

## **MICHIGAN ASTHMA HOSPITALIZATIONS FOLLOWING THE DR. RON DAVIS SMOKE FREE AIR LAW: A LONGITUDINAL COHORT STUDY**

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### **ABSTRACT**

**Objective** To determine the impact of the 2010 Michigan Smoke Free Air (SFA) law on the rate of asthma hospitalizations in Michigan adults and to determine any differential effects by race, sex and age.

**Methods** Adult asthma hospitalizations were obtained from the Michigan Inpatient Hospital Database (MIDB). Poisson regression was used to model relative risks for asthma hospitalization following the smoking ban with adjustments for sex, race, age, insurance type and month of year. Race, age and sex-based analyses were performed.

**Results** In the first year following implementation of the SFA law, adjusted adult asthma hospitalization rates decreased 8% (95% CI 7-10%,  $P < 0.0001$ ): black hospitalization rates decreased 7% (95% CI 5-9%,  $P < 0.0001$ ) and white hospitalization rates decreased 10% (95% CI 8-12%,  $P < 0.0001$ ), there were no differences in adult asthma hospitalization rates by age or sex.

**Conclusions** The implementation of the SFA law is associated with a reduction in adult asthma hospitalization rates, with a greater decrease in white hospitalization rates compared to black rates. These results support continued implementation of the SFA law, however, more research is needed to determine the causes for these disparate health benefits.

## Introduction

The negative health consequences from exposure to secondhand smoke (SHS) have been well documented. In addition to causing lung cancer, heart disease and stroke, SHS exposure has been associated with increased risk for other cancers, premature birth, infertility and respiratory disease [1, 2]. In an effort to reduce the public's exposure to SHS, 28 states have banned smoking in bars, restaurants and worksites, with another 12 states that have implemented partial smoking bans in these places [3].

Dozens of studies have examined whether public smoking bans have changed the number of myocardial infarction and stroke events, but less research has reported on asthmatic events [4, 5]. The first asthma ED study examined the smoking ban in Lexington-Fayette county, KY and found a 24% decline in adult ED visits post-ban [6]. Other studies examining asthma rates following state, province and country-wide smoking bans have reported 0-22% reductions in asthma hospitalization rates [5, 7-10]. To date, there are no comprehensive analyses examining post-smoking ban asthma hospitalization outcomes by race, sex and age.

With over 10% of the adult population self-reported to have asthma, Michigan has the 12<sup>th</sup> highest asthma prevalence in the country [11]. While the prevalence of asthma in Michigan black and white adult populations is **almost** similar (10.7% vs. 9.5%, respectively), black adults are over four times as likely to be hospitalized for asthma [12]. Michigan women are hospitalized slightly more than men (19.3 per 10,000 vs. 13.6 per 10,000), but women also have a higher asthma prevalence (12.6% vs. 7.0%) [12]. Asthma hospitalizations have been increasing in the adult Michigan population since 2000.

The Dr. Ron Davis Smoke Free Air Law (SFA law), implemented May 1, 2010, banned smoking in Michigan bars, restaurants, work places and other indoor public areas. In this study, we examine whether the SFA law associated with a change in the rate of asthma hospitalizations. The primary goal of this observational time series study was to examine the rate of asthma hospitalizations before and after implementation of the SFA law. The secondary goal of the study was to determine if there were any differences in hospitalization rates by race, sex or age group following implementation of the SFA law.

## **Methods**

Hospital admissions data were taken from the Michigan Inpatient Hospital Database (MIDB) from January 2002 through December of 2012. The MIDB is purchased by the Michigan Department of Community Health (MDCH) from the Michigan Health and Hospital Association (MHA). The MHA compiles the data from over 95% of the hospitals in the state of Michigan. Data available from these medical records include admission date, primary discharge diagnosis, age, sex, race and patient's insurance type. The Division for Vital Records and Health Statistics (DVRHS) at MDCH reviews and edits the data in the MIDB. Age, sex and race are verified with MDCH Vital Records, the Annual Survey of Health Facilities conducted by MDCH, National Editing Procedure from the National Center for Health Statistics, hospital medical records personnel, and census data from the U.S. Bureau of Census. About 25% of all MIDB records are missing race data: DVRHS can match almost half of these missing cases (12% of total cases) to known race data from the Michigan Birth Registry, Michigan Death Registry and from a patient's previous hospital visit where race information was recorded. Race is imputed for the remaining 13% of unknown cases according to the known proportion of hospitalizations by zip code, race, age and sex. Tobacco use data were not available from the MIDB.

### *Case Selection*

Asthma hospitalizations were determined by primary discharge diagnosis for asthma (International Classification of Diseases, Ninth Revision: 493.xx). In order to study adult asthma while minimizing the potential confounder of COPD, we limited the study to 20-64 year olds.

