

# Hannibal

## Air Quality Monitoring Study



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# CASE

Campus-Community Alliances for Smoke-Free Environments

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## Executive Summary

Secondhand smoke (SHS) was classified in 1992 by the U.S. Environmental Protection Agency (EPA) as a cause of cancer in humans. It contains more than 7,000 chemicals of which more than 250 are known to be poisonous. For such a substance, there is no minimum safe level of exposure. The 2006 U.S. Surgeon General's Report, reviewing thousands of research studies, finds SHS is a cause for stroke, emphysema, bronchitis, asthma, respiratory infections, Sudden Infant Death Syndrome and other illnesses. SHS is responsible for almost 50,000 deaths per year from heart disease and lung cancer in nonsmokers. The 2006 Surgeon General's Report concluded that policies for smokefree environments are the most effective method of reducing SHS exposure in public places and workplaces.

The purpose of this study was to sample the air quality in Hannibal public places and workplaces and compare results to the EPA Air Quality Index. Indoor air quality for fine particulate matter pollution (PM<sub>2.5</sub> particles) was sampled in 11 public places on before and after the city smokefree ordinance went into effect. Eight locations allowed smoking indoors and three locations were smokefree.

Key findings of this study include:

- Before the ordinance was in effect:
  - Particulate matter air pollution for –
    - The 8 smoking-allows locations averaged 216  $\mu\text{g}/\text{m}^3$  (EPA rating of “very unhealthy”).
    - The 3 smokefree locations averaged 7  $\mu\text{g}/\text{m}^3$  (EPA rating of “good”).
    - The level of particulate matter air pollution was nearly 30 times higher in places that allowed smoking compared to those where smoking was not allowed.
    - Due solely to their occupational exposure, a full-time employee in one of those Hannibal public place that allowed smoking was exposed to 329% the EPA's average annual limit for particulate matter air pollution.
    - On average, about 7% of people were actively smoking in the locations where smoking was permitted. This is less than 1/4<sup>th</sup> the adult smoking prevalence of 29.3% for Marion County, and refutes the commonly held misperception that a higher percent of hospitality industry customers or employees smoke.
  - After the ordinance was in effect:
    - One incident of smoking was observed in one of the public places, indicating high compliance with the ordinance.
    - Particulate matter air pollution for the public places that previously allowed smoking averaged 30  $\mu\text{g}/\text{m}^3$  (EPA rating of “moderate”) and represents an 88% reduction for this pollutant. When the one non-compliant place is removed, the particulate matter pollution average for previously smoking-allowed places was 5.7  $\mu\text{g}/\text{m}^3$  (EPA rating of “good”) and represents a 97% reduction for this pollutant.
    - A full-time employee in one of these Hannibal public places that previously allowed smoking would be exposed to less than 1/2 the EPA's average annual limit for particulate matter air pollution. When the one non-compliant place is removed, the employee exposure would be less than 1/10<sup>th</sup> the EPA limit.

Findings of this study are consistent with those of similar previous studies that found that approximately 90% or more of the fine particle pollution could be attributed to SHS.

## Introduction

Secondhand smoke (SHS) contains more than 7,000 chemicals, of which more than 250 are known to be either toxic and/or carcinogenic, and by itself was classified in 1992 by the U.S. Environmental Protection Agency as a human carcinogen.<sup>1</sup> Exposure to SHS is responsible for an estimated 35,000 deaths per year from heart disease and lung cancer in nonsmokers.<sup>2</sup> The U.S. Surgeon General issued reports in 1984 and 2006 concluding SHS was also a cause for stroke, emphysema, bronchitis, asthma, respiratory infections, Sudden Infant Death Syndrome and other illnesses. The Surgeon General also concluded there is no safe level of exposure to SHS.<sup>1,3,4</sup>

With specified exemptions, Missouri state law requires all public places to prohibit smoking unless designated smoking areas are provided. Such designated areas are not to exceed 30% of its entire space. Missouri state law does not preempt local governments from enacting more stringent smokefree ordinances.

