Published in final edited form as:

Tob Control. 2013 May ; 22(3): 184–189. doi:10.1136/tobaccocontrol-2011-050157.

Association between local indoor smoking ordinances in Massachusetts and cigarette smoking during pregnancy: a multilevel analysis

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Abstract

Objective—To estimate the association between local clean indoor air ordinances and prenatal maternal smoking across 351 municipalities in Massachusetts before the 2004 statewide ban and to test the effect of time since ordinance adoption on the association.

Methods—The authors linked 2002 birth certificate data of women who gave birth in the state and reported a Massachusetts residence (n=67 584) to a database of indoor smoking ordinances in all municipalities. Multilevel regression models accounting for individual- and municipality-level variables estimate the associations between the presence of local smoking ordinances, strength of the ordinances, time since ordinance adoption and prenatal smoking.

Results—Compared with those living in municipalities with no ordinances, women living in municipalities with a smoking ordinance had lower odds of prenatal smoking (OR=0.72, CI=0.53 to 0.98). No effect was found for 100% smoke-free ordinances. For the analyses testing the effect of time, pregnant women living in municipalities with ordinances enacted >2 years were less likely to smoke than those in municipalities with more recent (<1 year) ordinances.

Conclusions—Preventing smoking among women of reproductive age is a public health priority. This study suggests that indoor smoking ordinances were associated with lower prenatal

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Competing interests None.

Ethics approval Harvard School of Public Health and Massachusetts Department of Public Health.

Contributors All authors contributed to the manuscript. KHN was responsible for obtaining the public use database and lead the analyses and drafting of the manuscript. SVS, GS and RJW contributed to the design, interpretation of the analysis and revising the manuscript.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Study data belongs to the Massachusetts Department of Public Health and not to the study authors. Access to the birth certificate data is given exclusively by the Department.

smoking prevalence and the favourable effect increased over time. Findings highlight the public health benefit of tobacco control policies.

INTRODUCTION

There is substantial evidence demonstrating clean indoor air regulations reduce exposure to secondhand smoke known to increase risk for adverse health including lung cancer, heart disease and childhood asthma. However, a growing number of studies suggest that clean indoor air regulations have a direct impact on cigarette smoking prevalence.¹ Clean air policies may be enacted in both private (ie, workplace regulation prohibiting smoking at a designated worksite) and public sectors (ie, state law smoking ban in enclosed public places like restaurants and bars) and can vary in the degree of restrictions from a partial to complete smoke-free ban. Early studies of smoking policies in the private sector, specifically the workplace, found positive outcomes among workers including decreased numbers of cigarettes smoked per day, higher quitting rates and an increased likelihood of cessation.² Subsequent research examined the effect of clean indoor air legislation enacted in both private and public sectors on smoking prevalence in the broader population, not just those who are directly affected by a workplace policy, noting significant declines in population smoking prevalence following the legislation.¹³ More recent research found reductions in hospital admissions of smoking-related illnesses, including acute coronary events and asthma, following the implementation of smoke-free legislation.¹

Moreover, tobacco laws, ordinances and policies in the USA can be instituted at various levels of government: municipality, state and federal. To date, most studies have focused on state or national laws and few compare the relationship between policy and smoking across local jurisdictions despite the influence of local tobacco control activity on policy development at higher level jurisdictions.⁴⁵ Another important aspect of smoke-free legislation is the length of time it has been adopted. Findings from studies on this topic are mixed; some suggest a strong positive effect on smoking prevalence up to a year following policy adoption but levelling off or declining over time, while others show an increasing effect over time.⁶⁷ Studies that use a 'before-and-after' smoking policy design comparing a single point in time and/or geographic area may have methodological limitations because they do not account for confounding effects of secular and geographic factors on smoking prevalence before the introduction of the policy.

The effect of clean indoor air policies on smoking behaviour has also been shown to vary across groups including youth and women.³⁸ Women of reproductive age who smoke are at increased risk for negative health consequences for themselves, adverse pregnancy outcomes and negative effects on their unborn child, including increased risk for complicated births, low birth weight and neuro-behavioral and physical health problems in children later in life.⁹ Preventing smoking among pregnant women therefore is a public health priority.