## *Analysis*

We used Poisson regression to model monthly asthma hospitalization rates during our 11 year study period. Because we were analyzing counts in a state-wide population, we specified Poisson distribution. Population offset was determined by the annually published MDCH Department of Vital Records and Health Statistics (DVRHS) intercensal estimates for age, race and sex [13]. These estimates are bridged for race using the National Center for Health Statistics methodology [14]. Because we adjusted for age in the model, we based the regression on unadjusted asthma hospitalization rates. To study the effect of the ban, we employed an indicator variable set as “0” for pre-ban (months before May 2010) and “1” for post-ban (May 2010 and beyond). Because adult asthma hospitalizations have been increasing since 2000, we included a time variable (1 to 132 months) and an interaction term between the ban and time (ban\*time) in our model. The analyses were adjusted for age, sex, race, insurance type and month of year (1 to 12). We adjusted for month of year due to the seasonal pattern of asthma hospitalizations [15]. Age adjustments were determined by following the intercensal population estimates (20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64). Separate analyses stratified the population by race (black, white), sex (male, female) or age (20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64) and adjusted for the same factors as in the previous analyses. A chi square test of association was performed to determine if there was an association between race and insurance type. Statistics were computed using SAS version 9.2 (SAS Institute, Cary, North Carolina).

This study was declared exempt by MDCH IRB.

## Results

From January 2002 through December 2012, there were 88,438 events of 20-64 year old hospitalizations in the MIDB with a primary discharge diagnosis of asthma (**Table 1**). Women, blacks and the Medicaid/Medicare populations were hospitalized at higher rates than men, whites and privately insured populations. Race data were missing from 0.2% of events that were analyzed.

After adjusting for age, sex, race, insurance type and month of year, there was an 8% reduction in the population-wide rate of asthma hospitalizations over the first 12 months following implementation of the SFA law (RR 0.92, CI 0.90 – 0.93,  $P < 0.0001$ ) (**Table 2**). When we stratified the data by race, we found a significant difference between black and white hospitalization rates following the SFA law: in the first 12 months of the ban, black hospitalization rates decreased 7% (RR 0.93, CI 0.91 – 0.95,  $P < 0.0001$ ) while white hospitalization rates decreased 10% (RR 0.90, CI 0.88 – 0.92,  $P < 0.0001$ ) (**Table 2**). There was a significant reduction in the rate of hospitalizations for men and women, but there were no differences between the two groups (data not shown).

**Figure 1** shows the population-adjusted monthly asthma hospitalization rate for Michigan adults. The hospitalization rate increases with time. Following the SFA law, there is a reduction in the asthma hospitalization rate. We stratified our analyses by black and white monthly asthma hospitalizations in **Figure 2**. The black population has a higher rate of asthma hospitalizations than the white population. Following implementation of the SFA law, blacks and whites both have a reduced rate of asthma hospitalization, however, the effect is more

pronounced in whites than in blacks (annual decrease in hospitalization rates is 10.5% in whites vs. 7.8% in blacks). **Figure 3** shows the change in relative risk for asthma hospitalizations for the whole population and stratified by race. The relative risk for asthma hospitalizations decreases following implementation of the SFA law, with the relative risk for whites decreasing the most.

Hospitalizations in Michigan citing asthma as the primary diagnosis average \$15,047 per hospital stay in 2011 dollars [16]. In the 31 months following implementation of the SFA law, our model shows a reduction of 3,230 adult asthma hospitalizations, saving \$48.6 million in health care costs.

## Discussion

In the 31 months following implementation of the SFA law, Michigan adult asthma hospitalization rates decreased by 8% after adjusting for age, sex, race, insurance type and month of year. There was a greater reduction in asthma hospitalizations among whites than blacks, but there were no significant changes in hospitalization rates by sex or age.

There have been several studies that have found the implementation of a smoke free air law to associate with a reduction of asthma events [6-9, 17-20]. However, this study is the first to use statewide data to show a racial disparity in benefits from the law. Because blacks have a higher smoking prevalence than whites, we were expecting to find a greater decrease in black asthma hospitalizations following the ban [21]. However, our findings are validated by another study examining a city-wide smoking ban in Texas: the number of post-ban white asthma hospitalizations decreased, with no significant change in black hospitalizations [19]. In light of this racial disparity, we hypothesize that the SFA law has either changed smoker behavior, non-smoker exposure to SHS, or both. SFA laws have been shown to encourage smokers to reduce consumption or quit smoking altogether [22, 23]. If race is a marker for economic status, whites will have more resources to help them quit smoking. Likewise, more middle and upper class people will patronize bars and restaurants and benefit from the reduction in SHS exposure.

The 8% decrease in hospitalizations that we have reported is within the range of other post SFA law asthma studies [4]. Tobacco smoke is a known asthma trigger, so it is reasonable to find a decrease in asthma hospitalizations when exposure to SHS is restricted. Asthmatics who are

hospitalized have poorly controlled asthma and represent the most severe cases. It would be interesting to study the change in ED visits following implementation of the SFA law.

