The Impact of Smoke-Free Air Legislation and Cigarette Prices on Hospitalizations in the United States

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Abstract

This paper examines the impact of tobacco control policies on cancer, cardiovascular, and respiratory health outcomes among adults in the United States. To measure these effects, I employ a Poisson model with county and year fixed effects, while controlling for county demographic, economic, and environmental characteristics. Results suggest that comprehensive smoke-free air legislation leads to statistically significant declines in the number of hospitalizations for breast cancer, coronary atherosclerosis, and asthma. Similarly, increased cigarette prices lead to declines in the number of hospitalizations for each diagnosis, and are statistically significant for asthma and coronary atherosclerosis. Subsequent analysis indicates these findings are broadly consistent across all age subgroups and model specifications. As expected, the counterfactual outcome appendicitis is unaffected by either tobacco control policy. These results indicate that smoke-free air legislation and cigarette taxation are effective methods of reducing the number of hospitalizations for cancer, cardiovascular, and respiratory conditions.

Communities in the United States are increasingly turning to smoke-free air legislation and cigarette taxation as a method of reducing tobacco consumption and protecting nonsmokers from the harms of secondhand smoke. Environmental tobacco smoke contains thousands of chemicals, including 70 carcinogens and 250 toxins (IARC 2004a; CDC, 2016). Many of these components are causally related to cancer, cardiovascular disease, and are known

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to exacerbate respiratory conditions. The result is more than 480,000 annual deaths in the United States due to active smoking, and an additional 41,000 deaths due to secondhand smoke (USDHHS, 2014).

The mechanisms by which smoke-free air legislation and cigarette prices affect exposure to active and secondhand smoke are well documented in the existing literature. Legally prohibiting indoor smoking leads to a near elimination of fine particle air pollution in affected venues, allowing nonsmokers to benefit from reduced exposure to secondhand smoke (Hahn, 2010). Among current smokers, smoke-free air laws lead to reduced cigarette consumption and induce additional quit attempts (Fichtenberg and Glantz, 2012; Albers et al., 2007). Previous research provides suggestive evidence that smoke-free air legislation reduces smoking prevalence, with results ranging from no change to 32% declines (Callinan et al., 2010). Similarly, increased cigarette prices lead to declines in smoking prevalence, cigarette consumption, and smoking initiation, all of which reduce exposure to secondhand smoke among nonsmokers (USDHHS, 2012).

Several biological links connect cigarette smoke with disease incidence. For individuals with asthma, inhalation of tobacco smoke causes inflammation of the airways, restricts air flow to the lungs, and increases the likelihood of asthma symptoms (CDC, 2014). Many of the chemicals in tobacco smoke, including carbon monoxide, are less than 2.5 micrometers in diameter, allowing them to pass through the lungs and enter the bloodstream. The presence of carbon monoxide in the bloodstream triggers red blood cell and platelet production, increasing the risk of blood clot formation and arterial plaque accumulation (Benewitz, 2003; USDHHS, 2010). Other effects include a stiffening of the arterial lining, arterial inflammation, reduced blood flow, and increased blood pressure. These conditions lead to the development of coronary atherosclerosis, a chronic disease denoted by arterial plaque buildup and reduced blood flow, and acute myocardial infarction events, which occurs when blood flow to the heart becomes blocked. Additionally, the carcinogenic compounds introduced into the bloodstream interact with and damage DNA (Cal/EPA, 2005a). These genetic mutations are permanent, and can lead to uncontrolled cellular growth inherent in cancer (USDHHS, 2010). Other components of cigarette smoke, while not carcinogenic, are known to promote tumor growth (USDHHS, 2010; IARC, 2007). For breast cancer in particular, tobacco compounds associated with the disease have been identified, as have specific gene mutations in breast tissue (Terry and Rohan, 2002).

Smoking cessation and avoidance of secondhand smoke are effective methods to reduce the health risks described above. For active smokers, the relative risk of coronary atherosclerosis and acute myocardial infarction is 2.10-2.90 times greater than never smokers, and is reduced nearly 50% one year after smoking cessation (Lightwood and Glantz, 1997; Kramer et al., 2006). Within 5-9 years, the risk returns to the level of never-smokers (USDHHS, 2010; Kramer et al., 2006). Exposure to passive smoke increases the relative risk of heart disease by 1.25 times, and increases the risk of death by roughly 30% (He et al., 1999; Glantz and Parmley, 1990). Similarly, the relative risk of breast cancer is 1.68-2.20 times greater for current smokers, and is 1.89 times greater for individuals exposed to secondhand smoke (Cal/EPA, 2005; Collishaw et al., 2009, IARC, 2012). For respiratory conditions such as asthma, smoking cessation and the elimination of exposure to environmental tobacco smoke leads to improvements in lung function and less severe symptoms (Chaudhuri et al., 2006; CDC, 2014).

This paper analyzes the extent to which tobacco control policies impact the number of breast cancer, acute myocardial infarction, coronary atherosclerosis, and asthma hospitalizations among US adults. Appendicitis hospitalizations are used as a counterfactual outcome, as they are not likely to be affected by tobacco control policies in the short run. To measure these effects, I employ a Poisson model with county and year fixed effects, while controlling for county demographic, economic, and environmental characteristics. Results suggest that smoke-free air legislation leads to statistically significant declines in hospitalizations for breast cancer, coronary atherosclerosis, and asthma. Statistically significant effects are generally not observed for acute myocardial infarction or appendicitis hospitalizations. Increases in the real cigarette price lead to fewer hospitalizations for each diagnosis, and are statistically significant for asthma and coronary atherosclerosis. For the counterfactual outcome, appendicitis, the real cigarette price has no effect on the number of hospitalizations. All findings are generally consistent across age subgroups and model specifications.

This study is the first to examine the effects of comprehensive smoke-free air legislation and county level cigarette prices on cancer, cardiovascular, and respiratory hospitalizations in the United States. It is also the largest in the literature to date, examining up to 40 states from 1991-2014. The longer time span and larger number of states allows for a more accurate estimation of the impact of each tobacco control policy, and presents results representative of the general population. Finally, it is the first economic study to examine the effects of tobacco control policies on breast cancer and coronary atherosclerosis hospitalizations.

2. Background and Data

2.1 Tobacco Control Policies

Early smoke-free air legislation in the United States began during the 1970's, but did little to reduce nonsmokers' exposure to secondhand smoke. These laws often included exemptions or allowed for indoor smoking sections, which did not provide adequate protection from environmental tobacco smoke (USDHHS, 2010). In 1992, the Environmental Protection Agency (EPA) classified secondhand smoke as a Group A carcinogen, prompting the enactment of more restrictive smoke-free air legislation (EPA, 1992). These "comprehensive" laws prohibited all indoor smoking with no exceptions. Figure 1 tracks the percentage of the US population protected by comprehensive smoke-free air legislation in bars, restaurants, public workplaces, and private workplaces from 1991-2014. Over this time period, public and private workplace restrictions have consistently provided the most protection, with bars lagging behind. Coupled with Figure 2, which displays the number of counties enacting comprehensive smoke-free air legislation each year, these graphs reflect the changing development of smoking bans over time. The modest increase in coverage throughout the 1990's results from the laws originally being enacted at the local level, covering a single public venue, and affecting a small proportion of the county population. The rapid expansion during the 2000's reflects the transition from local to state level legislation, with each new law affecting larger segments of the population.