On December 5, 2011, the Hannibal City Council approved a measure to place a question regarding an ordinance for smokefree public places and workplaces on the next city election ballot. On April 3, 2012 voters approved the question with 56% of the votes in the affirmative. The council then adopted an ordinance on May 15, 2012 with an effective date of July 1, 2012.

Policies prohibiting smoking have been shown as an effective method for eliminating SHS exposure in public places and workplace environments. While many businesses voluntarily establish smokefree policies, the hospitality industry (including restaurants, bars, bowling alleys, etc.), representing approximately 10-14% of workplaces, has been slow to enact smokefree policies. Consequently, workers and patrons are exposed to SHS. An increase in state- and city-wide smokefree ordinances across the United States has resulted in declining SHS exposure among the overall U.S. population,<sup>5</sup> but unlike Hannibal, a majority of Missouri municipalities and populations remain without comprehensive smokefree laws.

To protect public health, the U.S. Environmental Protection Agency (EPA) issued National Ambient Air Quality Standards which include fine particulate matter as one of the criteria pollutants. The EPA first issued standards for daily exposure to pollution consisting of particulate matter of 2.5 microns in size (PM<sub>2.5</sub>) in 1971 with periodic revisions, the latest in 2006 and currently in a public comment period. Current EPA standards based on review of thousands of peer-reviewed scientific studies recommend exposure during a 24-hour period to be not greater than 35 µg/m<sup>3</sup>. Further, over the period of a year a person's exposure should not have a daily average of more than 15 micrograms per cubic meter (µg/m<sup>3</sup>). EPA assigned levels for PM<sub>2.5</sub> ranging from "good" to "hazardous" with accompanying health advisories as presented in Table 1.<sup>6</sup> Because the impact on health is the same regardless of whether the air is in an outdoor or indoor environment, the EPA index is a valuable measure of health risk.

**Table 1. U.S. Environmental Protection Agency – Air Quality Index**

Air Quality	PM <sub>2.5</sub> (µg/m <sup>3</sup> )	Health Advisory
Good	≤ 15	None
Moderate	16-35	Unusually sensitive people should consider reducing prolonged or heavy exertion
Unhealthy for Sensitive Groups	36-55	People with heart or lung disease, older adults and children should reduce prolonged or heavy exertion
Unhealthy	56-150	People with heart or lung disease, older adults and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion
Very Unhealthy	151-250	People with heart or lung disease should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.
Hazardous	≥ 251	People with heart or lung disease, older adults, and children should remain indoors and keep activity levels low. Everyone else should avoid all physical activity outdoors.

## Methods

### Overview

Indoor air quality for fine particulate matter pollution was sampled for 11 public places in Hannibal on Friday, December 3, 2011 and Friday, October 19, 2012. Eight of the locations allowed smoking indoors and three locations were smokefree. Particulate matter smaller than 2.5 micrograms (PM<sub>2.5</sub>) was measured. The PM<sub>2.5</sub> particles are easily inhaled deep into the lungs and can pass into the bloodstream, and are associated with pulmonary and cardiovascular disease and mortality.

### Measurement Protocol

A minimum average of 45 minutes was spent in each location to monitor air for data collection. The number of people at the location and the observed number of burning cigarettes were recorded during the air quality sampling period. A sonic measuring device was used to measure room dimensions, enabling unobtrusive calculation of the volume of each location. Active smoker density was calculated by dividing the average number of burning cigarettes by the volume of the room in meters. The number of burning cigarettes was divided by the number of people at the location to determine the percent of people smoking.

A TSI Sidepak AM510 Personal Aerosol Monitor (TSI, Inc., St. Paul, MN) was used to sample and record the levels of particulate matter pollution in the air. The Sidepak uses a built-in sampling pump to draw air through the device, where the particulate matter in the air scatters the light from a laser to assess the real-time concentration of particulate matter smaller than 2.5 micrograms to be recorded as PM<sub>2.5</sub>. The concentrations of particulate matter were recorded as micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ). The Sidepak was zero-calibrated prior to each use by attaching a HEPA filter according to the manufacturer's specifications. The Sidepak was set to a one-minute log interval, which averages the previous 60 one-second measurements.