In the mid-1990s, Massachusetts state experienced a dramatic fall in the prevalence of smoking during pregnancy that was attributed to work of the Massachusetts Tobacco Control Program, which was formed in 1994 as a response to 'Question 1', a voter initiative raising the state cigarette excise tax to fund a statewide tobacco control program.¹⁰ The programme raised public awareness for stronger tobacco control measures and funded local efforts to push for indoor smoking regulation. Since 1992, the percentage of women who smoked during pregnancy declined by 48%, from 15.2% to 7.9% in 2002.¹¹ Despite the observed temporal pattern, currently no empirical study has examined the relationship between smoking regulations and prenatal smoking prevalence in Massachusetts.

We therefore test the hypothesis that local indoor smoking ordinances are associated with a lower likelihood of smoking during pregnancy after accounting for municipality-level

clustering and adjusted for potential individual- and municipality-level confounders including an indicator for baseline community smoking social norms. Our study focuses on the time period before the 2004 Massachusetts statewide smoke-free legislation was implemented to compare the effect of restaurant and bar smoking ordinances across 351 municipalities (cities and towns). The breadth of restrictions as well as the time the policy was adopted varied immensely across municipalities; this patchwork of smoking regulations provides us with a unique opportunity to examine smoking variation. We explicitly examine the number of years since policy adoption as a predictor of prenatal smoking and allow for the effect to vary across municipalities.

METHODS

We first constructed a data set that contained relevant information at two levels—the individual and municipality levels—to conduct a cross-sectional analysis on the relationship between policy and smoking during pregnancy. Information about smoking behaviour during pregnancy was obtained from birth certificates of all births of Massachusetts-resident mothers that occurred in the state during 2002.¹¹ The year 2002 was chosen as a meaningful time-point because it predated the 2004 statewide indoor smoking ban. The unit of observation was the mother; thus, singleton, twin or higher order multiple births for the same mother were counted as one. There were 63 678 Massachusetts residents who gave birth in the state between 1 January and 31 December 2002. Data on local smoking ordinances in restaurants and bars were obtained from the Massachusetts Tobacco Control Program, which maintains a database of tobacco-related policies in the state's 351 cities and towns or municipalities.¹⁰ The 2000 US Census provided relevant contextual data at the municipality level. Lastly, similar to previous studies,^{8,12} election data on Question 1 was used as an indicator of community support for tobacco control and was acquired from the Office of Massachusetts Secretary of State (Public Document No. 43, Massachusetts Elections Statistic, 1992). Study procedures were approved by the Commonwealth of Massachusetts Department of Public Health and the Harvard School of Public Health Human Research Committee Institutional Review Board.

Measures

Dependent variable—Health-related questions asked on birth certificates including smoking were expanded in 1989 and since then has been collected by the Massachusetts Department of Public Health. Mothers were asked whether they smoked at any time during pregnancy and, if yes, the average number of cigarettes smoked per day. Smoking during pregnancy was coded 'yes' if the number of cigarettes smoked daily equalled one or more.

Independent variables—The tobacco control database contained information on any restaurant and bar smoking ordinance adopted for each of the 351 municipalities. Based on our primary hypothesis that the presence of an ordinance is associated with lower maternal prenatal smoking prevalence, we coded a variable indicating the absence or presence of a local ordinance enacted by the end of year 2001. We then created a second variable to capture the strength of the ordinance indicating whether or not the town adopted an ordinance that completely banned smoking in restaurants (100% smoke free) or partial smoke-free ordinances including smoking restricted to enclosed, separately ventilated areas or no smoking allowed but variances allowed; and smoking restricted to designated areas or not restricted.

