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Comprehensive Smoke-Free Policies: A Tool for Improving Preconception Health?

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Abstract

Lower income women are at higher risk for preconception and prenatal smoking, are less likely to spontaneously quit smoking during pregnancy, and have higher prenatal relapse rates than women in higher income groups. Policies prohibiting tobacco smoking in public places are intended to reduce exposure to secondhand smoke; additionally, since these policies promote a smoke-free norm, there have been associations between smoke-free policies and reduced smoking prevalence. Given the public health burden of smoking, particularly among women who become pregnant, our objective was to assess the impact of smoke-free policies on the odds of preconception smoking among low-income women. We estimated the odds of preconception smoking among low-income women in Ohio between 2002 and 2009 using data from repeated cross-sectional samples of women participating in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). A logistic spline regression was applied fitting a knot at the point of enforcement of the Ohio Smoke-free Workplace Act to evaluate whether this policy was associated with changes in the odds of smoking. After adjusting for individual- and environmental-level factors, the Ohio Smoke-free Workplace Act was associated with a small, but statistically significant reduction in the odds of preconception smoking in WIC participants. Comprehensive smoke-free policies prohibiting smoking in public places and workplaces may also be associated with reductions in smoking among low-income women. This type of policy or environmental change strategy may promote a tobacco-free norm and improve preconception health among a population at risk for smoking.

Keywords

Smoking; Policy; Low-income; Women; WIC; Preconception health

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Tobacco smoking continues to be the major leading cause of cancer death in women, as well as a major contributor to cardiovascular morbidity and mortality [1]. Perinatal smoking increases the risk of poor maternal and infant health outcomes such as premature rupture of membranes, placental abruption, low birth weight, and preterm delivery [2, 3]. Preconception smoking is also associated with reduced fertility and delay in conception among women of reproductive age [3]. Because these can be prevented if women stop smoking before or during early pregnancy, smoking is recognized as an important indicator of preconception health. In the United States (US), approximately half of pregnancies are unintended, which is associated with a delay in a woman's knowledge of her pregnancy and thus subsequent behavior changes. Additionally, only 20 % of women successfully quit during pregnancy, therefore cessation is recommended before pregnancy [4, 5]. Despite recommendations against smoking for women, especially during pregnancy, data from 2007 indicate 10.4 % of women who gave birth in the US reported smoking during pregnancy [6, 7].

Lower income women are at higher risk for preconception and prenatal smoking, are less likely to spontaneously quit smoking during pregnancy, and have higher postnatal relapse rates than women in higher income groups [8–12]. Despite continued reductions in smoking prevalence in the US, the Midwestern region of the country remains as one of the regions with the highest smoking prevalence among women [13]; Ohio has the 6th highest prevalence of adult smoking in the US, with an estimated prevalence of 22.1 % of female adults reporting current smoking [13]. Further, within Ohio the smoking prevalence is even higher among low-income women and women without a health plan, among whom 44.6 % report smoking [14, 15]. Women who live in the Appalachian region of the United States are known to have poorer preconception and other health behaviors generally, including higher tobacco use with 31.3 % of women living in Ohio's Appalachian counties reporting current smoking [16, 17].

The social environment is known to contribute to prenatal smoking, including having a partner who smokes, a higher proportion of smoking friends, and more frequent exposures to secondhand smoke [18]. Comprehensive smoke-free policies prohibiting smoking in all indoor areas of public places and workplaces reduce exposure to secondhand smoke [19], which is known to be both a health hazard [19] and a trigger for continued smoking [20]. Smoke-free environments have been shown to support the cessation process [21]. The impact of smoke-free policies on smoking prevalence and consumption has also been evaluated. To date, studies have shown a relationship between smoke-free policies and reduced cigarette consumption [22, 23]; additional studies have been mixed, with some identifying small reductions in smoking prevalence [24], while others have been inconclusive [25]. Further, our knowledge of the effect of such policies on smoking behaviors with specific populations is relatively weak [25, 26]. Given the potential health benefits of population level changes in smoking prevalence, further exploration of this relationship between smoke-free policies and smoking prevalence is warranted, especially for vulnerable populations.

