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Association between clean indoor air laws and voluntary smokefree rules in homes and cars

Kai-Wen Cheng,1 Cassandra A Okechukwu,2 Robert McMillen,3 Stanton A Glantz4

ABSTRACT

Objectives This study examines the influence that smokefree workplaces, restaurants and bars have on the adoption of smokefree rules in homes and cars, and whether there is an association with adopting smokefree rules in homes and cars.

Methods Bivariate probit models were used to jointly estimate the likelihood of living in a smokefree home and having a smokefree car as a function of law coverage and other variables. Household data were obtained from the nationally representative Social Climate Survey of Tobacco Control 2001, 2002 and 2004–2009; clean indoor air law data were from the American Nonsmokers’ Rights Foundation Tobacco Control Laws Database.

Results ‘Full coverage’ and ‘partial coverage’ smokefree legislation is associated with an increased likelihood of having voluntary home and car smokefree rules compared with ‘no coverage’. The association between ‘full coverage’ and smokefree rule in homes and cars is 5% and 4%, respectively, and the association between ‘partial coverage’ and smokefree rules in homes and cars is 3% and 4%, respectively. There is a positive association between the adoption of smokefree rules in homes and cars.

Conclusions Clean indoor air laws provide the additional benefit of encouraging voluntary adoption of smokefree rules in homes and cars.

INTRODUCTION

The prevalence of cigarette smoking in the USA has decreased from 50% in the 1940s to around 20% in the 2000s.1–2 The widespread knowledge of the health risks associated with cigarette smoking and secondhand smoke (SHS) and the implementation of antismoking programmes and legislation restricting public smoking have been credited with this decrease.3–4 Nevertheless, there were still 88 million nonsmokers aged 3 years and over who were exposed to SHS in 2007–2008.5

Epidemiological and laboratory studies have concluded that SHS exposure causes cardiovascular disease, lung cancer, acute respiratory illness, sudden infant death syndrome, and other health consequences in infants and children.6–11 Due to state and local smoking restrictions, the proportion of people protected by comprehensive smokefree legislation in workplaces, restaurants and bars has increased dramatically between 2000 and 2009 from less than 1% to 36%.12 With an extension of smokefree legislation into many public areas, private places such as homes and cars have become the primary setting for exposure to SHS,13 especially for children.3,14

A growing body of literature has found that smokefree laws in public places are associated with an increase in the adoption and support of voluntary smokefree rules in homes.15–24 Most studies investigating the relationship between smokefree laws and SHS exposure in private places such as homes have been conducted in Europe; one US study found similar associations between county-level adoption of smokefree rules and household-level adoption of home smokefree rules.18 It remains unknown whether the influence of smokefree laws extends to SHS exposure in cars and whether there is an association between adoption of home and car smokefree rules. Our study extends previous research by examining the influence of smoking restrictions in workplaces, restaurants and bars on the adoption of smokefree rules in homes and cars. In addition, we investigate whether such car smokefree rules may simply be an extension of home rules or vice versa by taking into account the underlying factors that may be correlated with the adoption of home and car smokefree rules.

METHODS

Data

Person-level data are from the 2001, 2002 and 2004–2009 Social Climate Survey of Tobacco Control (SCS-TC), an annual, cross-sectional nationally representative telephone survey conducted by the Social Science Research Center at the Mississippi State University. Eligible respondents were non-institutionalised and English-speaking people aged 18 or over living in a household with a landline telephone. The sample was weighted according to race and gender within each census region, to be representative of the US population, on the basis of US Census estimates. Once a household was contacted, the interviewer requested to speak with the person in the household 18 years of age who would be having the next birthday. Five attempts were made to contact selected adults who were not home.