The trend in real cigarette prices follows a similar path during this time. Figure 3 shows the mean real cigarette price each year from 1991-2014, as well as the range of prices across all states. Large increases in the mean price occurred in 1999 and again in 2009. In addition to the industry initiated price increase in 1999 to pay for the Master Settlement Agreement, many states subsequently increased their cigarette excise taxes. The price change in 2009 is the result of an increase in federal cigarette taxes in order to fund the State Children's Health Insurance Program (SCHIP). Despite the progression of these policies, as of 2017, large disparities exist across states in the level of cigarette taxation, while only 58.3% of the US population is protected by comprehensive smoke-free air legislation in all four venues (CTFK, 2017; ANRF, 2017).

2.2 Previous Smoke-Free Air Research

The first study to examine the impact of smoke-free air legislation on health outcomes occurred in Helena, Montana (Sargent et al., 2004). Researchers analyzed the effect of a public place smoking ban on primary and secondary diagnoses of acute myocardial infarction in a single hospital. Although the law was suspended after six months, acute myocardial infarction diagnoses declined nearly 40% during that time. A follow-up study in Pueblo, Colorado, examined the effects of a city level smoke-free air law on a slightly larger population, finding a 27% decline in acute myocardial infarction hospitalizations (Bartecchi et al., 2006).

Later research examining entire states has found slightly smaller results. For example, a comprehensive smoke-free air law in New York State led to an 8% decline in hospitalizations for acute myocardial infarction (Juster et al., 2007). After the enactment of smoke-free air laws in Florida, Oregon, and New York, the effect on acute myocardial infarction hospitalizations ranged from no change to 18.4% declines (Loomis and Juster, 2012). In Arizona, a statewide smoking ban decreased the number of acute myocardial infarction and asthma hospitalizations by 13% and 22%, respectively, while in Delaware a similar law led to 4.7% and 5% declines (Herman and Walsh, 2011; Moraros et al., 2010). Further, a statewide smoke-free air law in Colorado led to a 5.9% increase in acute myocardial infarction hospitalizations, though the effect was not statistically significant (Basel et al., 2014). International studies tend to find similar results, with changes in acute myocardial infarction hospitalizations ranging from a 27% decline to a 9% increase in the post-ban period (Meyers et al., 2009).

Nearly all of the studies above examined a limited population and controlled for few, if any, independent variables. This suggests their findings may not be representative of the general population, and potentially suffer from omitted variable bias. Several studies attempt to obtain improved estimates by including controls for demographic characteristics, access to healthcare, or state level cigarette taxes. In each case, declines in acute myocardial infarction and asthma hospitalizations are markedly smaller than those found previously, and are not statistically significant (Mead et al., 2016; Shetty et al., 2010; Ho et al., 2016). While including a measure of the state level cigarette tax controls for a portion of the unobserved variation in tobacco control policies, it also imposes the assumption that each county within a state faces the same cigarette price. With many local and county municipalities free to impose taxes independent of the state, controlling for state level cigarette taxes is a flawed measure of the actual cigarette price faced by consumers.

2.3 Hospital Discharges

Hospital inpatient discharge data was obtained from individual state health departments, hospital associations, and the Healthcare Cost and Utilization Project. For each state, observations were restricted to in-state residents admitted to the hospital, regardless of discharge status. The dataset is further restricted to include only observations for adults ages 18 and older.[2]

Each primary diagnosis group is defined according to the Healthcare Cost and Utilization Project's Clinical Classification System (CCS), which aggregates individual primary diagnosis codes from the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) into larger, disease-specific groupings. The CCS and ICD-9-CM codes for each health outcome are shown in Table 1. Discharge counts for each diagnosis are aggregated by patient age group (18+, 18-64, 65+) to the county level, defined as patient county of residence using either Federal Information Processing Standards (FIPS) codes or patient ZIP code. Due to data availability, not all states are represented each year from 1991-2014. Figure 4 details the number of states in the dataset by year.

[2]Discharges from West Virginia include counts for ages 15-17 and are assumed to equal zero.

2.4 Tobacco Control Policies and County Characteristics

Data detailing the enactment date and number of individuals protected by comprehensive smoke-free air legislation in bars, restaurants, public workplaces, and private workplaces was developed by the University of Illinois at Chicago Health Policy Center, using data from the US Census and the American Nonsmoker's Rights Foundation database (ANRF, 2017). Each venue-specific variable takes into account the proportion of the county protected by each law, and the percentage of the year that a law is in effect. For example, if a county enacts a comprehensive smoking ban covering all restaurants on January 1 of a given year, the percentage of the population protected by the restaurant ban equals 100% for that and all future years. If the county instead enacts the same legislation on July 1, the law would be in effect for one half of the year, and the restaurant ban would equal 50% for that year and 100% in all subsequent years.

Smoke-free air legislation is often enacted simultaneously in multiple venues, making it difficult to disentangle the individual effect of each law. In this study, a policy indicator is set equal to 1 when the simple average level of protection across all four venues is greater than or equal to 50%, and 0 otherwise. However, using the simple average assigns an identical weight to each venue, and imposes the assumption that individuals are equally affected by a law in any venue. In reality, more time is likely spent in the workplace than in a bar or restaurant. Therefore, the impact of a public or private workplace ban is likely to be greater than a bar or restaurant ban. To more accurately reflect the difference in time spent in each venue, a second indicator variable is created. This weighted policy indicator is set equal to 1 for the years in which at least 50% of the county population is protected by smoke-free air legislation across all four venues, and 0 otherwise, with twice the weight placed on laws covering public and private workplaces. Finally, two additional variables are created to capture the cumulative effects of smoke-free air legislation over time; $YearsSinceSFA_{it}$ is equal to the number of years since smoke-free air legislation was enacted, and $YearsSinceSFA_{it}^2$ is equal to the squared number of years since smoke-free air legislation was enacted.

County level cigarette tax data was constructed by the Institute for Health Research and Policy at the University of Illinois at Chicago, using state and federal tobacco tax data from the Tobacco Institute's *Tax Burden on*

Tobacco, and county level tax data from the Campaign for Tobacco-Free Kids (Orzechowski and Walker, 2016; CTFK, 2017). Due to data limitations, only taxes greater than or equal to 5% of the total price are included in the dataset. The base price of a pack of cigarettes, without tax, is listed as of November 1 of each year. These prices are then weighted to obtain the annual base price. Finally, any federal, state, county, and local taxes are added to the annual base price, and are adjusted for the percentage of the year they are in effect. For example, if a county implements a $1.00 per pack tax on cigarettes beginning on January 1 of a given year, the price of cigarettes for that and all future years includes the full $1.00 increase. If the same tax were implemented on July 1, the tax is only in effect for one half of the year, and the price of cigarettes would increase by $0.50 during the first year and $1.00 in all subsequent years. When local governments impose cigarette taxes independent of the county in which they reside, county residents face multiple cigarette prices. To account for this within-county variation in price, any taxes below the county level are weighted by the local town's share of the county population, and this weighted average is included in the county price. Finally, all cigarette prices are adjusted to 2014 dollars using Consumer Price Index (CPI) data from the Bureau of Labor Statistics.

To control for changes in county size and age composition, yearly population estimates for adults ages 18+, 18-64, and 65+ were obtained from CDC WONDER and the US Census American FactFinder. To control for economic characteristics, median household income data at the county level was collected from the Area Health Resources Files, and combined with CPI data to obtain the real median household income in 2014 dollars. The county level unemployment rate was obtained from the Bureau of Labor Statistics, and monthly estimates are aggregated to a yearly average for each county.