The day, month and year of ordinance adoption by the municipality is given for each ordinance in the data set. The variable time since ordinance adoption was constructed by subtracting 31 December 2001 from the date the ordinance was adopted. The time variable

was categorised as <1, 1–2, 2–3 and ≥3 years (with no overlap in time between the categories). Potential individual-level covariates identified for inclusion in statistical models were based on theoretical ground, risk factors for prenatal smoking identified in the prior maternal and child health epidemiologic literature, and availability of variables in the birth certificates data. Covariates included maternal education (high school diploma or general equivalency diploma) or less, some college and bachelor degree or higher; maternal age in years (<24, 25–29, 30–35 or ≥36 years); race/ethnicity (non-Hispanic Caucasian, Hispanic, non-Hispanic African–American, Asian/Pacific Islander or other); marital status (married vs unmarried including single, divorced and widowed); nativity or birthplace of the mother (foreign born vs US born, including Puerto Rico) and parity (number of pregnancies, not including the current pregnancy, treated as a continuous variable). Select municipality-level covariates drawn from the 2000 US Census were included in the analyses based on prior studies.^{12–14} Support for Question 1 indicating whether or not a municipality voted for the 1992 ballot initiative that mandated an increase in the cigarette tax was used as a measure of the anti-smoking sentiment in the municipality that preceded the implementation of most of the restaurant/bar smoking regulations. The variable is coded ‘yes’ in support of Question 1 if ≥51% of voters in the municipality voted for the initiative, otherwise ‘no’. Other municipality covariates included were population size (<20 000, 20 000–49 999 and ≥50 000), education (continuous variable defined as proportion of residents with a high school education or more), per cent Caucasian (percentage of residents who identified their race as non-Hispanic Caucasian) and per cent female (percentage of residents who were identified their gender as female). There was a significant correlation between education and income at the municipality level; we decided to use municipality-level education because education was also available at the individual level, whereas income was not.

Statistical analysis

We employed a cross-sectional analysis using multilevel modelling to relate local smoking ordinance to maternal prenatal smoking. From the birth certificate data set, individuals missing key study variables (smoking, race/ethnicity, nativity, age, parity, education and marital status) were excluded, and the final study sample size is 67 584. Birth certificate data were linked to the census data using a Federal Information Processing Standards (FIPS) code and then appended to the local ordinance and election data by the name of municipality to create the final data set used in the study analyses. All data sets were linked successfully (ie, 100% match by FIPS code or municipality name). We used two-level hierarchical logistic regression models which allows for determination of the independent effects of restaurant and bar smoking ordinances on prenatal smoking behaviour, accounting for both individual- and area-level influences simultaneously as well as adjusting for possible spurious relationships in the main association.¹⁵ In SAS software (version 9.1, SAS Institute, Cary, NC, USA) and using a binomial logit-link with second order Predictive/Penalized Quasi-likelihood approximation procedures allowing for dispersion, we calculated the ORs and their 95% CIs by municipality. Findings with a p value of <0.05 were considered statistically significant.

For the time analyses, we first tested the interaction between strength of smoking regulation and length of time and found that the interaction term was statistically significant, suggesting that the effect of the policy on smoking during pregnancy varied according to the length of time since policy adoption. Based on these results (not shown), we conducted further analyses on a restricted sample of individuals living in towns with any smoking ordinance to test the time effect. The final data set included only individuals (n=57 900) living in the 219 towns with any restaurant and bar regulation in effect by 31 December 2001 (so excluded were the 9684 individuals living in the 152 towns without any smoking

ordinance). We modelled time as a level 2 variable, and the most recent time segment (<1 year) was set as the reference group.

RESULTS

Descriptive statistics illustrating study variables are shown in table 1. Most women were currently married (79%); 52% were 30 years or older; 77% were Caucasian, 7% were African-American, 9.2% were Latino and 6.9% were other; and 22% were foreign born. Forty-eight per cent reported at least a college education, 24% some college and 28% had at least a high school degree. Prevalence of smoking during pregnancy in the study sample was 6.5%.

The mean population size of municipalities was approximately 18 088. About two thirds had <15 000 residents (n=230, 65.5%). Municipalities were predominately Caucasian (96%). The mean percentage of residents with at least a high school education was 34% (SD=18.5%). Almost two thirds, 219 of 351, cities and towns passed a smoking ordinance by the end of 2001, and 37 of them adopted a 100% smoke-free ordinance. The length of time the policy has been adopted prior to the end of 2001 ranged from 0.08 to 18.7 years (mean=2.6 years, SD=3.1). One hundred fifty-seven towns had a policy for <1 year (48%); in contrast, 113 towns had a policy in effect for >3 years (32%). The majority of municipalities (n=228) voted in support of Question 1 to raise cigarette excise taxes.