Our study is strengthened by the large dataset available to us: we examined statewide hospitalization data for 100 months preceding the SFA law and 32 months following the ban. Because this is a multi-year study, we were able to adjust for seasonality, which is a known confounder for asthma hospitalization rates [15]. This research has limitations. As an observational study, we can only determine an association between implementation of the SFA law and the reduction in hospitalizations, we cannot determine causality. Due to changes in BRFSS methodology, we cannot accurately assess changes in tobacco use patterns following implementation of the SFA law. Additionally, MIDB data do not include information on patient smoking status, so we are unable to differentiate between firsthand or secondhand smoke exposure.

This study contributes to a growing body of literature associating smoke free legislation with improved public health and decreased health care costs. We were surprised to find such a significant health disparity following the SFA law: more work is necessary to understand the causes for these different hospitalization rates to promote the health benefits to all Michigan populations.

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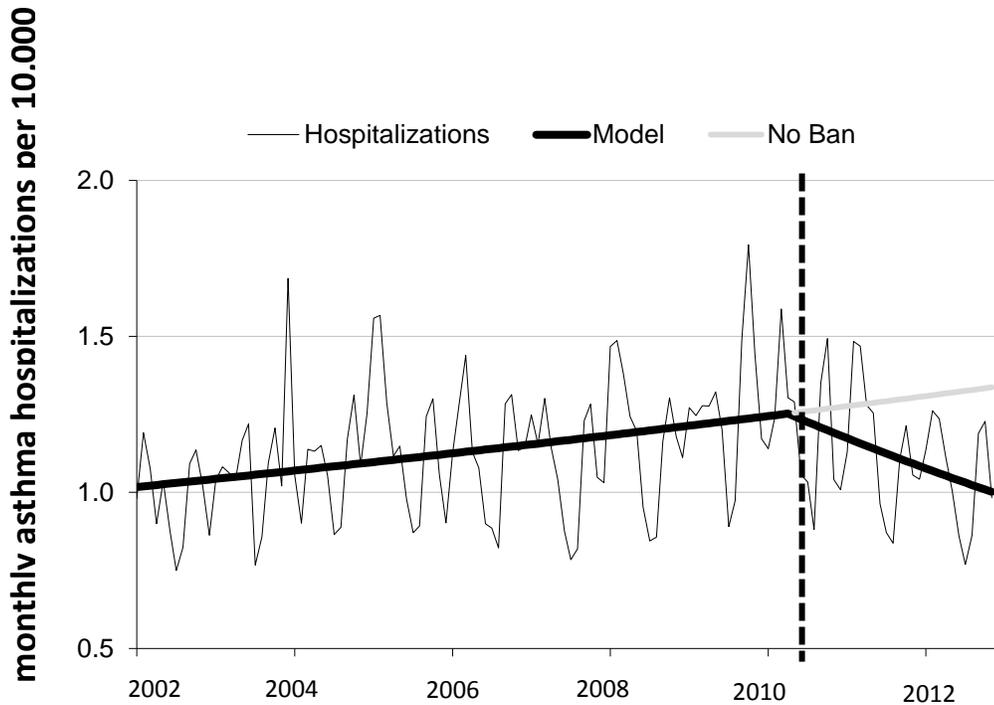
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	Hospitalizations		%
Sex	Male	24913	28.2
	Female	63525	71.8
Race	Black	38326	43.3
	White	48396	54.7
	Other	1564	1.8
	Missing	152	0.2
Age	20-24	4482	5.1
	25-29	5435	6.1
	30-34	6398	7.2
	35-39	8789	9.9
	40-44	11800	13.3
	45-49	14221	16.1
	50-54	14524	16.4
	55-59	12441	14.1
	60-64	10348	11.7
Insurance	Private	38024	43.0
	Medicaid	22061	24.9
	Medicare	18912	21.4
	Other	9392	10.6
	Missing	49	0.1