Air quality sampling was conducted discreetly in order to not disturb the normal behavior of workers or patrons. For each location, the first and last minute of logged data were removed because they were averaged with outdoor and/or entryway air. The remaining data points were averaged to provide an average PM<sub>2.5</sub> concentration within the location.

Descriptive data including the location volume in cubic meters ( $\text{m}^3$ ), number of people, number of burning cigarettes, and smoker density (number of burning cigarettes per 100  $\text{m}^3$ ) were recorded for each location and averaged for all locations. Additionally, the results are compared to the EPA Air Quality Index.

## Results

The locations were visited on Friday evenings before and after the July 1, 2012 effective date of the smokefree ordinance. Average PM<sub>2.5</sub> levels for the 8 sampled locations that allowed smoking was 216.2  $\mu\text{g}/\text{m}^3$  (range: 12.9 – 667.2  $\mu\text{g}/\text{m}^3$ ). The 3 smokefree locations had an average PM<sub>2.5</sub> level of 7.3  $\mu\text{g}/\text{m}^3$  (range: 6.3 – 9.1  $\mu\text{g}/\text{m}^3$ ). The level of particulate matter air pollution was 29.6 times higher in those locations that allowed smoking compared to those prohibiting smoking. On average, 2.5 cigarettes (range: 0 – 13 cigarettes) were burning during the monitoring time frame at smoking venues. This represents an overall average of 7.2% of patrons smoking at any given time. Tables 2 and 3 provide additional details of the monitored venues.

**Table 2. Hannibal Air Quality Data before ordinance**

Location	Average # burning cigarettes	Active smoker density	% burning cigarettes to # people	Average PM <sub>2.5</sub> level (µg/m <sup>3</sup> )	EPA Air Quality Index category
A*	-	-	-	6.4	Good
B*	-	-	-	6.3	Good
C*	-	-	-	9.1	Good
Average	-	-	-	7.3	Good
D	2.3	0.70	17.3	330.0	Hazardous
E	0.4	0.07	2.7	38.4	Unhealthy to Sensitive Groups
F	0.8	1.03	6.5	80.3	Unhealthy
G^	0.0	0.00	0.0	12.9	Good
H	4.5	1.42	18.0	667.2	Significant Harm
I	2.0	0.23	3.0	263.0	Hazardous
J	2.7	0.78	10.3	76.5	Unhealthy
K	7.2	0.36	6.9	261.3	Hazardous
Average	2.5	0.35	7.2	216.2	Very Unhealthy