Local smoking ordinance

Results from the null multilevel regression models suggest that presence of an ordinance was independently associated with prenatal maternal smoking (table 2, model 1). These effects remained significant after adjusting for both individual- and municipality-level variables (table 2, model 2). Women living in a municipality with a clean indoor air ordinance were less likely to smoke during pregnancy compared with those living in a municipality without an ordinance (OR=0.72; model 2). The marginal effect for 100% smoke-free ordinances on prenatal smoking was not statistically significant. Among individual-level variables, education was negatively associated with smoking during pregnancy, with the highest odds of smoking among individuals with a high school degree or less. Hispanic ethnicity, being married and foreign-born status were protective against smoking. Among the municipality factors, only municipality education was significantly, and inversely, associated with prenatal smoking. After adjusting for the other variables included in the models, population size, voting on Question 1 and per cent Caucasian were not significant predictors of prenatal smoking.

Time of smoking ordinance

Results from the regression analyses of time on prenatal smoking are given in table 3. After adjusting for both individual-and municipality-level factors, length of time was negatively associated with pregnancy-related smoking but only after 2 years. In municipalities with a smoking ordinance in effect for ≥ 2 years, individuals reported lower odds of smoking during pregnancy (OR=0.65–0.76) compared with those living in municipalities with policies instituted for <1 year. The effect for individuals living in municipalities with a newly established policy, 1–2 years, was not significant.

DISCUSSION

We examined the effects of clean indoor air policy variables including strength of ordinance and time since ordinance adoption on prenatal maternal smoking using multilevel regression techniques. Our study result is consistent with two other studies demonstrating a declining

trend in prenatal smoking prevalence after a smoking ban.¹⁶ However, this study is to our knowledge the first multilevel investigation of the relationship between clean indoor air legislation and pregnancy-related smoking. Our primary finding suggests that the presence of a local clean indoor air ordinance is associated with a reduced odds of prenatal smoking among women living in the affected jurisdiction, above and beyond individual socio-demographic characteristics and municipality-level contextual predictors. The magnitude of effect due to restaurant and bar ordinances in our findings is equal to 28% which greatly exceeds the 2%–3% estimate in decreased population smoking prevalence in simulation models by Levy et al.¹⁷ This discrepancy could be attributed to their model assumptions, which differ from our study population, geographic unit of analysis and policy level (local vs state). This finding adds to the growing body of literature documenting a positive influence of clean indoor air policies on population smoking prevalence. Overall though, the evidence is not conclusive as some studies have shown no effect among adults in general as well as youth. Moreover, prior studies have methodological limitations including inadequate control for potential confounders (particularly at the contextual level), a single period before–after policy implementation design, evaluation using too short time period after policy or focus on a single jurisdiction.¹¹⁸ Studies similar to ours using a multilevel analytic approach are better able to assess the contribution of both individual- and contextual-level factors on smoking prevalence.⁴⁸

For the test of time, our result suggests that compared with women who lived in municipalities with a relatively new clean indoor air ordinance of <1 year, those who lived in municipalities with a more established law of ≥ 2 years were significantly less likely to report smoking during pregnancy. Our findings are consistent with previous studies showing a higher magnitude of effect with increasing time, although some studies report dissimilar results.⁶⁷¹⁹ Differences in findings for the time effect across these studies may be related to study timeframe which for populations such as youth may be critical since smoking policies can affect their behaviour later than the period under study. Our study did not show significance for the additional effect of 100% smoke-free ordinances, which is inconsistent with previous studies showing a relatively stronger impact of total compared with partial bans on smoking behaviour. Variances in smoking restrictions are estimated to significantly cut the effects of smoking bans.¹⁷ Further research is therefore needed to examine the effect of different strengths of smoking laws on smoking outcomes.