The cooperation rate for the survey was about 85% for surveys in 2001–2007, 77% in 2008 and 60% in 2009. The cooperation rate was calculated by the number of respondents who completed interviews divided by the number of eligible respondents successfully contacted. The sample size was about 3000 for each wave during 2001–2004 and about 1500 for each wave during 2005–2009. The 2006 survey randomly asked the question about home smokefree rules in two different ways, with 883 respondents being asked the version that is consistent with the surveys in other years, and these respondents were included in the study. We did not include the 2000 and 2003 surveys because...
the 2000 survey did not provide information on smoking restrictions in cars, and neither the 2000 nor 2003 surveys included information on smoking status for household members to identify whether the household included a smoker. The surveys were reviewed by the Institutional Review Board at Mississippi State University. Verbal informed consent was obtained from participants.

The SCS-TC 2001, 2002 and 2004–2009 included information on self-reported smokefree rules in homes and cars, self-reported SHS exposure in several areas (home, own car, someone else’s car, indoor public places, other indoor areas, public sidewalk, and the doorway of the building); smoking behaviours (smoking status and intensity), household composition (living with children) and demographics.

In addition, the dataset provided information on whether there was anyone living in the household who currently smoked cigarettes. The questions of which household member smoked (spouse or significant other, children, adult children and other adults) allow researchers to identify whether the respondent lived with any smokers.

The data on clean indoor air laws come from the American Nonsmokers’ Rights Foundation (ANRF) US Tobacco Control Laws Database. This database provides the information on when smoking laws are introduced, the coverage (ie, workplaces, restaurants or bars), the strength of the laws (ie, 100% smokefree, some coverage and no coverage), and whether the laws are at the city, county or state level. As described previously, a county was categorised as having a ‘full coverage’, ‘partial coverage’ or ‘no coverage’ laws based on whether there was a 100% smokefree law for either workplaces, restaurants or bars, and whether the law covered the entire county population due to state, county or municipal laws singly or in combination. This categorisation allows for discernment of cases whereby local jurisdictions (municipalities or counties) may have implemented smokefree laws prior to county-wide (or state-wide) adoption. If a 100% smokefree law covered the entire county population, that county was categorised as having a ‘full coverage’. If a 100% smokefree law covered only part of county population, that county was categorised as having a ‘partial coverage’. If there was no 100% smokefree law at any jurisdiction level, that county was categorised as ‘no coverage’. Using county of residence provided in SCS-TC, the law coverage in 2001, 2002 and 2004–2009 was linked to respondents’ answers to the SCS-TC survey to identify coverage by smokefree laws for each respondent in each year of the survey.

Variables
Respondents were asked, ‘Which of the following best describes your household’s rules about smoking?’ If respondents answered ‘not allowed in any part of home’, they were classified as having a home smokefree rule; for those who answered ‘allowed in some areas’ or ‘allowed in all areas’ were classified as not having a home smokefree rule. Respondents were also asked, ‘Please tell me which best describes how cigarette smoking is handled in your car?’ If respondents answered ‘no one allowed to smoke in my car’, they were classified as having a car smokefree rule; for those who answered ‘only special guests are allowed to smoke in my car’ or ‘people are allowed to smoke in my car’ or ‘not sure’ were classified as not having a car smokefree rule. The respondents with missing data on the smokefree rule in homes (N=17, 0.11% of survey sample) and the respondents with missing data on the smokefree rule in cars (N=1189, 7.81% of survey sample) were excluded from the analysis. Respondents who did not own a car account for all the missing data for the smokefree rule in cars.

A respondent was identified as a current smoker if he or she had smoked over 100 cigarettes in their lifetime and currently smoked cigarettes. Demographic variables included age cohort (aged 18–24, 25–44, 45–64 and 65+), education attainment (high school below, some college, and college and above), race (Caucasians, African American and others), gender (men, women), marital status (married, not married) and employment status (employed, not employed).

For household information, respondents were asked ‘How many children under 18 years of age currently live in your household?’ Those who answered ‘at least one’ were classified as living in a household with children; others were classified as not living in a household with children. Respondents were also asked ‘Whether your spouse or significant other living in your household currently smokes cigarettes’, ‘Whether your adult children living in your household currently smoke cigarettes’, ‘Whether your children living in your household currently smoke cigarettes’, ‘Whether other adults living in your household currently smoke cigarettes’. Respondents who were smokers or answered ‘yes’ to any of the above questions were classified as living in a smoker household.

