The North Carolina Smoke Free Restaurants and Bars Law and Emergency Department Admissions for Acute Myocardial Infarction

A Report to the North Carolina State Health Director

PREPARED BY THE NC TOBACCO PREVENTION AND CONTROL BRANCH EPIDEMIOLOGY AND EVALUATION UNIT WITH SPECIAL THANKS TO THE UNIVERSITY OF NORTH CAROLINA DEPARTMENT OF EMERGENCY MEDICINE

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Background

Several studies have already been completed showing the effects of smoke-free legislation on rates of acute myocardial infarctions (heart attacks or AMIs).[1-10] A special committee appointed by The Institute of Medicine (IOM) referenced several of these studies in a 2009 report wherein they concluded that there was sufficient evidence to suggest a causal relationship between smoke-free legislation and reduced risk of acute cardiovascular events, such as AMI.[11] While the IOM committee was reluctant to declare a magnitude of effect, three meta-analyses have reported overall declines in AMI rates of 8, 10, and 17 percent in areas covered by smoke-free legislation.[12-14] The 2006 Surgeon General's report includes data on the relationship between several health problems and secondhand smoke (SHS) exposure and provides biological evidence of the plausibility of the association between smoke-free legislation and decreased incidence of AMI.[15] For more information on the biological relationship between SHS exposure and acute cardiovascular events, please see: 2010 Surgeon General's Report—How Tobacco Smoke Causes Disease: The Biology and Behavioral Basis for Smoking-Attributable Disease.[16]

Methods

Data

ED Data. Using data from the North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT), we extracted any emergency department visit record from the years 2008 to 2010 that were made by anyone over the age of 18 with a first-listed ICD-9 CM diagnosis code for an AMI (codes 410.x1-410.x0). For every sex, age (18-59 and 60+), and North Carolina county cross-classification, we calculated the total number of weekly ED visits with a first-listed AMI diagnosis. Visits that did not have information on sex, age, and/or county, and those that were made by residents of areas outside of North Carolina, were excluded from analysis.

Supporting data. We collected county-level gender- and age-specific estimates of population from North Carolina's Office of State Budget and Management. We extracted county-specific weekly average temperature data from the Southeast Regional Climate Center (http://www.sercc.com). For counties without a weather station, average temperature was based on average weekly temperatures recorded in all counties that are adjacent to the county with the missing data. Data on weekly rates of ED visits for influenza like illness (ILI) were accessed from the NC DETECT system and defined using NC DETECT's syndrome based reporting definition.

Statistical Analysis

We used an interrupted time series design to evaluate whether the implementation of smoke-free legislation on Jan. 1, 2010, was associated with a change in the rate of ED visits for AMI. We calculated crude and adjusted rate ratios by modeling the weekly number of ED visits for each stratum of sex, county, and age, and using as the offset variable the natural logarithm of the corresponding population estimate. Our main independent variable was a binary

indicator that represented whether the week occurred during a time when the smoke-free legislation was in place; coded as '1' for dates Jan. 1, 2010, and onward, and '0' for all other dates.

The following variables were considered for inclusion in the models: gender, age (18-59 vs. 60+), an indicator variable representing the Christmas holidays, a variable representing time, average weekly temperatures, and log-transformed weekly flu rates. We also considered for inclusion in the models a variable that represented the week of each year (week 0 through week 52). This variable was intended to adjust for seasonal patterns. Therefore, because the rate of ED visits was lowest around week 26 of each year, we recoded this variable to be a linear term with week 26 equal to 0 and so-on. We entered this linear term, as well as a quadratic and cubic term for this newly coded week in year variable, into the models.

After determining that the data were not over-dispersed, we conducted analyses using generalized estimating equation (GEE) Poisson regression models with an autoregressive correlation matrix to adjust for short-term autocorrelations within clusters of gender, age, and county. We used backwards selection to identify the best fitting model and examined Quasilikelihood under the Independence model Criterion (QIC) statistics, which are similar to Akaikes Information Criterion statistics, to compare models. A smaller QIC statistic indicates a more favorable model.