The primary mechanism proposed through which the policy affects smoking prevalence is altering social norms around smoking. Smoking policies increase social unacceptability by decreasing the visibility of negative role model smokers and reinforce an image of smoking as dangerous to others in addition to oneself.²⁰ Smoking bans affect youth attitudes towards smoking and teen non-smokers who are more likely to perceive that adults disapprove of smoking will delay their smoking initiation. Perceived social disapproval is associated with slower progression towards regular smoking, lower smoking prevalence and higher intention to quit smoking.²¹ Pregnant women in particular are very concerned about the social acceptability of smoking and perceived lack of approval of their smoking.²² It is plausible that indoor air policies influence prenatal smoking largely by deterring youth smoking. Along the same vein, women who are regular smokers prior to becoming pregnant have a hard time quitting during pregnancy. Also, community settings such as restaurants and bars may have a stronger impact on smoking than school settings, which suggests the importance of broader community norms on youth smoking.

There are several strengths of this study. An advantage was the use of comprehensive, register-based state data that are reliable, routinely collected each year and cover the entire state population. Also, a multilevel analytic strategy allowed us to tease apart the influences of individual variables that have been previously found to impact prenatal smoking,

therefore minimising the possibility that the associations found resulted from bias or confounding. We also used a measure of baseline anti-smoking sentiment, a 1992 ballot measure that has been shown to be significantly associated with the adoption of smoke-free regulations. Lastly, by focusing on the time period prior to the enactment of the 2004 state ban, our study separated the effects of state and local clean indoor air laws, which have been found to complicate findings.²³

Some limitations are also worth noting. Cross-sectional data prevent determination of direction of causality; nevertheless, our finding is consistent with the direction of trends reported in longitudinal studies.²⁴ The generalisability of this study is not clear since we examined the independent effect of clean indoor air legislation, one of several components of Massachusetts' comprehensive tobacco control. However, while the goal is comprehensive tobacco control legislation, it is of research importance to study the independent and relative contribution of different policy measures like cigarette taxation and youth access and education on smoking prevalence, especially since some studies have failed to find an association between certain policy measures and population smoking prevalence.²⁵ Future studies examining the influence of smoking ordinances on pregnancy smoking rates should focus on states with higher prevalence rates of prenatal smoking, particularly among lower income and less-educated women, to enhance the generalisability of the results. In addition, our policy indicator was the presence of a local ordinance which does not necessarily confer its enforcement¹⁴ nor actual exposure as residents may move across jurisdictions over the life course. Finally, the use of self-reported smoking data is likely to both be influenced by unmeasured individual characteristics and may be dependent on the respondents ability as well as willingness to recall such events. Underreporting of smoking has been investigated in birth certificate data due to reasons including lack of specificity in the question regarding smoking during the pregnancy period and stigma associated with the behaviour, though birth certificate data are generally consistent with the trends in smoking based on data collected from other systems including CDC's Pregnancy Risk Assessment Monitoring System and Behavioural Risk Factor Surveillance System and may not significantly impact the validity of the findings.²⁶

Changing attitudes, beliefs and norms around smoking have increased support for stronger tobacco control regulations such as clean indoor air policies. As more places enact some type of provision that restricts smoking, it is important to document the differential impact of tobacco control initiatives on the smoking behaviours of diverse populations. Despite its public health impact, clean indoor air regulations are not completely accepted without debate and contention. Since as early as the 1980s, the tobacco industry has recognised that smoke-free workplaces have a major effect on cigarette consumption. To protect their economic interests, the industry lobbies for state pre-emption laws that will undermine local clean air ordinances which often are stricter than state laws and consequently dilute the potential health benefits of these policies.²⁷ Our findings increased understanding of the influence of these policy levers on the patterning of smoking during pregnancy and could inform government planners and tobacco control advocates in designing an effective policy framework that supports the objective of reducing tobacco-related death and disease.

Acknowledgments

We are very grateful to Dr Stanton Glantz of the Department of Medicine at the University of California, San Francisco, for his insightful feedback that led to improvement of the study analyses.

Funding KHN received support from the National Cancer Institute Diversity Supplement Award (R01CA129096). SVS was supported by the National Heart, Lung, and Blood Institute Career Development Award (K25 HL081275) and the Robert Wood Johnson Investigator Award in Health Policy Research. GS was supported by the National Cancer Institute (K05 CA108663).

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What this paper adds

Findings of lower prenatal smoking among women living in municipalities with a clean indoor air ordinance compared with those living in municipalities with no such ordinance. In addition, the effect of time since policy ordinance adoption on smoking prevalence increases over time. The first known study examining the association between clean indoor air policy and prenatal smoking using multilevel analyses accounting for individual- and municipality-level factors.