Data analysis
The bivariate associations of each independent variable with a smokefree rule in homes and cars were examined using Pearson’s χ² test. The multivariate analysis applied a bivariate probit model which jointly estimated the likelihood of living in a smokefree home and having a smokefree car by taking into account that the adoption of the two rules may be correlated. The multivariate analysis included the respondents who had information for the smokefree rules in homes and cars. The covariates include law coverage (full, partial and no coverage), age cohort, education attainment, race, gender, marital status, employment status, whether child <18 years old lives in the household, whether any smoker lives in the household and year variables. The estimated ρ from the model indicates whether the unexplained influences on the likelihood of having a home smokefree rule and the likelihood of having a car smokefree rule are correlated, and the sign direction of the estimated ρ indicates whether the unexplained influences on home and car rules are positively or negatively correlated. In the bivariate probit model, the marginal effect (ME) of each independent variable on the outcome for an average hypothetical person. With a categorical independent variable, ME indicates the partial effect of the independent variable on the outcome for an average hypothetical person evaluated using average covariates in different categorical situations. In the bivariate probit model, SEs were robust to heteroskedasticity and clustered at the state level.

Alternative model specifications
The primary analysis treated year as a continuous variable. We conducted an alternative analysis that treated year as a categorical variable (using dummy variables) to avoid having to make any assumptions about the shape of the underlying secular trends. In addition, we conducted alternative multivariate analyses using bivariate probit models including several interaction terms: smoker household × partial coverage, smoker household × full coverage, year × partial coverage, and year × full coverage were added into the model to estimate whether the influence of smokefree laws on smokefree rules in homes and cars differ by types of
households, and whether the influences of smokefree laws on a smokefree rule in homes and cars differ by year.

Statistical calculations
All analyses were weighted by sex, race, age and census region to produce nationally representative estimates. Analyses were conducted using STATA/SE 12 in 2012–2013.

RESULTS
Sample description
The prevalence of people indicating that they lived in a smokefree home increased from 74% in 2001 to 79% in 2009. Smokefree home prevalence among people living in a nonsmoker household was consistently high, reaching 90% in 2009, while the prevalence among people living in a smoker household ranged from 32% in 2001 to only 45% in 2009 (figure 1).

The prevalence of having a car smokefree rule hovered around 75% among people living in all households and around 89% for people living in nonsmoker households from 2001 to 2009 (no significant time trend; figure 2). Among people living in smoker households, the prevalence of smokefree car policies fell from 47% in 2001 to a low of 28% in 2006 before rebounding to 34% in 2009 (a quadratic regression against time yielded significant negative linear and positive quadratic terms; p<0.01 for both).

People living in a county with partial or full coverage of smoking restrictions in public places have a higher rate of a smokefree rules in homes and cars compared with those living in a county without any law coverage (full: 81.0%, partial: 81.2%, none: 74.3% for smokefree home; full: 81.5%, partial: 83.7%, none: 76.7% for smokefree car).

Respondents living in a household with smokers have a lower rate of a smokefree rules in homes and cars compared with those living in a household without any smokers. People aged 18–24 have the lowest rate of smokefree rules in cars compared with older age categories. African Americans have the lowest rate of smokefree rules in homes compared with Caucasians and other races, while Caucasians have the lowest rate of smokefree rules in cars compared with African Americans and other races. People who are employed have a higher rate of smokefree home rules than those who are not employed.

Female, nonsmoker and married respondents have a higher rate of smokefree rules in homes and cars than men, smokers and unmarried people. Respondents with higher education have a higher rate of smokefree rules in homes and cars compared with less educated people.

Bivariate analysis
Bivariate analysis (table 1) indicated that smokefree rules in homes and cars are significantly associated with law coverage,
household type, respondent's smoking status, and respondent's socioeconomic status and demographics, such as gender, marital status, age, education and ethnicity (all p<0.01).