Annual concentrations of the pollutant $PM_{2.5}$ were collected from the EPA and the CDC Public Health Tracking Network. Outdoor air pollution is negatively correlated with tobacco control policies, and has been linked to increased cancer, cardiovascular, and respiratory events (Brook et al., 2010; Burnett et al., 1999; Kim et al., 2017). Hundreds of monitoring stations across the United States routinely measure concentrations of $PM_{2.5}$ in the atmosphere. For the years 1991-2010, monthly average estimates of the pollutant were obtained from the EPA, encompassing nearly 10.4 million square miles of North America. This region was broken down into a grid comprised of 36km adjacent square zones, with GPS coordinates defining the four corner points and one central point of each zone. Additionally, GPS data detailing the central location of each county in the United States was obtained from the US Census, Geography Division. The distance between the central point of each county and the central point of each 36km measurement zone were calculated, and pollution values were assigned to counties based on the shortest distance between them.[3] The dataset was then collapsed by county and year to obtain the yearly average concentration of $PM_{2.5}$ in each county. For the years 2011-2014, data were obtained from the CDC Public Health Tracking Network, which utilizes EPA monitoring station information, and linear interpolation was used to obtain estimates for counties without monitoring stations in 2013 and 2014.

Over the study period, limited pollution data was available for both Hawaii and Alaska. Monitoring stations differ in the particles they analyze, and $PM_{2.5}$ is not always measured. In both states, Air Quality Index (AQI) values and concentrations of $PM_{2.5}$, PM_{10}, and O_3 were collected from available monitoring stations.[4] Using EPA conversion charts, concentrations of O_3 were first converted to equivalent AQI values, then all AQI data were converted to concentrations of $PM_{2.5}$. Daily concentrations of PM_{10} were converted into corresponding units of $PM_{2.5}$ using a conservative conversion rate (HK EPD, 2012).[5]

Finally, the number of bars and restaurants in each county were obtained from the US Census, County Business Register. Establishments are defined according to either the Standard Industrial Classification (SIC) system or North America Industry Classification System (NAICS). Changes to the coding system occurred in 1997, 2002, 2007, and 2012, and US Census conversion files were used to translate updated codes to the earlier, more general SIC codes. This data is intended to control for the accessibility of each venue within a county. For example, if a county with many restaurants enacts a

[3]As a specification check, counties were assigned the average pollution level from the two closest 36km measurement zones but this did not impact the results.

[4]PM_{10} is any particle less than or equal to 10 micrometers in diameter, O_3 is the concentration of Ozone, and AQI is a standardized measure of pollution which can more easily be disseminated to the public.

[5]The conversion rate $PM_{2.5} = 0.75 * PM_{10}$ was used to translate PM_{10} concentrations into $PM_{2.5}$ estimates.

restaurant smoking ban, the impact will likely be greater than if an identical law were enacted in a county with relatively few restaurants.

3. Methods

A Poisson model with robust standard errors is used to measure the effect of tobacco control policies on the number of hospitalizations in county i during year t for each primary diagnosis group and age subgroup. The estimating equation for Models 1 and 2 can be written as:

$$y_{it} = exp(\beta_1 SFA_{it} + \beta_2 CigPrice_{it} + \beta_3 X_{it} + \alpha_i + \mu_t + \epsilon_{it}) \quad (1)$$

Where SFA_{it} is the smoke-free air indicator variable, $CigPrice_{it}$ is the real price of cigarettes including all taxes, and X_{it} are county level variables, including population, percent of the population that is non-white, real median household income, percent of the population that is unemployed, the concentration of $PM_{2.5}$, the number of bars per 1,000 population, and the number of restaurants per 1,000 population. Finally, α_i and μ_t are county and year fixed effects, respectively.

In Model 1, the smoke-free air indicator is equal to 1 when the simple average level of protection is at least 50% across all four venues, and 0 otherwise. Model 2 is identical to Model 1 but the indicator variable is equal to 1 when the weighted average level of protection is at least 50% across all four venues, and 0 otherwise.

Models 1 and 2 implicitly assume that the effects of smoke-free air legislation are constant over time; a smoking ban is assumed to be equally effective from years 1 to 2 as it is from years 9 to 10. To relax this assumption, equation (1) is modified as follows, and estimated using Models 3 and 4:

$$y_{it} = exp(\beta_1 SFA_{it} + \beta_2 CigPrice_{it} + \beta_3 YearsSinceSFA_{it} + \beta_4 YearsSinceSFA_{it}^2 + \beta_5 X_{it} + \alpha_i + \mu_t + \epsilon_{it}) \quad (2)$$

Model 3 estimates equation (2) using the simple average SFA_{it} variable, while Model 4 uses the weighted average SFA_{it} variable. The additional variables $YearsSinceSFA_{it}$ and $YearsSinceSFA_{it}^2$ control for the cumulative effects of smoke-free air legislation over time. The remaining independent variables are identical to Models 1 and 2 in equation (1).

In each model above, the expected sign of the policy variables are less than one for all diagnoses except appendicitis, which is ambiguous. The linear effects of smoke-free air legislation should be less than one if the health benefits increase over time, and the non-linear effects are ambiguous and depend on the rate of change in each health outcome. The effect of $PM_{2.5_{it}}$ should be greater than one, as higher pollution levels are expected to lead to an increase in the number of hospitalizations for each diagnosis, while the remaining variables are each ambiguous.

A potential source of bias is the possibility that individuals may relocate to another county after the passage of a smoke-free air law or cigarette price increase. To address this concern, Table 2 displays the observable characteristics among treated counties one year prior to and one year following the enactment of smoke-free air legislation. With the exception of the unemployment rate and real median household income, each variable is essentially unchanged before and after a county enacts smoke-free air legislation covering at least 50% of the population.

Implicit in each model is the assumption that informal smoking bans or bans covering less than 50% of the population across all four venues did not exist prior to the observed start date in the dataset. If such bans did exist, and led to measurable improvements in health, the smoke-free air policy estimates will not fully capture the total effect of these laws. This is because a county will have begun to benefit from the resulting decline in smoking prevalence and reduced exposure to secondhand smoke prior to the start of their observed treatment date. To test for this possibility, I re-estimate Model 2 using leading policy indicators for three years prior to the enactment of smoke-free air legislation. This exercise is then repeated under the alternative assumption that a county is considered protected by smoke-free air legislation when the average level of protection across all four venues is at least 25%.

Finally, I perform an additional sensitivity test, re-estimating Model 4 under the alternative assumptions that a county is considered protected by smoke-free air legislation when the average level of protection covers at least 25%, 50%, 75%, and 100% of the population across all four venues.

4. Results

Results of Model 1 are shown in Table 3 for each diagnosis and age group. They suggest that after controlling for county level characteristics, county fixed effect, and year fixed effects, comprehensive smoke-free air legislation leads to a statistically significant decrease in hospitalizations for breast cancer (4.8%), coronary atherosclerosis (9.1%), and asthma (11.4%). While the results for breast cancer are similar across all age subgroups, findings for coronary atherosclerosis and asthma appear to be driven by a particular age group. For example, hospitalizations among adults ages 65+ declined by 12.3% for coronary atherosclerosis and 6.4% for asthma. For adults ages 18-64, the number of hospitalizations decreased by 5.2% and 12.0%, respectively. A $1.00 increase in the real cigarette price leads to a 6.8% decrease in coronary atherosclerosis hospitalizations, and a small decline in the number of hospitalizations for all other diagnoses. Acute myocardial infarction and appendicitis hospitalizations are not affected by either tobacco control policy.