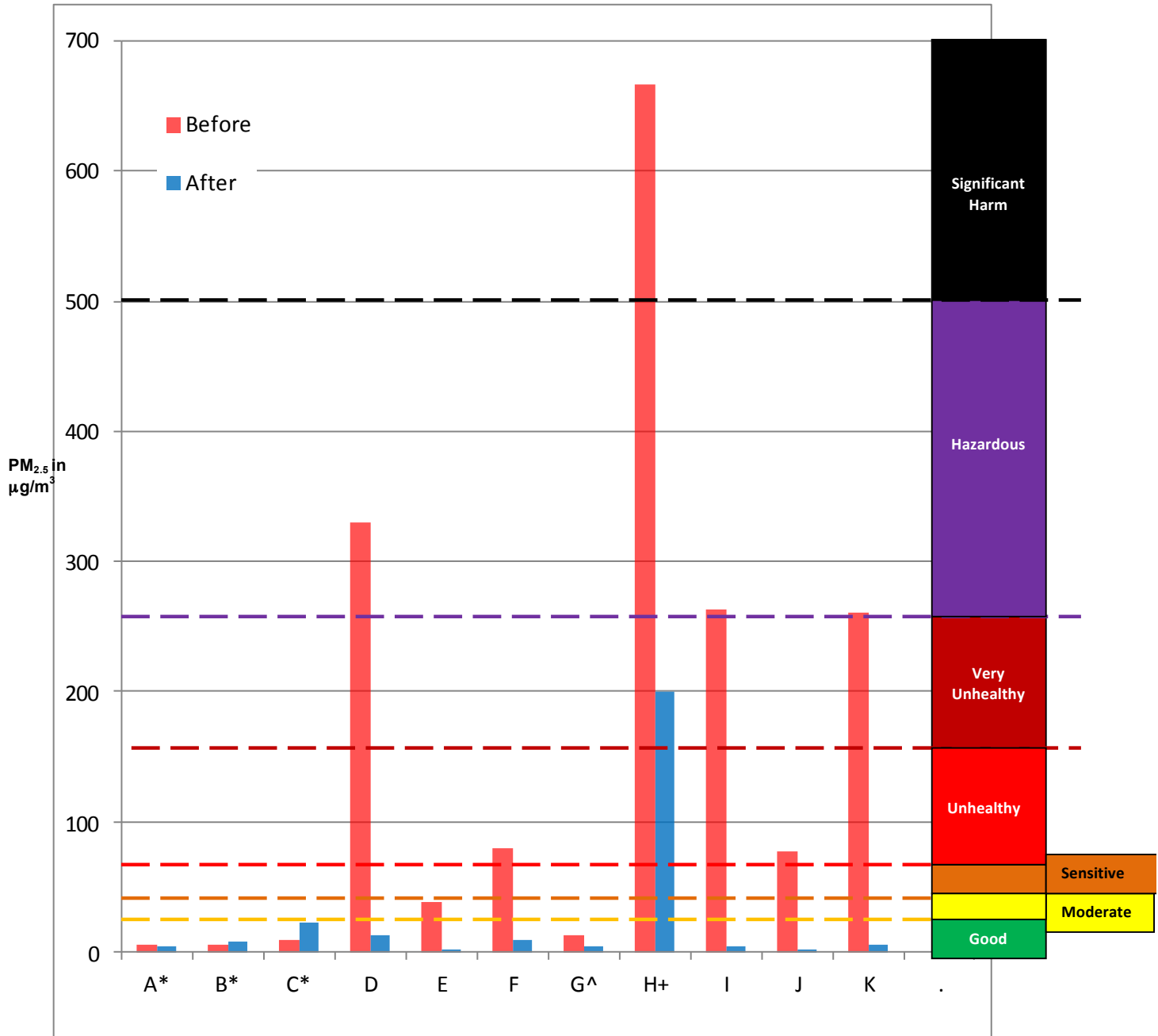
\*smokefree venue  
^no smoking observed

**Table 3. PM<sub>2.5</sub> Levels in Hannibal Public Places that previously allowed smoking**

Public Place	Before Ordinance		After Ordinance		% PM <sub>2.5</sub> change
	Average PM <sub>2.5</sub> level (µg/m <sup>3</sup> )	EPA Air Quality Index category	Average PM <sub>2.5</sub> level (µg/m <sup>3</sup> )	EPA Air Quality Index category	
D	330.0	Hazardous	11.6	Good	-96.5%
E	38.4	Unhealthy to Sensitive Groups	1.9	Good	-95.0%
F	80.3	Unhealthy	8.8	Good	-89.0%
G	12.9	Good	4.7	Good	-63.6%
H	667.2	Significant Harm	199.9*	Very Unhealthy	-70.0%
I	263.0	Hazardous	4.9	Good	-98.1%
J	76.5	Unhealthy	1.9	Good	-97.5%
K	261.3	Hazardous	6.3	Good	-97.6%
Average	216.2	Very Unhealthy	30.0	Moderate	-88.4%

\* 1 incident of smoking observed

Figure 1 presents air quality data of the 3 smokefree and 8 previously smoking-allowed places with comparison to the EPA Air Quality Index standards.