In November 2006, Ohio voters passed the Ohio Smoke-free Workplace Act, which prohibits smoking in workplaces and public places; the law took effect on December 7, 2006, and enforcement began on May 3, 2007 [27]. This manuscript aims to evaluate the research question of whether self-reported preconception smoking among low-income women was associated with the adoption of a statewide, comprehensive smoke-free policy.

Methods

Data Collection

This study used Pregnancy Nutrition Surveillance System (PNSS) data from a cross-sectional sample of mothers who gave birth during 2002–2009 in Ohio. PNSS is a nutrition surveillance system developed by the Centers for Disease Control and Prevention (CDC) that monitors birth outcomes of low-income pregnant women who participate in federally funded public health programs [28]. Data are collected during prenatal and postpartum clinic visits, aggregated at the state level, and then submitted to the CDC on a quarterly basis.

Study Sample and Variables

The overall sample consisted of pregnant and postpartum women enrolled in Ohio WIC who gave birth (alive or stillbirth) during March 2002 through December 2009 (n = 543,718). Pregnant women who had only a prenatal record (n = 47,721) were excluded since postpartum record data on gestational age and infant date of birth were unavailable. Complete and postpartum records with missing values for gestational age (n = 2,792), gestational age of less than 20 weeks (n = 5,626), or gestational age greater than 44 weeks (n = 1,666) were also excluded. The study sample self-reported their preconception smoking status, defined as smoking at any point during the three months before pregnancy, at their initial clinic visit; women with missing data on preconception smoking status were excluded (n = 2,002).

The final study sample consisted of 483,911 pregnant and postpartum women. For the regression analysis, 6.3 % of the study sample (n = 30,281) was not used due to missing values for preconception smoking status or covariates.

From the PNSS data, covariates included in this analysis were self-reported race/ethnicity (white non-Hispanic, Black non-Hispanic, and other), educational attainment (categorized as less than high school, high school graduate, or more than high school), maternal age in years (categorized as less than 20, 20–29, or greater than 29), maternal income (categorized as 50 % of the federal poverty level or lower, or greater than 50 % of the poverty level), county of residence, and parity status (no previous pregnancy, one or more previous pregnancies). State cigarette taxes for the study period were categorized, by month, in dollars. Geographic region was assigned based on an individual’s county of residence, using the designations consistent with the Ohio Medicaid Assessment Survey [14]. The 2005 Appalachian Regional Commission designations were used to assign counties as Appalachian [29]. This study was approved by the Ohio Department of Health and The Ohio State University Institutional Review Boards.

Data Analysis

Spline regression was chosen for analysis because it allows for a non-linear change in the outcome variable based on an identified time point, or knot [30]; this technique is suitable for the evaluation of policy impacts following a specific policy change, while retaining an interpretation within a familiar regression framework. In the case of a policy evaluation, the knot is defined at the policy enactment date which allows for statistical testing for a change in slope after the policy is in effect.

Since preconception smoking status was defined as smoking status during the three months before pregnancy, the time variable (in monthly units) was based on three months prior to participant date of last menstrual period (estimated using self-reported information on infant date of birth and gestational age). Monthly time units ranged from April 2001 through January 2009, with a knot specified at May 2007. Overall sample characteristics were described using frequencies and means. Chi square tests were used to compare the distribution of categorical participant characteristics (race/ethnicity, educational attainment, maternal age, poverty level, parity, and geographic region) pre- and post-smoke-free air policy. The two-sample *t* test was used to compare the mean state cigarette tax pre- and post-smoke-free air policy. The study outcome was preconception smoking status defined as smoker or nonsmoker. Logistic regression analysis was used to examine whether odds of preconception smoking significantly changed after enforcement of the Ohio Smoke-free Workplace Act. A logistic spline model was fitted with knot at t*,