I now move to Model 2, which estimates the effect of tobacco control policies using the weighted average SFA_{it} variable. Results in Table 4 are consistent with estimates from Model 1. Comprehensive smoke-free air legislation leads to statistically significant declines in breast cancer (3.8%), coronary atherosclerosis (10.3%), and asthma (13.7%) hospitalizations. These findings are again consistent across all age subgroups. A $1.00 increase in the real cigarette price leads to a 6.6% decline in coronary atherosclerosis hospitalizations, while all other diagnoses remain essentially unchanged. Comparing the results of Model 2 with those of Model 1 suggests that the additional weight placed on workplace smoking bans has a larger effect on coronary atherosclerosis and asthma hospitalizations than on breast cancer. Similar to Model 1, neither tobacco control policy leads to changes in the number of appendicitis hospitalizations for any age group.

Tables 5 and 6 show the results of Model 3, which controls for the cumulative effects of smoke-free air legislation. Statistically significant declines in hospitalizations for breast cancer (3.6%), coronary atherosclerosis (5.7%), and asthma (13.5%) are observed. A $1.00 increase in the real cigarette price leads to a statistically significant decrease in asthma hospitalizations for adults ages 18+ (10%) and ages 18-64 (7.9%). Similarly, increased cigarette prices lead to statistically significant declines in coronary atherosclerosis hospitalizations for each age group. Contrary to Models 1 and 2, acute myocardial infarction hospitalizations now decline by 1.2%, but remain not statistically significant. Linear coefficients are positive for acute myocardial infarction, coronary atherosclerosis, and asthma, but are generally not statistically significant. For coronary atherosclerosis and asthma, the benefits of smoke-free air legislation may be short lived, as the non-linear effects are positive and statistically significant. The results of Model 4 in Tables 7 and 8 are essentially unchanged from those of Model 3. In both Models 3 and 4, tobacco control policies do not lead to changes in hospitalizations for appendicitis.

4.1 Sensitivity Analysis

In Models 1-4, a county is assumed to be protected by comprehensive smoke-free air legislation when the average coverage level across all four venues is at least 50% in a given year. Tables 9 and 10 display the results of Model 4 using alternative levels of coverage equal to at least 25%, 50%, 75%, and 100% of the population. Each specification uses the full dataset of adults ages 18+, and results suggest that the effect on each diagnosis varies depending on the cutoff level being used. For example, acute myocardial infarction hospitalizations decline as the minimum coverage requirement increases from 25% to 100%, while breast cancer, coronary atherosclerosis, and asthma each appear to fluctuate across coverage levels. Appendicitis hospitalizations are statistically significant only at the 100% coverage level.

Model 2 is then used to estimate the effects of leading policy variables on the number of hospitalizations for each diagnosis, with results shown in Table 11. Statistically significant declines are observed for coronary atherosclerosis and asthma hospitalizations for two and three years prior to the enactment of smoke-free air legislation covering at least 50% of the population, respectively. These pre-treatment changes may occur if individuals self-select into counties based on health preferences prior to smoke-free air legislation being enacted. As shown above in Table 2, the nearly identical characteristics of counties prior to and following the enactment of smoke-free air legislation suggests this is unlikely. Another possibility is the method of defining smoke-free air coverage in this study. For example, if a county enacts a single smoking ban, the average level of protection across all four venues is equal to 25%, and any resulting change in the number of hospitalizations is not attributed to the smoke-free air policy. If single venue bans provide measurable health benefits at the county level, which the results in Tables 9 and 10 suggest they do, and if these bans precede the enactment of additional smoking restrictions in alternate venues, this may explain the statistically significant effects observed in Table 11. This would also suggest the estimates of Models 1-4 in Tables 3-8 underestimate the true effect of smoke-free air legislation.

Table 12 shows the results of Model 2 using leading policy variables, assuming that a county is protected by smoke-free air legislation when the average level of protection across all four venues is at least 25%. When using this lower threshold of smoke-free air coverage, only one diagnosis shows a statistically significant decline leading up to the policy implementation date. Asthma hospitalizations are significant at the 10% level for 1 and 3 years prior to the enactment of smoke-free air legislation.

5. Conclusion

This study analyzes the impact of comprehensive smoke-free air legislation and county level cigarette prices on the number of cancer, cardiovascular, and respiratory hospitalizations in the United States. Examining up to 80% of adult hospitalizations, while controlling for a rich set of county characteristics, produces estimates that more closely reflect the general population and are less likely to suffer from omitted variable bias.

Previous research suggests that tobacco control policies reduce active smoking and exposure to secondhand smoke, which leads to improved health outcomes. Studies examining the impact of smoke-free air legislation on hospitalization rates for cardiovascular and respiratory conditions find wide ranging effects. Declines in acute myocardial infarction and asthma hospitalizations range from 40% and 22% declines, respectively, to slight increases. I find results consistent with recent studies that examine larger populations and include additional control variables, as acute myocardial infarction hospitalizations did not change significantly as a result of either tobacco control policy. For asthma hospitalizations, I find declines of roughly 13%, 15%, and 6% for the age groups 18+, 18-64, and 65+. Two key insights from this study relate to the examination of breast cancer and coronary atherosclerosis in response to changes in tobacco control policies. Results suggest that breast cancer hospitalizations decline by 2.3%-4.8%, and these findings are consistent across all age subgroups. Similarly, coronary atherosclerosis hospitalizations decline by 5.6%-10.3%, with the largest effects observed for adults ages 65+. Additionally, changes in the real cigarette price lead to 6.6%-10% declines in coronary atherosclerosis and asthma hospitalizations.

I then performed several specification tests, the first of which tested for the presence of pre-treatment changes in hospitalizations. Results suggest there is generally no significant change in health outcomes leading up to the enactment of smoke-free air legislation. An examination of observable characteristics before and after smoke-free air legislation is enacted suggests no significant change occurs.

Similar to previous research, this study has several limitations. First, individual exposure to secondhand smoke is not observable and is assumed to be constant within a county and identical across individuals. Second, individuals are assumed to be affected only by tobacco control policies in their county of residence. Despite these limitations, the findings of this study have important policy implications. Nearly 42% of the population remains unprotected by smoke-free air legislation across all four venues, and millions of consumers face relatively low cigarette prices across many states. Expanding coverage of smoke-free air legislation and increasing the real cigarette price would do much to reduce the number of cancer, cardiovascular, and respiratory hospitalizations in the United States.

References

1. IARC Working Group on the Evaluation of Carcinogenic Risk to Humans. “Tobacco Smoke and Involuntary Smoking.” IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, no. 83, 2004.
2. Centers for Disease Control and Prevention. “National Biomonitoring Program.” Centers for Disease Control and Prevention, 23 Dec. 2016, www.cdc.gov/biomonitoring/tobacco.html.
3. U.S. Department of Health and Human Services, Public Health Service, Office of the Surgeon General. “The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General.” 2014.
4. Hahn, Ellen J. “Smokefree Legislation: A Review of Health and Economic Outcomes Research.” American Journal of Preventive Medicine, vol. 39, no. 6, ser. 1, 2010, pp. S66–S76.
5. Fichtenberg, Caroline M, and Stanton A Glantz. “Effect of SmokeFree Workplaces on Smoking Behaviour: Systematic Review.” Tobacco Control, vol. 21, no. 2, Mar. 2012, pp. 154–161.
6. Albers, A. B, et al. “Effect of Smoking Regulations in Local Restaurants on Smokers’ Anti-Smoking Attitudes and Quitting Behaviours.” Tobacco Control, vol. 16, no. 2, 2007, pp. 101–106.
7. Callinan, Joanne E, et al. “Legislative Smoking Bans for Reducing Secondhand Smoke Exposure, Smoking Prevalence and Tobacco Consumption.” Cochrane Database of Systematic Reviews, 2010.
8. U.S. Department of Health and Human Services, Public Health Service, Office of the Surgeon General. “Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General.” 2012.
9. Centers for Disease Control and Prevention. “Asthma: Basic Information.” Centers for Disease Control and Prevention, 3 Aug. 2012.
10. Benowitz, Neal L, et al. “Influence of Nicotine on Cardiovascular and Hormonal Effects of Cigarette Smoking.” Clinical Pharmacology and Therapeutics, vol. 36, no. 1, 1984, pp. 74–81., doi:10.1038/clpt.1984.142.
11. U.S. Department of Health and Human Services, Public Health Service, Office of the Surgeon General. “How Tobacco Smoke Causes Disease.” 2010.
12. California Environmental Protection Agency. “Proposed Identification of Environmental Tobacco Smoke as a Toxic Air Contaminant.” July 2005.
13. IARC Handbooks of Cancer Prevention. “Reversal of Risk After Quitting Smoking.” Tobacco Control, vol. 11, 2007.
14. Terry, Paul D, and Thomas E Rohan. “Cigarette Smoking and the Risk