NOTE: \*A,B,C smokefree before ordinance  
 ^G had no observed smoking before ordinance  
 + H had observed smoking after ordinance

**Figure 1 – Air Quality Measures for Hannibal Public Places – Before/After Ordinance**

## Discussion

Particulate matter pollution is a complex mixture of extremely small particles that when breathed in can reach the deepest regions of the lungs. Exposure to PM<sub>2.5</sub> is linked to a variety of significant health problems, ranging from aggravated asthma to premature death in people with heart and lung disease.

### Pre-Ordinance

Before the Hannibal smokefree ordinance was in effect PM<sub>2.5</sub> pollution was 29.6 times higher in public places that permitted smoking compared to a smokefree public place (216.2 µg/m<sup>3</sup> vs. 7.2 µg/m<sup>3</sup>).

Of the 8 smoking-allowed venues:

- 1 had air quality classified as “good” (no smoking observed)
- 1 as “unhealthy for sensitive groups” (such as asthmatics)
- 2 as “unhealthy”
- 3 as “hazardous”
- 1 as “significant harm”

The average air quality in the sampled smoking-allowed public places was classified as “very unhealthy” while the average air quality for the smokefree public place was classified as “good”.

Due solely to occupational exposure, a full-time employee in one of these smoking-allowed public places was 329% the EPA’s average annual daily limit for particulate matter air pollution.

Counts of the number of people and of the number of burning cigarettes revealed on average 7.2% of the people in these public places were actively smoking, which is less than 1/4<sup>th</sup> the adult smoking prevalence of 29.3% for Marion County.<sup>7</sup>

### Post-Ordinance

Average particulate matter air pollution for the 8 public places that previously allowed smoking was 30.0 µg/m<sup>3</sup>, a decrease of 88.4% compared to the 216.2 µg/m<sup>3</sup> average seen before the ordinance was in effect. It is of note that one lit cigarette was observed at the place that had an average of 199.9 µg/m<sup>3</sup>. When this place is removed from consideration, the average for the remaining 7 places is 5.7 µg/m<sup>3</sup> for a 97.3% decrease of this pollutant.

Of these 8 previously smoking-allowed venues that became smokefree under the city ordinance:

- 7 now had air quality classified as “good”
- 1 as “very unhealthy”

Occupational exposure to this type of air pollution was found to be less than half (46%) of the EPA average annual daily limit rather than the 329% noted prior to the ordinance. When the one non-compliant place is removed, the exposure for the remaining 7 places was only 9% the EPA limit.

In regard to the one non-compliant place, the reader is informed that fine particulate matter pollution is but one of the more than 250 toxins found in secondhand smoke. Other toxins include arsenic, cadmium, formaldehyde, lead and radioactive Polonium 210. Because secondhand smoke accounts for about 90% of fine particulate matter in indoor environments where smoking is allowed (see discussion of Delaware below) and because it can be readily measured with proper equipment, it is used as an indicator of the level of secondhand smoke toxins in the air.

Other sources for fine particulate matter pollution in indoor environments can include deep fat frying or grilling of foods, and sources of combustion, such as open fireplaces.

The sampling team at the non-compliant place noted eye irritation and a heavy odor of grease. Shortly after preparing a food order at a grill, an employee turned off the hood ventilation fan. It is more likely the high particulate matter recorded for this place was more due to poor ventilation equipment and practices than to the one lit cigarette that was observed. However, the smokefree ordinance still had a significant impact in reducing particulate matter pollution by 70%, from 667  $\mu\text{g}/\text{m}^3$  (significant harm) to 200  $\mu\text{g}/\text{m}^3$  (very unhealthy).