$$Logit(p) = \beta_0 + \beta_1 ethnicity\_2_i + \beta_2 ethnicity\_3_i + \beta_3 education\_2_i + \beta_4 education\_3_i + \beta_5 age\_2_i + \beta_6 age\_3_i + \beta_7 poverty_i + \beta_8 tax_i + \beta_9 parity\_1_i + \beta_{10} parity\_2_i + \beta_{11} region\_2_i + \beta_{12} region\_3_i + \beta_{13} region\_4_i + \beta_{14} time_i + \beta_{15}(time_i - t*)_+$$

where t* equals May 2007, the date of policy enforcement, and $(time_i - t*)_+$ is equal to $(time_i - t*)_+$ when $time_i > t*$ and is equal to zero when $time_i \leq t*$ [31]. Covariates adjusted for in the model included race/ethnicity, educational attainment, maternal age, poverty level, state cigarette tax, and parity. Linearity in the logit for the continuous variable cigarette tax was tested using the Box-Tidwell transformation. An alpha level of 0.05 was used to identify statistical significance. Variance inflation factor (VIF) of independent variables ranged from 1.08 to 7.91. The relatively low values of VIF suggest that multicollinearity is not a major concern. Analyses were completed using SAS (Version 9.2 of the SAS System for Windows. Copyright 2008, SAS Institute Inc, Cary, NC).

Results

A description of the study sample is shown in Table 1. Women were most frequently white non-Hispanic (65.3 %), 20–29 years old (61.3 %), high school graduates (52.0 %), and residents of a metropolitan region (56.3 %). The proportion of women with household income up to 50 % of the federal poverty level was similar to the proportion of women with greater than 50 % of the federal poverty level (50.9 vs. 49.1 %, respectively). Although some categorical participant characteristics (race/ethnicity, educational attainment, maternal age, poverty level, parity, and geographic region) were statistically significantly different before and after the smoke-free policy ($p < 0.001$ for all), the characteristics of the sample did not

meaningfully change. Due to increases in cigarette tax from $0.24 to $1.25 over the study period [32], the mean state cigarette tax was significantly different pre- and post-smoke-free air policy (p <0.001).

In Table 2, odds ratios for the multivariate logistic spline regression model are presented. Non-white race, higher educational attainment, greater than 50 % of federal poverty level were all significantly associated with a lower odds of preconception smoking. Being younger than 20 or 30 or older was associated with lower odds of preconception smoking. Having one or more children, and living in the metropolitan or Appalachian regions were associated with lower odds of preconception smoking; living in rural non-Appalachian areas was associated with higher odds of preconception smoking compared to women living in suburban regions (OR = 1.05; CI 1.02–1.08). From April 2001 through May 2007 (the period before Ohio Smoke-free Workplace Act), there was no significant change in the odds of preconception smoking among low-income women (OR = 1.00). However, there was a statistically significant reduction in the odds of preconception smoking during the time period after policy enforcement (OR = 0.98, 95 % CI 0.98–0.99). For every 6 months after policy enforcement, the odds of preconception smoking among a sample of low-income women decreases by 11 % after accounting for ethnicity, socioeconomic factors, age, parity, region of the state, and cigarette taxes.

Discussion

The Ohio Smoke-free Workplace Act was associated with a small but significant decrease in the odds of preconception smoking among low-income WIC participants. While in the years prior to the Act there was no trend or significant change over time in preconception smoking status, after enforcement of the Act, a significant trend of decreasing preconception smoking was detected. These changes were statistically significant after accounting for changes in the sales tax on cigarettes, a factor known to be predictive of changes in smoking behavior among low-income women [33]. These results help to demonstrate protective benefits on preconception health for low-income populations that are supported through comprehensive tobacco control policies [34, 35]. Overall, these results provide small but significant evidence for changes that may help to reduce disparities in preconception health [36].

Pregnancy is an opportune time to encourage women to quit smoking for their lifetime. Yet, in spite of the wealth of evidence about the negative effects of smoking on fetal health, most female smokers who become pregnant continue smoking, and more than half of those who do quit resume smoking after delivery [37]. Both continuation of smoking during pregnancy and relapse to smoking after delivery are more common among lower income women [37]. Given the difficulty many pregnant women addicted to tobacco have quitting during pregnancy, population-based measures to reduce smoking among the general population of non-pregnant women and social inequalities should be supported. Given the small, but significant impact on smoking prevalence in this priority population, future studies should investigate whether this trend is sustained over time, and whether these results are replicated in other regions with comprehensive smoke-free policies.