To evaluate our findings and their implications, we also refit the final models using false dates for the smoke-free legislation (Week 26 of year 2008, week one of 2009, and week 26 of 2009).

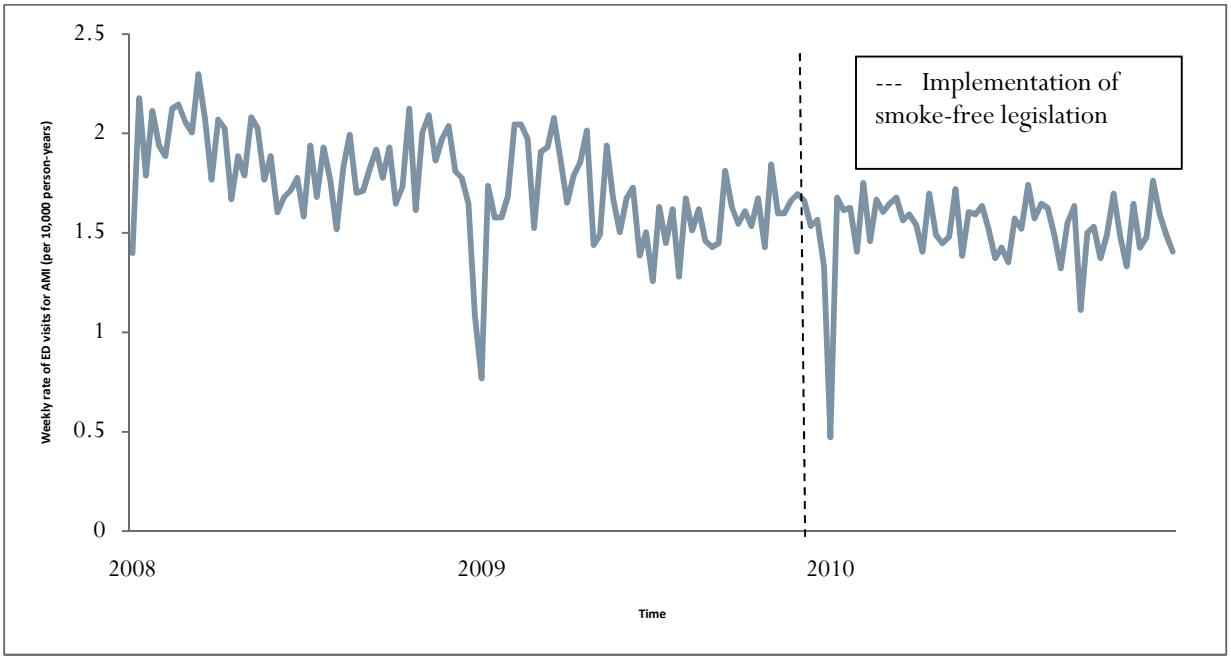
Results

In North Carolina, the number of ED visits for AMI decreased from 2008 to 2010. This trend was consistent for the entire population of North Carolina (Table 1). Interestingly, the rates appear to have consistently declined between the year 2008 and 2009; after that period the rates leveled off at a consistently lower level in the year 2010 (Figure 1).

Table 1. Number of Emergency Department visits in North Carolina with a first-listed diagnosis for acute myocardial infarction for years 2008 to 2010, overall and by categories of age and gender.

		Men		Women	
Year	All events	18-59	60 +	18-59	60+
2008	9428	2385	3196	946	2901
2009	8317	2070	2969	826	2452
2010	8000	1916	2885	778	2421

Figure 1. Weekly rates of emergency department visits for acute myocardial infarction from Jan.1, 2008, until Dec. 31, 2010, all N.C. ED visits for individuals ages 18 and up.