A study of eight hospitality venues in Delaware before and after a statewide smokefree law was implemented found about 90% of the fine particle pollution could be attributed to tobacco smoke.<sup>8</sup> Similarly, a study of 22 hospitality venues in western New York found a 90% reduction in  $\text{PM}_{2.5}$  levels in bars and restaurants and an 84% reduction in large recreation venues.<sup>9</sup> Similar findings of reductions of more than 90% of  $\text{PM}_{2.5}$  levels in public places were reported after several communities in Kentucky implemented smokefree workplace ordinances.<sup>10</sup>

### Health Considerations

Studies have directly assessed the effects of SHS exposure on human health. One study found that respiratory health improved rapidly in a sample of bartenders after a state smokefree workplace law was implemented in California, as well as after national smokefree laws were implemented in Ireland and Scotland.<sup>11,12,13</sup> Additional studies found a significant reduction in cotinine (a metabolic byproduct of nicotine) and of polycyclic aromatic hydrocarbons (a known human carcinogen found in SHS) in the bodies of hospitality industry workers or customers.<sup>14,15</sup> Experimental studies examining blood chemistries of smokers and nonsmokers find negative effects of even brief (minutes to hours) exposures to SHS on the cardiovascular system.<sup>16,17</sup>

A “66 casino” study by Repace found that incremental  $\text{PM}_{2.5}$  pollution from secondhand smoke in approximately half of the smoking-allowed casinos exceeded a level known to impact cardiovascular health in nonsmokers after less than 2 hours of exposure, posing acute health risks to patrons and workers.<sup>13</sup> This is of particular importance in that the EPA previously determined in a 2003 publication that even short term exposure to  $\text{PM}_{2.5}$  air pollution can aggravate irregular heartbeat, set the stage for heart attacks, and for those with heart disease can cause a heart attack with no warning symptoms. Older adults, who comprise a significant proportion of casino customers, are at greater risk as they may have undiagnosed heart or lung disease.<sup>18</sup>

Still additional studies found a significant reduction in cotinine (a metabolic byproduct of nicotine) and of polycyclic aromatic hydrocarbons (a known human carcinogen found in SHS) in the bodies of bar and/or casino employees or customers.<sup>19,20</sup> A study of air quality in Pennsylvania casinos found that despite low smoking prevalence and with ventilation rates 50% higher than those previously recommended by engineers for smoking-permissible casinos, levels of polycyclic aromatic hydrocarbons and particulate matter were 4 and 6 times respectively that of outdoor air and cotinine levels increased among customers. This study estimated 6 Pennsylvania casino workers’ deaths annually per 10,000 at risk; a risk 5 times greater than that of Pennsylvania mining disasters.<sup>21</sup>