**Multivariate analysis: a bivariate probit model**
The bivariate probit model adjusted for all covariates (table 2) indicated that compared with a 'no coverage' by smokefree law at the area level, 'full coverage' smokefree legislation is associated with an increased likelihood of having a home and car smokefree rule by 5% and 4%, respectively (ME=0.05, 95% CI 0.03 to 0.08 for smokefree home; ME=0.04, 95% CI 0.02 to 0.07 for smokefree car) and 'partial coverage' is associated with smokefree rules in homes and cars by 3% and 4%, respectively (ME=−0.37, 95% CI −0.41 to −0.33 for smokefree home; ME=−0.32, 95% CI −0.35 to −0.28 for smokefree car). Compared with those living in nonsmoker households, people living in smoker households are significantly less likely to report that they have a smokefree rule in homes and cars.

Table 1 Profiles of respondents having a smokefree rule in their homes or cars 2001, 2002, 2004–2009

<table>
<thead>
<tr>
<th></th>
<th>Living in home with 100% smokefree rule</th>
<th>Having a car with 100% smokefree rule</th>
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<tr>
<td></td>
<td>N=15198</td>
<td>N=14026</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>p Value</td>
</tr>
<tr>
<td>100% law coverage</td>
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<td>74.3%</td>
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<tr>
<td>None</td>
<td></td>
<td>81.2%</td>
</tr>
<tr>
<td>Partial</td>
<td></td>
<td>81.0%</td>
</tr>
<tr>
<td>Full</td>
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<td>77.1%</td>
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<tr>
<td>Household composition</td>
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<td>Living with children</td>
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<tr>
<td>Not living with children</td>
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<td></td>
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<tr>
<td>Household type</td>
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<tr>
<td>Not a smoker household</td>
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<tr>
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<td>Smoking status</td>
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<tr>
<td>Nonsmoker</td>
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<tr>
<td>Age</td>
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<tr>
<td>Age 18–24</td>
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<td>74.7%</td>
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<tr>
<td>Age 25–44</td>
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<td>Age 45–64</td>
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<td>Age 65+</td>
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<tr>
<td>Not married</td>
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<tr>
<td>Education</td>
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<td>High school graduates</td>
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<tr>
<td>Some college</td>
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<tr>
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<tr>
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<tr>
<td>Race/ethnicity</td>
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<td>Caucasian</td>
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<td>77.0%</td>
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<tr>
<td>African American</td>
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<td>70.9%</td>
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<tr>
<td>Other races</td>
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<tr>
<td>Gender</td>
<td>&lt;0.01</td>
<td>74.7%</td>
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<tr>
<td>Men</td>
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</tr>
<tr>
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<td>75.3%</td>
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<tr>
<td>Not employed</td>
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p Values from χ² tests.
The total number of observations for SCS-TC 2001, 2002, 2004–2009 is 15,215. Excluding the missing data for the home smokefree rule (N=17) results in a sample size of 15,198 respondents for the smokefree rule in homes; excluding the missing data for the car smokefree rule (N=1,189) results in a sample size of 14,026 respondents for the smokefree rule in cars.

The positive ρ estimated from the bivariate probit model indicated that the decisions to have a smokefree home and car are positively correlated (ρ=0.57, 95% CI 0.54 to 0.61), reflecting some underlying influences causing a common behavioural change in smokefree rule adoption in homes and cars.

College graduation and above is associated with an increased likelihood of having a home and car smokefree rule (ME=0.05, 95% CI 0.03 to 0.07 for home smokefree; ME=0.06, 95% CI 0.04 to 0.07 for car smokefree). Being a smoker is associated with a decreased likelihood of reporting a smokefree home and car (ME=−0.18, 95% CI −0.21 to −0.14 for home smokefree; ME=−0.25, 95% CI −0.30 to −0.20 for home smokefree; ME=−0.32, 95% CI −0.35 to −0.28 for car smokefree).

Some different predictors of having a smokefree rule in homes and cars are present. The presence of children at home significantly increased the likelihood of having a smokefree rule in both homes and cars (ME=−0.41 to −0.33 for home smokefree; ME=−0.32 to −0.20 for car smokefree).