Both individual and environmental factors play an important role in promoting reductions in smoking behaviors, including cessation. Intervention studies to promote smoking cessation in pregnancy have reduced the proportion of women who continue to smoke in late pregnancy, but the difficulty of addressing highly addicted tobacco users, and the lack of access to clinical services among many low-income women, warrants the use of population-based measures [38]. Comprehensive smoke-free policies have been associated with changes in the social norms around smoking that predict reductions in smoking behaviors [39]; while the exact mechanism of change initiated by comprehensive smoke-free policies on smoking prevalence is not well understood, studies suggest the importance of strong antismoking social norms as a facilitator of smoking cessation [40, 41].

There are several important considerations to bear in mind when evaluating these study results. First, self-reported smoking data are used, which may underestimate the true odds of smoking and the association observed in this population [42]; yet, recall of preconception smoking status generally has been characterized as having good sensitivity and specificity [43]. Despite the potential for underestimation of true prevalence, we assume that any bias present is unlikely to be associated in time to the enactment of the workplace smoke-free policy, and therefore non-differentially misclassification. Second, our study assumes a consistency in both the prevalence of smoking and the demographic characteristics of the WIC population in Ohio. As previously noted, the smoking prevalence in Ohio did not dramatically change, so we believe that it is reasonable to assume that this similar pattern would be observed among the WIC population. While demographic characteristics pre- and post-smoke-free air policy were statistically significantly different, this was likely due to the large sample size since the characteristics of the sample did not meaningfully change before and after the smoke-free policy. Income was not a required element of PNSS for postpartum-only women after 2007, resulting in an increase in records without data on poverty level. However, our results were not meaningfully changed (data not shown) when either poverty or postpartum only women were removed from the model. In this repeated cross-sectional design, repeat pregnancies were not accounted for, and may limit the variability due to the within-subject correlation; for the smokers in the sample, any correlation for continued smoking prior to pregnancy would likely bias the result toward the null. The use of last menstrual period is known to have limited precision as an exclusive measure of infant size [44] that authors deemed this date to be an acceptable estimate for estimating a time period prior to pregnancy for the goal of the present analysis. As a strength, these analyses use a very large sample of all low-income women enrolled in WIC in the state of Ohio; therefore, results are likely generalizable to other states with a similar demographic profile among WIC participants and tobacco taxation rates. As with all regression analyses, concerns regarding multicollinearity necessitate thoughtful variable selection, which is why pertinent factors in the individual and social context were applied in the present model; the resulting variance inflation factors for variables in the present analysis suggest a relatively low degree of correlation among study variables and an acceptable level of risk in the use of several related variables.

The Ohio Smoke-free Workplace Act, as with other comprehensive clean indoor air policies prohibiting smoking in all indoors areas of public places and workplaces, was enacted to protect workers and the public from exposure to secondhand smoke. In addition, this

policy has been associated with a reduction in acute myocardial infarction [45]. Our study contributes evidence in support for the public health benefit provided by a statewide, comprehensive smoke-free policy in helping to reduce the odds of smoking among an at-risk population. While policy and environmental changes are not part of the 10 recommendations to improve preconception health put forward in 2006 by the CDC/ATSDR Preconception Care Work Group and the Select Panel on Preconception Care [5], these strategies may be effective for smoking and other behavioral indicators of preconception health (e.g., physical activity, fruit and vegetable consumption) [4], especially among important subgroups.

Conclusion

These types of comprehensive smoke-free policies have been demonstrated as effective means to achieve important public health gains in tobacco control, and are essential to continue to reduce the disease burden that results from smoking. While not currently a dominant strategy for improving preconception health, these types of policy and environmental changes are important tools for practitioners and policy makers to consider in promoting public health behavior change.