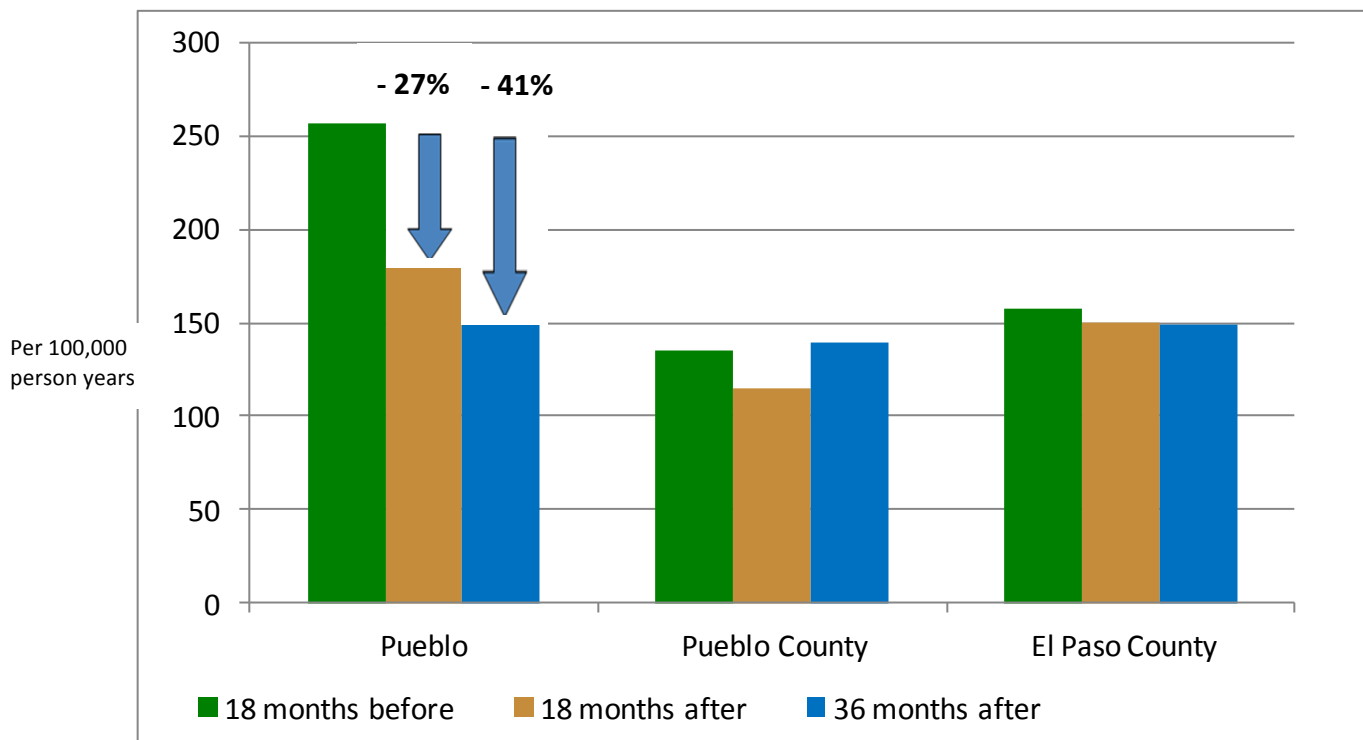
Additional studies report an average of a 17% reduction in hospital admissions for acute myocardial infarctions (heart attacks) within the first year after implementation of a smokefree ordinance or law in the communities.<sup>22,23,24,25,26,27,28,29,30,31,32</sup> Of note in Figure 2 are reports in which hospitalizations for heart attacks were reduced by 28% in Pueblo, Colorado, within the first 18 months after their smokefree ordinance was implemented; and that the decline continued to a 41% reduction within the first 36 months after the time the ordinance was implemented. However, rates in surrounding Pueblo County and adjacent El Paso County, which had no smokefree ordinances, remained virtually flat for the same periods.<sup>33,34</sup>



A recurring theme is demonstrated by a growing body of evidence showing that smokefree policies are proven to provide health benefits for both smokers and nonsmokers. Health benefits are especially greater among non-smokers as seen in studies that found reductions of 30% - 60% among non-smokers for hospitalization for heart attack within the first year of law for smokefree workplaces and public places.<sup>19,35</sup> A Swiss study found a 50% reduction for such hospitalizations among people previously diagnosed with coronary heart disease.<sup>30</sup>

Such evidence reinforces the Centers for Disease Control & Prevention recommendation that physicians advise their patients at risk of or with known coronary heart disease to avoid places where they may be exposed to secondhand smoke.<sup>36</sup>

**Figure 2 – Hospitalizations for Heart Attacks; Pueblo, Colorado 2002-2006**



### Conclusions

Prior to the enactment of the Hannibal smokefree ordinance, smoking-allowed public places in the city had nearly 30 times the fine particulate matter air pollution of the smokefree public places. Average air quality for a smokefree public place was rated “good” by EPA standards, while that of smoking-allowed locations was “very unhealthy”. After the ordinance, average air quality for places that previously allowed smoking improved to a rating of “moderate”. Removal of one non-compliant place would improve the average air quality to “good”.

Before the ordinance, full-time employees in public places that allow smoking were exposed to 329% the established annual EPA exposure limit to protect human health from fine particle air pollution. After the ordinance these same places saw a decline to 46% the EPA exposure standard; 9% when the non-compliant place isn’t included.

Employees and patrons in public places in Hannibal where smoking had been allowed were exposed to very unhealthy levels of an air pollutant known to cause heart disease, cancer and other diseases. Except for the one non-compliant place, air quality in regard to fine particulate matter pollution in formerly smoking-allowed public places is no longer considered a threat to the health of employees or the public.

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