of Breast Cancer in Women: A Review of the Literature." Cancer Epidemiology, Biomarkers & Prevention, vol. 11, Oct. 2002, pp. 953–971.
15. Lightwood, James M, and Stanton A Glantz. "Short-Term Economic and Health Benefits of Smoking Cessation." Circulation, 19 Aug. 1997, pp. 1089–1096.
15. Kramer, Anneke, et al. "Relative Risk for Cardiovascular Atherosclerotic Events after Smoking Cessation: 6–9 Years Excess Risk in Individuals with Familial Hypercholesterolemia." BMC Public Health, 2006.
16. He, Jiang, et al. "Passive Smoking and the Risk of Coronary Heart Disease - A Meta-Analysis of Epidemiologic Studies." New England Journal of Medicine, vol. 340, no. 12, 1999, pp. 920–926.
17. Glantz, Stanton A, and William W Parmley. "Passive Smoking and Heart Disease." Circulation, vol. 83, no. 1, Jan. 1991.
18. Collishaw, N. E., et al. "Canadian Expert Panel on Tobacco Smoke and Breast Cancer Risk." OTRU Special Report Series, Apr. 2009.
19. IARC Working Group on the Evaluation of Carcinogenic Risk to Humans. "Tobacco Smoking." IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, vol. 100 E-7, 2012. 20. Chaudhuri, Rekha, et al. "Effects of Smoking Cessation on Lung Function and Airway Inflammation in Smokers with Asthma." American Journal of Respiratory and Critical Care Medicine, vol. 174, no. 2, 2006, pp. 127–133.
21. U.S. Environmental Protection Agency. "Guidelines for exposure assessment." Federal Register, 1992.
22. Campaign for Tobacco-Free Kids. "State Cigarette Excise Tax Rates & Rankings." Campaign for Tobacco-Free Kids, 9 Aug. 2017.
23. American Nonsmokers' Rights Foundation. "Percent of U.S. State Populations Covered by 100% Smokefree Air Laws." American Nonsmokers' Rights Foundation, 2 Oct. 2017.
24. Sargent, Richard P, et al. "Reduced Incidence of Admissions for Myocardial Infarction Associated with Public Smoking Ban: before and after Study." BMJ, vol. 328, 24 Apr. 2004, pp. 977–980.
25. Bartecchi, Carl, et al. "Reduction in the Incidence of Acute Myocardial Infarction Associated With a Citywide Smoking Ordinance." Circulation, vol. 114, no. 14, 2006, pp. 1490–1496.
26. Juster, Harlan R., et al. "Declines in Hospital Admissions for Acute Myocardial Infarction in New York State After Implementation of a Comprehensive Smoking Ban." American Journal of Public Health, vol. 97, no. 11, 2007, pp. 2035–2039.

27. Loomis, Brett R., and Harlan R. Juster. "Association of Indoor Smoke-Free Air Laws with Hospital Admissions for Acute Myocardial Infarction and Stroke in Three States." Journal of Environmental and Public Health, 2012.
28. Herman, Patricia M., and Michele E. Walsh. "Hospital Admissions for Acute Myocardial Infarction, Angina, Stroke, and Asthma After Implementation of Arizona's Comprehensive Statewide Smoking Ban." American Journal of Public Health, vol. 101, no. 3, 2011, pp. 491–496.
29. Moraros, John, et al. "The Impact of the 2002 Delaware Smoking Ordinance on Heart Attack and Asthma." International Journal of Environmental Research and Public Health, vol. 7, 2010, pp. 4169–4178.
30. Basel, Paul, et al. "The Effect of a Statewide Smoking Ordinance on Acute Myocardial Infarction Rates." The American Journal of Medicine, vol. 127, no. 1, 2014.
31. Meyers, David G., and John S. Neuberger. "Cardiovascular Effect of Bans on Smoking in Public Places." The American Journal of Cardiology, vol. 102, no. 10, 2008, pp. 1421–1424.
32. Mead, Erin L., et al. "Association between Florida's Smoke-Free Policy and Acute Myocardial Infarction by Race: A Time Series Analysis, 2000-2013." Preventive Medicine, vol. 92, 2016, pp. 169–175.
33. Shetty, Kanaka, et al. "Changes in U.S. Hospitalization and Mortality Rates Following Smoking Bans." Journal of Policy Analysis and Management, vol. 30, no. 1, 2011, pp. 6–28.
34. Ho, Vivian, et al. "A Nationwide Assessment of the Association of Smoking Bans and Cigarette Taxes With Hospitalizations for Acute Myocardial Infarction, Heart Failure, and Pneumonia." Medical Care Research and Review, 2016.
35. Alaska Department of Health and Social Services, Health Facilities Data Reporting (HFDR) Program. Juneau, AK.
36. HCUP State Inpatient Databases (SID). Healthcare Cost and Utilization Project (HCUP). 1991-2014. Agency for Healthcare Research and Quality, Rockville, MD.
37. Arkansas Department of Health, Hospital Discharge Data Systems Section. Little Rock, AR.
38. California, State of. Health and Human Services Agency, Office of Statewide Health Planning and Development. Sacramento, CA.
39. Colorado Hospital Association, Discharge Data Program Data. Greenwood Village, CO.
40. Connecticut, State of. Department of Public Health. Hartford, CT.

41. Delaware Health and Social Services, Division of Public Health. New Castle, DE.
42. Florida, State of. Agency for Health Care Administration, Florida Center for Health Information and Transparency. Tallahassee, FL.
43. Georgia Department of Public Health, Office of Health Indicators for Planning (OHIP). Atlanta, GA.
44. Hawaii Health Information Corporation. Honolulu, HI.
45. Illinois Department of Public Health. Chicago, IL.
46. Indiana State Department of Health Policy. Indianapolis, IN.
47. Iowa Hospital Association (IHA). Des Moines, IA.
48. Kansas Department of Health and Environment, Division of Public Health, Bureau of Epidemiology and Public Health Informatics. Topeka, KS.
49. Kentucky Cabinet for Health and Family Services, Office of Health Policy. Frankfort, KY.
50. Louisiana Department of Health, Office of Public Health. Baton Rouge, LA.
51. Maryland, State of. Department of Health and Mental Hygiene, Health Services Cost Review Commission. Baltimore, MD.
52. The St. Paul Group. Baltimore, MD.
53. Michigan Department of Health & Human Services. Lansing, MI.
54. Minnesota Hospital Association. St. Paul, MN.
55. Missouri Department of Health and Senior Services, Bureau of Health Care Analysis and Data Dissemination. Jefferson City, MO.
56. Montana, State of. Department of Public Health and Human Services, Office of Epidemiology and Scientific Support. Helena, MT.
57. Nebraska Department of Health and Human Services, Division of Public Health. Lincoln, NE.
58. University of Nevada, Las Vegas, Center for Health Information Analysis. Las Vegas, NV.
59. New Hampshire, State of. Department of Health and Human Services. Concord, NH.
60. New Jersey Department of Health. Trenton, NJ.
61. New Mexico Department of Health. Santa Fe, NM.
62. Oklahoma State Department of Health, Center for Health Statistics. Oklahoma City, OK.
63. Oregon Health Authority, Office of Health Analytics. Salem, OR.
64. Pennsylvania Health Care Cost Containment Council. Harrisburg, PA.
65. Rhode Island Department of Health, Center for Health Data & Analysis.