Table 1

Descriptive statistics and demographic variables

Individual-level variables	N	%	Mean	SD
Total participants	67 584			
Age				
<24 years	10 626	15.7		
25–29 years	15 797	23.4		
30–34 years	24 529	36.3		
35+ years	16 632	24.6		
Smoking during pregnancy	4385	6.5		
Race/ethnicity				
White non-Hispanic	51 783	76.6		
Black non-Hispanic	4915	7.3		
Hispanic	6206	9.2		
Other	4680	6.9		
Education				
High school or less	18 588	27.5		
Some college	16 512	24.4		
College degree or more	32 484	48.1		
Marital status				
No	14 379	21.3		
Yes	53 205	78.7		
Nativity				
US born	52 928	78.3		
Foreign born	14 656	21.7		
Parity			1.9	2.3
Town-level variables	N	%	Mean	SD
Population size				
Mean population			18088.6	37326.1
Towns with population <15 000 residents	230	65.5		
Towns with population 15 000–30 000 residents	68	19.4		
Towns with population >30 000 residents	53	15.1		
% Of female residents			51.0	2.0
% Of residents with at least high school education			33.6	18.5
% Of white residents			96.0	42.5
Whether majority town passed Question 1				
No	123	35.0		
Yes	228	65.0		
Smoking ordinance				
Any ordinance	219	62.4		
Strong ordinance (100% smoke free)	37	10.5		

Individual-level variables	N	%	Mean	SD
Time of policy adoption (years)				
Average time of policy adoption			2.6	3.1
<1 year	157	44.7		
1 time <2 years	50	14.3		
2 time <3 years	31	8.8		
3+ years	113	32.2		

Table 2

ORs (95% CI) from multilevel logistic regression models: presence of ordinance on prenatal maternal smoking (n=67 584)

	Model 1	Model 2
	OR (95% CI)	OR (95% CI)
No ordinance	1.00	1.00
Any ordinance	0.67 (0.54 to 0.83)	0.72 (0.53 to 0.98)
Strong ordinance	0.92 (0.67 to 1.27)	1.08 (0.89 to 1.30)
Race		
Caucasian		1.00
Hispanic		0.26 (0.23 to 0.30)
African-American		0.44 (0.38 to 0.52)
Other		0.51 (0.39 to 0.66)
Age		
+35 years		1.00
30–34 years		0.87 (0.79 to 0.96)
25–29 years		0.99 (0.89 to 1.09)
24 years		0.72 (0.64 to 0.80)
Education		
College or more		1.00
Some college		6.44 (5.69 to 7.28)
High school or less		12.10 (10.71 to 13.67)
Marital status		
Married		1.00
Single		3.46 (3.20 to 3.77)
Parity		1.02 (1.02 to 1.03)
Nativity		
Foreign born		1.00
US born		4.16 (3.61 to 4.79)
Town-level variables		
Town size (population)		
>30 000		1.00
15 000–30 000		1.04 (0.87 to 1.25)
<15 000		1.12 (0.93 to 1.35)
Vote on Question 1		
No		
Yes		0.84 (0.62 to 1.14)
Percentage of town residents who are Caucasian (mean)		1.00 (1.00 to 1.00)
Percentage who are female (mean)		1.00 (0.96 to 1.03)
Town education (mean)		1.01 (1.01 to 1.01)

Table 3

ORs (95% CI) from multilevel logistic regression models for time since smoking ordinance (n=57 900)

	Model 1	Model 2
	OR (95% CI)	OR (95% CI)
Length of policy exposure		
<1 year	1.00	1.00
1> time <2 years	0.66 (0.43 to 1.02)	0.79 (0.61 to 1.03)
2> time <3 years	0.41 (0.25 to 0.65)	0.65 (0.49 to 0.87)
3+ years	0.53 (0.36 to 0.78)	0.76 (0.60 to 0.95)

Controlling for individual characteristics (race, nativity, age, marital status, education, parity) and town-level variables (% of female residents, town population, town vote for Question 1, town-level education, % of white residents).