Comparison of QIC statistics suggested that the model that provided the best fit to the data was that which only adjusted for the weekly average temperature and for county. This model indicated that the rate of ED visits for AMI was 21percent lower following the implementation of the smoke-free restaurant and bars legislation. (Rate Ratio [RR] Estimate was 0.79 ; 95% CI: 0.75-0.83).

Model fit did not improve when we included interaction terms between the variable representing the tobacco legislation and quarter of the year, gender, or age category. Therefore, we have not reported any stratified estimates of that association.

To validate our findings, we used false dates for the start of the smoke-free restaurant and bars legislation. When the beginning of 2009 was set as the start date for the legislation, the model indicated that the rate of ED visits for AMI decreased by approximately 27 percent (RR: 0.73. 95% CI: 0.70-0.76). When week 26 of 2009 was set as the start of the legislation, the adjusted RR was near the null (0.99, 95% CI: 0.95-1.03). When week 26 of year 2008 was set as the start of the legislation, the model indicated that the rate of ED visits for AMI increased by 12 percent following the implementation of the bill (RR: 1.12, 95% CI: 1.08-1.16).

To calculate a rough estimate of healthcare cost savings, we multiplied the average weekly rate of AMI in 2009 (approximately 1.637 per 10,000 people) by the adult population in NC (divided by 10,000). We multiplied this result by .90 (representing an estimate of 90 percent of ED visits for AMI that result in hospitalizations). We multiplied that by the 2009 average AMI cost estimate for NC ($18065).[19] Then, to get a range of cost savings, we multiplied that number by the upper and lower bounds (.25 and .17, respectively) of the 95 percent confidence interval of our estimated ED AMI rate decrease of 21 percent.

Discussion

Results from this analysis suggest that, from 2008 to 2010, the rate of ED visits for AMI in North Carolina decreased. While it is impossible to tease out the exact magnitude of effect of the N.C. Restaurants and Bars Law, it is likely that it contributed to this decline. This suggested association is supported by the biologic plausibility data set forth in the Surgeon General's 2006 report which found suggestive evidence for the causal relationship between SHS and stroke.[15] The 2010 Surgeon General's report states: Even brief exposure to secondhand smoke can cause heart attacks, especially in individuals with underlying cardiovascular conditions.[16]

There are inherent limitations to this analysis, especially since it is ecologic in nature. It is impossible to disentangle the various factors that might have led to a decrease in the rate of ED visits for AMI following the implementation of the smoke-free restaurant and bars legislation. There was an obvious linear decrease in the rate of ED visits for AMI prior to the Jan.1, 2010. This is supported by the finding that falsely changing the date of the start of the tobacco ban to be Jan.1, 2009, produced a more negative effect estimate that was further from the null compared to that which we derived from modeling the association using the true date of the ban's implementation. Based on this ecologic analysis, it is not possible to declare with certainty that the reduced rates of ED visits for AMI are attributable to the tobacco legislation. However, it is reassuring that falsely setting week 26 of 2009 as the start date for the bill indicated that, before and after this false date, there was essentially no difference in the rate of ED visits for AMI. Furthermore, when week 26 of 2008 was set as the start date for the bill, the models suggested that rates of AMI increased following this date.

The conclusions from this study, that the tobacco legislation contributed to reduced rates of ED visits for AMI in North Carolina, are supported by toxicologic and epidemiologic data and serve as another data point in an international effort to determine the effect of smoke-free legislation on cardiovascular health outcomes.

Our results show a greater decrease than that shown by the three meta-analyses mentioned earlier in this report. We believe this may be at least partially attributable to NC's above average adult smoking rates (19.8 percent compared to US rate of 17.3 percent)[17,18], indicating a greater potential exposure to SHS prior to the ban. A decrease in SHS exposure in the workplace from 14.6 percent in 2008 to 7.9 percent in 2010 also supports this idea. (NC BRFSS, 2008 & 2010)

Active surveillance and monitoring in the years to come will contribute to further efforts at evaluating the effectiveness of this form of legislation. It would be helpful to conduct this type of analysis again once there are more year's worth of data available for analysis.

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