Providence, RI.
66. South Carolina Revenue and Fiscal Affairs Office. Columbia, SC.
67. Tennessee Department of Health. Nashville, TN.
68. Texas Department of State Health Services. Austin, TX.
69. Utah Department of Health, Office of Health Care Statistics. Salt Lake City, UT.
70. Vermont Department of Health, Division of Health Surveillance. Burlington, VT.
71. Virginia Health Information. Richmond, VA.
72. Washington State Department of Health, Division of Disease Control and Health Statistics. Olympia, WA.
73. West Virginia Health Care Authority. Charleston, WV.
74. Wisconsin Hospital Association. Madison, WI.
75. Wyoming Department of Health. Cheyenne, WY.
76. HCUP Clinical Classifications Software (CCS) for ICD-9-CM. Healthcare Cost and Utilization Project (HCUP). 1991-2014. Agency for Healthcare Research and Quality, Rockville, MD.
77. ICD-9-CM: International Classification of Diseases, 9th Revision, Clinical Modification. Salt Lake City, Utah.
78. Centers for Disease Control and Prevention. "CDC WONDER." Centers for Disease Control and Prevention, wonder.cdc.gov/.
79. United States Census Bureau. "American FactFinder." American FactFinder, factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.
80. Health Resources & Services Administration. "Area Health Resources Files." HRSA Data Warehouse – Area Health Resource Files, ahrf.hrsa.gov.
81. Bureau of Labor Statistics. Consumer price index - All Urban Consumers, 1991-2014. Retrieved from http://data.bls.gov
82. United States Environmental Protection Agency. "Outdoor Air Quality Data." United States Environmental Protection Agency, www.epa.gov.
83. Centers for Disease Control and Prevention. "National Environmental Public Health Tracking." Centers for Disease Control and Prevention, www.cdc.gov/nceh/tracking.
84. Brook, Robert D, et al. "Particulate Matter Air Pollution and Cardiovascular Disease." Circulation, 2010, pp. 2331–2378.
85. Burnett, Richard T., et al. "Effects of Particulate and Gaseous Air Pollution on Cardiorespiratory Hospitalizations." Archives of Environmental Health: An International Journal, vol. 54, no. 2, 1999, pp. 130–139.
86. Kim, Hyomi, et al. "Assessment of Temporal Variation for the Risk of

Particulate Matters on Asthma Hospitalization." Environmental Research, vol. 156, 2017, pp. 542–550.
87. U.S. Census Bureau, Geographic Products Branch. "Geography, U.S. Census Bureau." U.S. Census Bureau, www.census.gov/geo.
88. U.S. Census Bureau. "Business Register." Business & Industry, U.S. Census Bureau, www.census.gov/econ/geography.html.

Appendix

Figure 1: Comprehensive Smoke-Free Air Legislation, 1991-2014

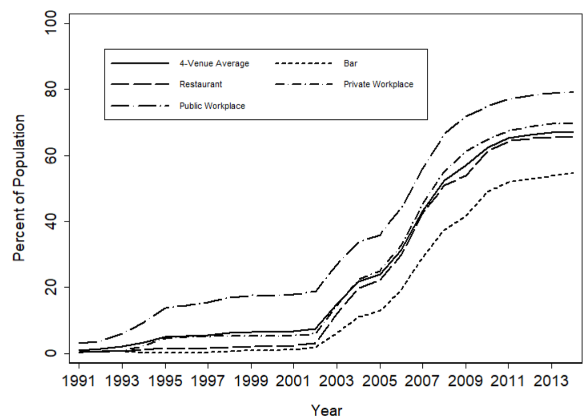

Figure 2: Number of Counties with Comprehensive Smoke-Free Air Legislation, 1991-2014

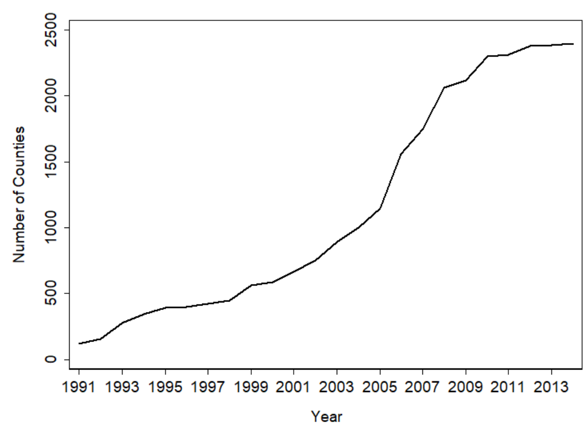

Figure 3: Yearly Cigarette Price (in 2014 dollars), 1991-2014

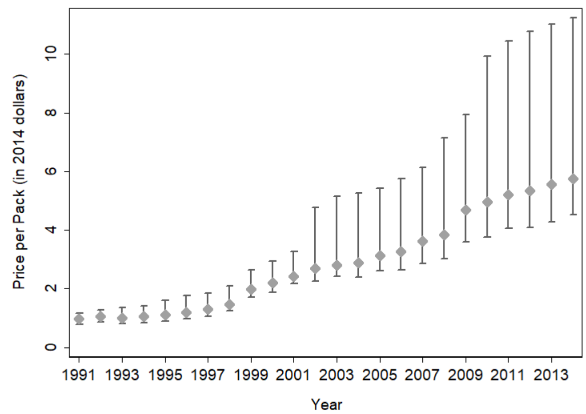

Figure 4: Number of States in Dataset, 1991-2014

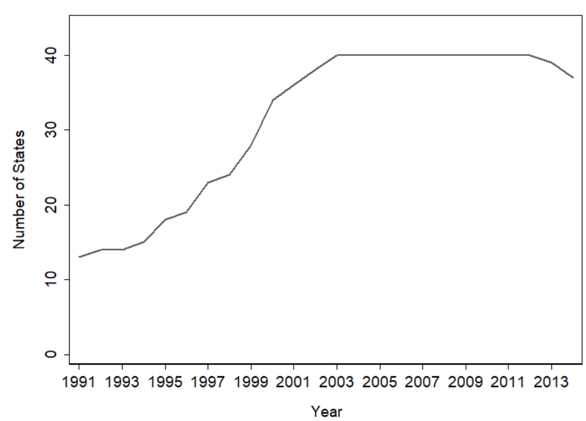

Table 1: Diagnoses and ICD-9, CCS Codes

Diagnoses	ICD-9 Codes	CCS Code
Breast Cancer	174.0-175.0, 175.9, 233.0, V10.3	24
Acute Myocardial Infarction	410.0-410.92	100
Coronary Atherosclerosis	411.0-414.06, 414.2-414.4, 414.8-414.9, V45.81, V45.82	101
Asthma	493.00-493.92	128
Appendicitis	540.0-540.9, 541, 542, 543.0, 543.9	142