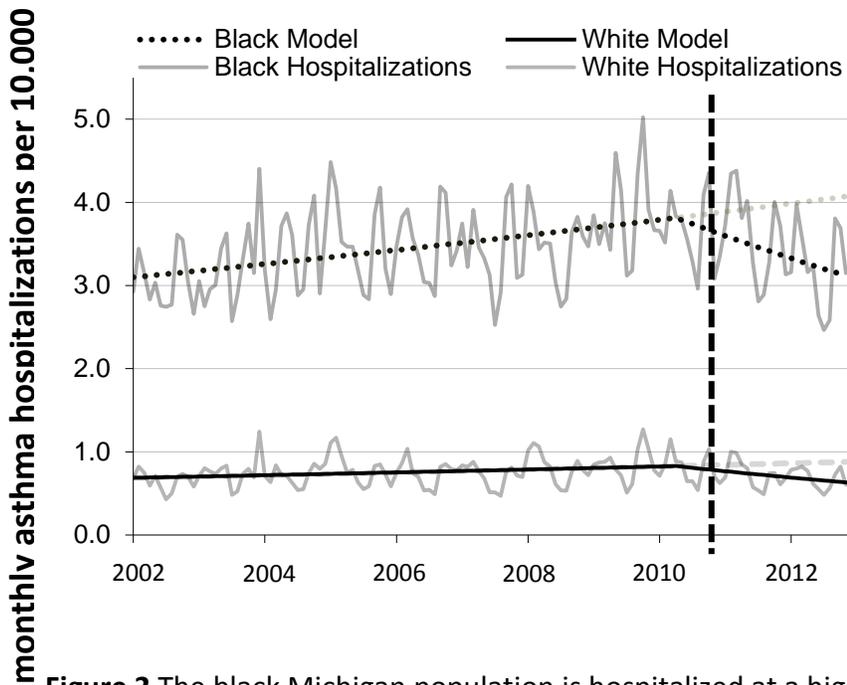
**Table 1** Population characteristics of Michigan asthma hospitalization events from January 2002 through December 2012.

	All			Black			White		
	RR	CI	P	RR	CI	P	RR	CI	P
<b>Unadjusted</b>	0.92	(0.90- 0.93)	<0.0001	0.92	(0.90 - 0.95)	<0.0001	0.90	(0.88 - 0.92)	<0.0001
<b>Adjusted</b>	0.92	(0.90 - 0.93)	<0.0001	0.93	(0.91 - 0.95)	<0.0001	0.90	(0.88 - 0.92)	<0.0001

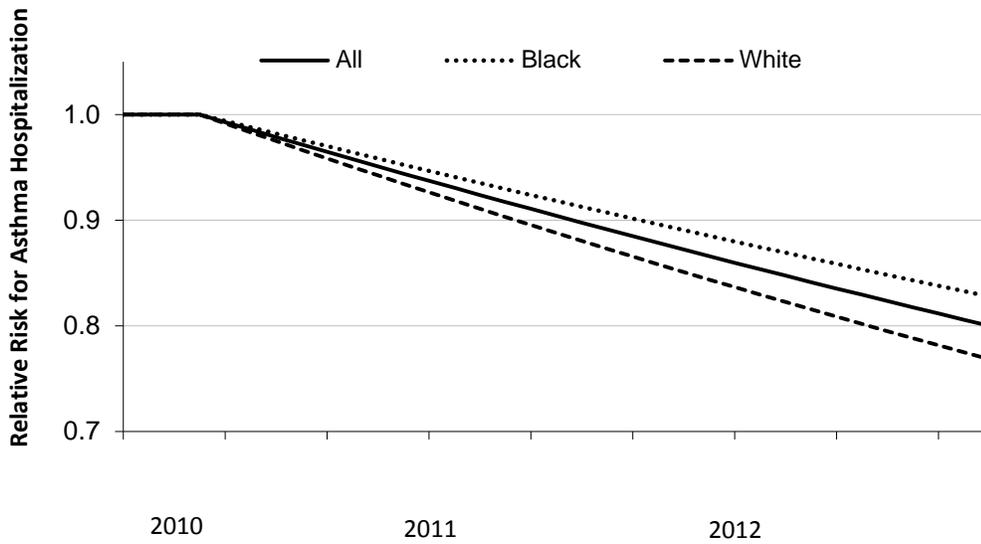
**Table 2** The relative risks for asthma hospitalization were computed for the entire adult Michigan population, the black population and the white population for the first 12 months following implementation of the SFA law (May 2010-April 2011). The models were adjusted for age, sex, race (in the All category only), insurance type and month of year. Each covariate significantly contributed to the model.



**Figure 1** The rate of asthma hospitalizations steadily increased in Michigan adults from 2002 - 2010. In the 32 months following implementation of the SFA law (May 2010), the rate of adult asthma hospitalizations steadily decreased. The thin black line represents the actual rate of asthma hospitalizations per 10,000 population per month, the thick black line represents our unadjusted model of the rate of asthma hospitalizations and the thick gray line represents the projected number of hospitalizations if the SFA law had not been passed.



**Figure 2** The black Michigan population is hospitalized at a higher rate than the white population. Following implementation of the SFA law the rate of asthma hospitalizations decreased for both races, although the decrease was larger for the white population. The light gray dotted lines represent the projected rate of hospitalizations for each race if the SFA law had not been passed.



**Figure 3** The modeled relative risk for asthma hospitalizations following implementation of the SFA law progressively decreases with time. The white population has a much lower relative risk for asthma hospitalization than the black population: this difference is statistically significant.