910)
Race	
White	2.090 (1.370–3.280)
Education	
High school	1.920 (0.880–4.200)
Some college	2.320 (1.040–5.160)
College	4.300 (1.900–9.720)

Model also included age, gender, and rural/urban residence, all not significant.