Table 2: County Characteristics, Pre- and Post-SFA Laws (1 Year)

Variable	Pre-SFA Law, Mean	Post-SFA Law, Mean
Population (in thousands)		
Age 18+	78.86	80.75
Age 18-64	65.36	66.75
Age 65+	13.50	14.01
% Pop. Non-White	8.33	8.58
Real Cigarette Price	3.85	4.50
$PM_{2.5}$ Concentration	9.44	8.83
Unemployment Rate	6.00	7.05
Real Median HH Income (in thousands)	36.74	39.73
Number of Bars per 1,000 Population	0.36	0.34
Number of Restaurants per 1,000 Population	2.14	2.11

Table 3: Model 1 - Tobacco Control Policies and Hospitalizations

Variables	Age 18+	Age 18-64	Age 65+
Breast Cancer			
SFA Laws	0.952***	0.965*	0.949**
	(0.014)	(0.015)	(0.016)
Real Cigarette Price	0.977	0.983	0.971
	(0.014)	(0.013)	(0.021)
Acute Myocardial Infarction			
SFA Laws	1.008	1.016	0.994
	(0.014)	(0.013)	(0.014)
Real Cigarette Price	0.991	0.991	1.004
	(0.009)	(0.008)	(0.009)
Coronary Atherosclerosis			
SFA Laws	0.909**	0.948*	0.877***
	(0.031)	(0.025)	(0.032)
Real Cigarette Price	0.932*	0.942*	0.924
	(0.030)	(0.024)	(0.038)
Asthma			
SFA Laws	0.886*	0.880*	0.936**
	(0.043)	(0.047)	(0.022)
Real Cigarette Price	0.902	0.929	0.969
	(0.053)	(0.053)	(0.038)
Appendicitis			
SFA Laws	0.989	0.988	0.987
	(0.017)	(0.017)	(0.015)
Real Cigarette Price	0.990	0.989	0.990
	(0.012)	(0.013)	(0.011)

Robust standard errors in parentheses
***p< 0.01, **p< 0.05, *p< 0.1
Not shown: County Controls, County FE, Time FE

Table 4: Model 2 - Tobacco Control Policies and Hospitalizations

Variables	Age 18+	Age 18-64	Age 65+
Breast Cancer			
SFA Laws, Weighted	0.962**	0.976	0.955**
	(0.013)	(0.015)	(0.015)
Real Cigarette Price	0.975	0.982	0.970
	(0.014)	(0.013)	(0.021)
Acute Myocardial Infarction			
SFA Laws, Weighted	1.016	1.023	1.001
	(0.015)	(0.015)	(0.015)
Real Cigarette Price	0.990	0.990	1.003
	(0.009)	(0.008)	(0.009)
Coronary Atherosclerosis			
SFA Laws, Weighted	0.897**	0.939*	0.863***
	(0.034)	(0.029)	(0.035)
Real Cigarette Price	0.934*	0.943*	0.926
	(0.030)	(0.024)	(0.038)
Asthma			
SFA Laws, Weighted	0.863**	0.850**	0.927**
	(0.048)	(0.053)	(0.023)
Real Cigarette Price	0.905	0.933	0.970
	(0.053)	(0.052)	(0.038)
Appendicitis			
SFA Laws, Weighted	0.988	0.986	0.995
	(0.015)	(0.016)	(0.014)
Real Cigarette Price	0.991	0.990	0.989
	(0.012)	(0.013)	(0.011)

Robust standard errors in parentheses
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Not shown: County Controls, County FE, Time FE

Table 5: Model 3 - Tobacco Control Policies and Hospitalizations

Variables	Age 18+	Age 18-64	Age 65+
Breast Cancer			
SFA Laws	0.964**	0.963*	0.973
	(0.013)	(0.014)	(0.016)
Real Cigarette Price	0.978	0.983	0.974
	(0.014)	(0.013)	(0.021)
Years Since SFA	0.994	1.003	0.987
	(0.005)	(0.005)	(0.007)
Years Since SFA, Squared	1.001	1.000	1.001
	(0.000)	(0.000)	(0.001)
Acute Myocardial Infarction			
SFA Laws, Weighted	0.988	0.993	0.980
	(0.011)	(0.011)	(0.012)
Real Cigarette Price	0.993	0.994	1.005
	(0.009)	(0.008)	(0.010)
Years Since SFA	1.005	1.008	1.003
	(0.005)	(0.005)	(0.005)
Years Since SFA, Squared	0.997**	0.997**	0.997**
	(0.001)	(0.001)	(0.001)
Coronary Atherosclerosis			
SFA Laws, Weighted	0.943*	0.976	0.908**
	(0.026)	(0.022)	(0.030)
Real Cigarette Price	0.934**	0.942**	0.938**
	(0.020)	(0.018)	(0.021)
Years Since SFA	1.020	1.008	1.034*
	(0.011)	(0.008)	(0.014)
Years Since SFA, Squared	1.005***	1.005***	1.006***
	(0.001)	(0.001)	(0.001)

Robust standard errors in parentheses
***p< 0.01, **p< 0.05, *p< 0.1
Not shown: County Controls, County FE, Time FE

Table 6: Model 3 - Tobacco Control Policies and Hospitalizations

Variables	Age 18+	Age 18-64	Age 65+
Asthma			
SFA Laws, Weighted	0.865**	0.845**	0.948*
	(0.040)	(0.045)	(0.021)
Real Cigarette Price	0.900**	0.921**	0.969
	(0.035)	(0.025)	(0.029)
Years Since SFA	1.074***	1.103***	1.017*
	(0.023)	(0.027)	(0.008)
Years Since SFA, Squared	1.002**	1.002*	1.002***
	(0.001)	(0.001)	(0.001)
Appendicitis			
SFA Laws, Weighted	0.968	0.974	0.980
	(0.020)	(0.018)	(0.015)
Real Cigarette Price	0.990	0.988	0.989
	(0.013)	(0.013)	(0.011)
Years Since SFA	1.004	1.005	1.004
	(0.006)	(0.005)	(0.004)
Years Since SFA, Squared	0.999	0.999	1.000
	(0.000)	(0.000)	(0.000)

Robust standard errors in parentheses
***p< 0.01, **p< 0.05, *p< 0.1
Not shown: County Controls, County FE, Time FE

Table 7: Model 4 - Tobacco Control Policies and Hospitalizations

Variables	Age 18+	Age 18-64	Age 65+
Breast Cancer			
SFA Laws, Weighted	0.966**	0.970*	0.970*
	(0.012)	(0.014)	(0.015)
Real Cigarette Price	0.976	0.981	0.972
	(0.014)	(0.013)	(0.021)
Years Since SFA	0.998	1.005	0.993
	(0.005)	(0.005)	(0.006)
Years Since SFA, Squared	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)
Acute Myocardial Infarction			
SFA Laws, Weighted	0.998	1.007	0.990
	(0.011)	(0.011)	(0.011)
Real Cigarette Price	0.989	0.991	1.001
	(0.009)	(0.008)	(0.010)
Years Since SFA	0.999	1.001	0.998
	(0.007)	(0.007)	(0.006)
Years Since SFA, Squared	0.998	0.999	0.999
	(0.001)	(0.001)	(0.001)
Coronary Atherosclerosis			
SFA Laws, Weighted	0.957	0.984	0.926*
	(0.026)	(0.022)	(0.029)
Real Cigarette Price	0.944*	0.949*	0.951*
	(0.022)	(0.020)	(0.024)
Years Since SFA	1.014	1.006	1.024*
	(0.009)	(0.007)	(0.011)
Years Since SFA, Squared	1.004***	1.004***	1.005***
	(0.001)	(0.001)	(0.001)