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Table 1

Sample characteristics of Ohio participants in the Women, Infants, and Children (WIC) program, 2001–2009

Characteristics (n = 453,630)	Overall % (n)	Pre-policy % (n)	Post-policy % (n)
Race/ethnicity			
White, non-hispanic	65.3 (296,295)	65.4 (242,156)	65.0 (54,139)
Black, non-hispanic	26.4 (119,739)	26.6 (98,619)	25.3 (21,120)
Other	8.3 (37,596)	8.0 (29,508)	9.7 (8,088)
Educational attainment			
<High school	28.9 (131,121)	29.2 (108,419)	27.2 (22,702)
High school	52.0 (235,734)	51.8 (191,407)	53.2 (44,327)
>High school	19.1 (86,775)	19.0 (70,457)	19.6 (16,318)
Maternal age (years)			
<20	23.3 (105,360)	23.1 (85,625)	23.7 (19,735)
20–29	61.3 (278,233)	61.4 (227,446)	60.9 (50,787)
>29	15.4 (70,037)	15.5 (57,212)	15.4 (83,347)
Parity			
0	40.7 (183,935)	41.4 (153,483)	36.5 (30,452)
≥1	59.5 (269,695)	58.6 (216,800)	63.5 (52,895)
Poverty level[a]			
≤50 %	50.9 (231,013)	49.4 (182,983)	57.6 (48,030)
>50 %	49.1 (222,617)	50.6 (187,300)	42.4 (35,317)
Current smoker during 3 months prior to pregnancy	42.7 (193,621)	43.3 (160,347)	39.9 (33,274)
State cigarette tax ($, mean ± SD)	0.76 ± 0.41	0.63 ± 0.37	1.25 ± 0.00
Geographic region[b]			
Suburban	10.6 (48,180)	10.6 (39,052)	11.0 (9,128)
Metropolitan	56.3 (255,520)	56.5 (209,355)	55.4 (46,165)
Rural non-appalachian	12.6 (56,776)	12.4 (46,022)	12.9 (10,754)
Appalachian	20.5 (93,154)	20.5 (75,854)	20.7 (17,300)

[a]Gross income compared to the poverty level set by the US Poverty Income Guidelines

[b]Classifies each Ohio county into one of four categories: Appalachian = designated by the Appalachian Regional Commission; metropolitan = a non-Appalachian county that contains at least one city with 50,000 or more inhabitants; suburban = a non-metropolitan, non-Appalachian county that meets the US Census definition of an urbanized area; rural, non-Appalachian = all other counties not classified as Appalachian, metropolitan or suburban

Table 2

Associations between preconception smoking and the Ohio smoke-free workplace act among low income women, pregnancy nutrition surveillance system, Ohio, 2002–2009

Variable	OR	95 % CI
Race/ethnicity		
White, non-hispanic	Ref	–
Black, non-hispanic	0.29	0.28–0.29
Other	0.19	0.19–0.20
Educational attainment		
<High school	Ref	–
High school	0.68	0.67–0.69
>High school	0.42	0.41–0.43
Poverty level[a]		
≤50 %	Ref	–
>50 %	0.59	0.58–0.60
Maternal age (years)		
<20	0.71	0.70–0.73
20–29	Ref	–
>29	0.80	0.79–0.82
Parity		
0	Ref	–
≥1	0.92	0.90–0.93
Geographic region[b]		
Suburban	Ref	–
Metropolitan	0.85	0.83–0.87
Rural non-appalachian	1.05	1.02–1.08
Appalachian	0.95	0.93–0.97
State cigarette tax	0.95	0.92–0.99
Time[c]	1.00	1.00–1.00
(Time − t*)[d]	0.98	0.98–0.99

[a]Gross income compared to the poverty level set by the U.S. Poverty Income Guidelines

[b]Classifies each Ohio county into one of four categories: Appalachian = designated by the Appalachian Regional Commission; metropolitan = a non-Appalachian county that contains at least one city with 50,000 or more inhabitants; Suburban = a non-metropolitan, non-Appalachian county that meets the US Census definition of an urbanized area; rural, non-Appalachian = all other counties not classified as Appalachian, metropolitan or suburban

[c]Represents effect of time pre-policy

[d]Represents effect of time post-policy