Some of the interactions between law coverage and year variable (year × partial, year × full) in the equations for smokefree home and smokefree car indicated that there is no significant evidence so that the associations change by year.

**DISCUSSION**

Using a different data source we confirmed our previous study findings that smokefree laws were associated with increased voluntary smoking restrictions at home. In addition, we found that being covered by smokefree legislation that protects one from exposure to cigarette smoke in public places is associated with individuals enacting smokefree rules in their own homes and cars. This finding is significant because of fears that enacting smokefree laws in public places will lead to increased exposure of vulnerable populations to SHS due to increased smoking in private spaces.

This finding of a positive association between comprehensive smokefree legislation and car smokefree rule adoption is consistent with the findings by Hitchman and colleagues who used the International Tobacco Control Four Country Survey (Australia, UK, Canada and USA) to show that countries with the most widespread comprehensive smokefree laws and tobacco control programmes have the lowest prevalence of smoking in cars with nonsmokers.

Importantly, this study provided the first nationally representative prevalence of car smokefree rules over time, from 2001 to 2009. Our results show that the prevalence of smokefree rules in cars among people living in a smoker household was consistently as low as 35% from 2001 to 2009. Given the scarcity of the data on smoking in cars, existing studies have only focused on the prevalence of car smokefree rules for specific state, ethnicity, children subgroups, or a certain year. While previous studies indicated that around 23% of children were exposed to SHS in cars in 2009 and 44% of smokers smoked in cars with nonsmokers in 2007, our findings indicated...
that, in general, 66% of people living with smokers reported that smoking was allowed in their cars in 2009. This evidence indicated a higher prevalence of potential SHS exposure in cars, and tobacco control efforts are urgently needed to promote smokefree cars, especially when children are present.

Limitations
One limitation is that the sequential cross-sectional nature of the data does not allow us to draw strict cause and effect conclusions. The information on home and car smokefree rules is self-reported, and subject to recall bias and social desirability. Mumford and colleagues reported that in 12% of their sample, members of the same household provided inconsistent answers to questions about 100% smokefree restriction inside the home. This inconsistency and non-compliance may lead to a misclassification of SHS exposure in the home by using home smokefree rule adoption as its proxy variable. If the misclassification of SHS exposure mainly comes from social desirability, so that people living in places with strict smokefree laws in public places may be more likely to answer that they have smokefree rules in their homes and cars than people living in places without smokefree laws, this may lead to our estimated association being biased upward.

In addition, public attitudes about cigarette smoking, a common determinant of smokefree laws and voluntary smokefree rules in homes and cars, may lead to a positive association between the likelihood of living in a place with strong smokefree laws and having a smokefree rule in private places. For example, people living in places with strong attitudes against (or towards) cigarette smoking are more likely to support (or not support) the smokefree bill and voluntarily adopt (or not adopt) smokefree rules in homes and cars.

We have data on coverage by, but not compliance with, smokefree laws. Neither the ANRF nor the SCS-TC provide information on compliance, and thus it is not possible to include the compliance in the analyses. The changing distribution of landline telephones during the study period creates another potential limitation. In the mid 2000s, wireless substitution of landlines for telephones during the study period creates another potential limitation. The changing distribution of landline telephones during the study period creates another potential limitation.

Finally, this study could only only draw conclusions about the relationship between smokefree law coverage and a smokefree rule in homes and cars for people who own a car, because our multivariate analysis only included those respondents with information on smokefree rules in homes and cars.

CONCLUSIONS

Homes and cars are usually seen as one of the last places that smokers can smoke without interference. This study found that the clean indoor air laws provide the additional benefit of encouraging voluntary adoption of smokefree rules in homes and cars.

What is already known on this subject
Smoking restrictions in public places and homes protect people from the health risks of secondhand smoke exposure and reduce cigarette smoking.

What this study adds

Enactment of laws making public places and workplaces smokefree is a powerful stimulus for adopting voluntary smokefree policies in homes and cars.