Robust standard errors in parentheses
***p< 0.01, **p< 0.05, *p< 0.1
Not shown: County Controls, County FE, Time FE

Table 8: Model 4 - Tobacco Control Policies and Hospitalizations

Variables	Age 18+	Age 18-64	Age 65+
Asthma			
SFA Laws, Weighted	0.860***	0.852**	0.943**
	(0.037)	(0.042)	(0.020)
Real Cigarette Price	0.907*	0.933*	0.974
	(0.039)	(0.030)	(0.031)
Years Since SFA	1.068***	1.089***	1.017*
	(0.019)	(0.023)	(0.007)
Years Since SFA, Squared	1.001*	1.001*	1.002**
	(0.001)	(0.001)	(0.001)
Appendicitis			
SFA Laws, Weighted	0.969	0.983	0.994
	(0.018)	(0.017)	(0.016)
Real Cigarette Price	0.990	0.989	0.988
	(0.013)	(0.013)	(0.011)
Years Since SFA	1.002	1.000	1.002
	(0.006)	(0.005)	(0.004)
Years Since SFA, Squared	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)

Robust standard errors in parentheses
***p< 0.01, **p< 0.05, *p< 0.1
Not shown: County Controls, County FE, Time FE

Table 9: Specification Test, Alternate Coverage Levels

Variables	25 Percent	50 Percent	75 Percent	100 Percent
Breast Cancer				
SFA Laws, Weighted	0.981	0.966**	0.987	0.970
	(0.012)	(0.012)	(0.014)	(0.017)
Real Cigarette Price	0.972	0.976	0.970*	0.977
	(0.014)	(0.014)	(0.015)	(0.014)
Years Since SFA	0.998	0.998	1.005	1.000
	(0.004)	(0.005)	(0.006)	(0.011)
Years Since SFA, Squared	1.000	1.000	1.000	1.000
	(0.000)	(0.000)	(0.001)	(0.002)
Acute Myocardial Infarction				
SFA Laws, Weighted	0.999	0.998	0.981	0.961*
	(0.012)	(0.011)	(0.012)	(0.015)
Real Cigarette Price	0.984	0.989	0.999	1.002
	(0.009)	(0.009)	(0.010)	(0.010)
Years Since SFA	1.001	0.999	0.994	0.987**
	(0.004)	(0.007)	(0.004)	(0.005)
Years Since SFA, Squared	0.999*	0.998	1.000	1.002**
	(0.001)	(0.001)	(0.000)	(0.001)
Coronary Atherosclerosis				
SFA Laws, Weighted	0.972	0.957	1.113**	1.214***
	(0.025)	(0.026)	(0.039)	(0.047)
Real Cigarette Price	0.952	0.944*	0.897***	0.874***
	(0.026)	(0.022)	(0.029)	(0.026)
Years Since SFA	1.005	1.014	1.028*	1.048***
	(0.008)	(0.009)	(0.013)	(0.012)
Years Since SFA, Squared	1.004***	1.004***	0.998	0.994
	(0.001)	(0.001)	(0.003)	(0.003)

Robust standard errors in parentheses
***p< 0.01, **p< 0.05, *p< 0.1
Not shown: County Controls, County FE, Time FE

Table 10: Specification Test, Alternate Coverage Levels

Variables	25 Percent	50 Percent	75 Percent	100 Percent
Asthma				
SFA Laws, Weighted	0.886**	0.860***	1.110*	1.127**
	(0.039)	(0.037)	(0.051)	(0.047)
Real Cigarette Price	0.919	0.907*	0.863*	0.871*
	(0.046)	(0.039)	(0.054)	(0.057)
Years Since SFA	1.051***	1.068***	1.031*	1.000
	(0.016)	(0.019)	(0.014)	(0.012)
Years Since SFA, Squared	1.001*	1.001*	0.998	1.001
	(0.001)	(0.001)	(0.002)	(0.002)
Appendicitis				
SFA Laws, Weighted	0.975	0.969	0.972	0.952*
	(0.021)	(0.018)	(0.021)	(0.020)
Real Cigarette Price	0.985	0.990	0.999	1.018
	(0.013)	(0.013)	(0.013)	(0.014)
Years Since SFA	1.004	1.002	0.995	0.980*
	(0.005)	(0.006)	(0.009)	(0.009)
Years Since SFA, Squared	0.999	1.000	0.999	1.000
	(0.000)	(0.000)	(0.001)	(0.001)

Robust standard errors in parentheses
***p< 0.01, **p< 0.05, *p< 0.1
Not shown: County Controls, County FE, Time FE

Table 11: Specification Test, Leading Policy Variables, At Least 50 Percent Coverage

Variables	(Lead=1)	(Lead=2)	(Lead=3)
Breast Cancer			
SFA Laws, Weighted	0.998	0.982	0.992
	(0.009)	(0.009)	(0.009)
Real Cigarette Price	0.970*	0.973*	0.964**
	(0.014)	(0.013)	(0.012)
Acute Myocardial Infarction			
SFA Laws, Weighted	1.004	1.004	1.007
	(0.007)	(0.006)	(0.005)
Real Cigarette Price	0.986	0.983*	0.976**
	(0.008)	(0.008)	(0.008)
Coronary Atherosclerosis			
SFA Laws, Weighted	0.939**	0.957**	0.978
	(0.022)	(0.017)	(0.014)
Real Cigarette Price	0.933*	0.952	0.969
	(0.029)	(0.029)	(0.030)
Asthma			
SFA Laws, Weighted	0.898**	0.922**	0.947*
	(0.035)	(0.029)	(0.023)
Real Cigarette Price	0.889	0.904	0.914
	(0.055)	(0.059)	(0.061)
Appendicitis			
SFA Laws, Weighted	0.990	0.991	1.009
	(0.007)	(0.008)	(0.007)
Real Cigarette Price	1.010	1.015	1.020
	(0.014)	(0.015)	(0.016)

Robust standard errors in parentheses
***p< 0.01, **p< 0.05, *p< 0.1
Not shown: County Controls, County FE, Time FE

Table 12: Specification Test, Leading Policy Variables, At Least 25 Percent Coverage

Variables	(Lead=1)	(Lead=2)	(Lead=3)
Breast Cancer			
SFA Laws, Weighted	1.006	0.993	0.992
	(0.009)	(0.009)	(0.010)
Real Cigarette Price	0.970*	0.973*	0.964**
	(0.014)	(0.014)	(0.012)
Acute Myocardial Infarction			
SFA Laws, Weighted	0.994	1.000	0.998
	(0.005)	(0.005)	(0.005)
Real Cigarette Price	0.986	0.983*	0.976**
	(0.008)	(0.008)	(0.008)
Coronary Atherosclerosis			
SFA Laws, Weighted	0.969	0.983	0.994
	(0.019)	(0.015)	(0.011)
Real Cigarette Price	0.933*	0.952	0.969
	(0.029)	(0.029)	(0.031)
Asthma			
SFA Laws, Weighted	0.933*	0.959	0.969*
	(0.031)	(0.026)	(0.015)
Real Cigarette Price	0.890	0.904	0.914
	(0.056)	(0.059)	(0.061)
Appendicitis			
SFA Laws, Weighted	1.008	0.999	1.003
	(0.013)	(0.011)	(0.009)
Real Cigarette Price	1.009	1.015	1.021
	(0.014)	(0.015)	(0.016)

Robust standard errors in parentheses
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Not shown: County Controls, County FE, Time FE