

# Springfield

## Air Quality Monitoring Study



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**C A S E**

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 public places in Springfield 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 eleven public places in Springfield on evenings in February and March of 2010 before the city's smokefree ordinance went into effect and in April 2012 after the ordinance was in effect for several months. Two locations did not allow smoking prior to the ordinance, while the other nine locations allowed smoking indoors prior to the ordinance.

Key findings of this study include:

- Before the ordinance was in effect:
  - Particulate matter air pollution for –
    - The nine smoking-allowed locations averaged 154 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ) for an EPA rating of "very unhealthy".
    - The two no smoking-allowed locations used as a control averaged 17  $\mu\text{g}/\text{m}^3$  for an EPA rating of "moderate".
  - The level of particulate matter air pollution was over 9 times higher in places that allowed smoking compared to that where smoking was not allowed.
  - Due solely to their occupational exposure, a full-time employee in one of those Springfield public places that allowed smoking would exceed the EPA's average annual limit for particulate matter air pollution by 230%.
  - On average, less than 8% of people were actively smoking in the locations where smoking was permitted. This is less than 1/3<sup>rd</sup> the adult smoking prevalence of 28% for Springfield and refutes the commonly held misperception that a higher percent of employees or customers in restaurants, bars or recreational venues smoke.
- After the ordinance was in effect:
  - Particulate matter air pollution for the public places that previously allowed smoking averaged 30  $\mu\text{g}/\text{m}^3$ , which is in the EPA rating of "moderate" and represents an 80% reduction for this pollutant.
  - A full-time employee in one of these Springfield public places that previously allowed smoking would be exposed to 1/2 the EPA's average annual limit for particulate matter air pollution.
  - Illegal smoking activity was observed in one of the nine public places that previously legally allowed smoking and suspected in another. Both locations had air quality rated as "unhealthy" both before and after the ordinance. Had these locations been in compliance with the smokefree ordinance, the average air quality for all previously smoking-allowed locations will have been better.

## 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. The specified exemptions are for bars, restaurants that seat less than 50 people, billiard parlors, and bowling alleys.

Policies prohibiting smoking are the most effective method for eliminating SHS exposure in public places and workplace environments. While many businesses voluntarily establish smokefree policies, the hospitality industry (bars, restaurants, bowling alleys, casinos, 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 a majority of Missouri municipalities remain without comprehensive smokefree laws.

On April 5, 2011 Springfield voters passed a ballot initiative for a smokefree ordinance which covered all workplaces and public places. This ordinance went into effect on June 12, 2012.

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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>7</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 eleven locations in Springfield before and after the smokefree workplace ordinance went into effect. Nine of the locations allowed smoking indoors while two did not allow smoking. 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, are associated with causing or exacerbating pulmonary and cardiovascular disease and mortality.

### Measurement Protocol

A minimum average of 61 minutes was spent in each public place to monitor air for data collection. The number of people inside the venue and the observed number of burning cigarettes were recorded every 10 minutes 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 (µg/m<sup>3</sup>). 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 (m<sup>3</sup>), number of people, number of burning cigarettes, and smoker density (number of burning cigarettes per 100 m<sup>3</sup>) 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 in evening hours before and after the ordinance went into effect. The nine sampled public places that allowed smoking had PM<sub>2.5</sub> levels averaging 153.6 µg/m<sup>3</sup>. The two smokefree venues sampled had an average PM<sub>2.5</sub> level of 17.0 µg/m<sup>3</sup>. The level of particulate matter air pollution was 9.1 times higher in those public places that allowed smoking compared to the smokefree venues. On average, 4.7 cigarettes were burning during the monitoring timeframe at smoking venues. This represents an overall average of 7.6% of patrons.

After the implementation of the smokefree ordinance, the same two public places that were smokefree had an average PM<sub>2.5</sub> level virtually the same level as before the ordinance went into effect (17.0 µg/m<sup>3</sup> before; 15.6 µg/m<sup>3</sup> after). In comparison, the same nine public places that previously allowed smoking had an average PM<sub>2.5</sub> level of 30.0 µg/m<sup>3</sup>, an 80.5% reduction for this pollutant. Smoking was observed at one of these places.

Additional details of the monitored venues are provided in Tables 2 and 3.

**Table 2. Smokefree and Smoking Establishments in Springfield – Before Ordinance**

Public Place	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
<b>SMOKEFREE ESTABLISHMENTS</b>					
A	-	-	-	18.5	Moderate
B	-	-	-	15.5	Good
Average	-	-	-	17.0	Moderate
<b>SMOKING ESTABLISHMENTS</b>					
C	2.3	0.87	20.5	74.7	Unhealthy
D	4.0	0.20	12.3	57.1	Unhealthy
E	1.8	0.43	3.0	93.0	Unhealthy
F	6.3	0.26	5.7	101.0	Unhealthy
G	11.5	0.67	6.5	830.8	Significant Harm
H	3.4	1.82	3.4	40.8	Unhealthy for Sensitive Groups
I	1.0	0.09	3.4	17.1	Moderate
J	3.0	0.78	6.8	90.9	Unhealthy
K	9.4	2.62	6.8	78.3	Unhealthy
Average	4.7	0.90	7.6	153.6	Very Unhealthy

**Table 3. PM<sub>2.5</sub> Levels in Springfield Public Places**

Public Place	Before Ordinance		After Ordinance		% PM <sub>2.5</sub> reduction
	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	
A*	18.5	Moderate	19.0	Moderate	-3%
B*	15.5	Good	12.3	Good	-20%
Average*	17.0	Moderate	15.7	Moderate	- 75%
C	74.7	Unhealthy	18.8	Moderate	- 30%
D^	57.1	Unhealthy	74.3	Unhealthy	- 82%
E	93.0	Unhealthy	16.9	Moderate	- 91%
F	101.0	Unhealthy	9.2	Good	- 98%
G	829.8	Significant Harm	16.3	Moderate	- 98%
H	40.8	Unhealthy for Sensitive Groups	66.0	Unhealthy	+ 62%
I	17.1	Moderate	34.2	Moderate	+ 101%
J	90.9	Unhealthy	27.7	Moderate	- 69%
K	78.3	Unhealthy	6.6	Good	- 92%
Average	153.6	Very Unhealthy	30.0	Moderate	- 80%

\*Smokefree before the ordinance

^Smoking observed after the ordinance

Figure 1 presents air quality data averages of the two non-smoking and nine smoking public places with comparison to the EPA Air Quality Index standards: Figure 2 presents individual data.

**Figure 1 – Average Air Quality Measures for Springfield Public Places  
Feb-Mar 2010 & Apr 2012**

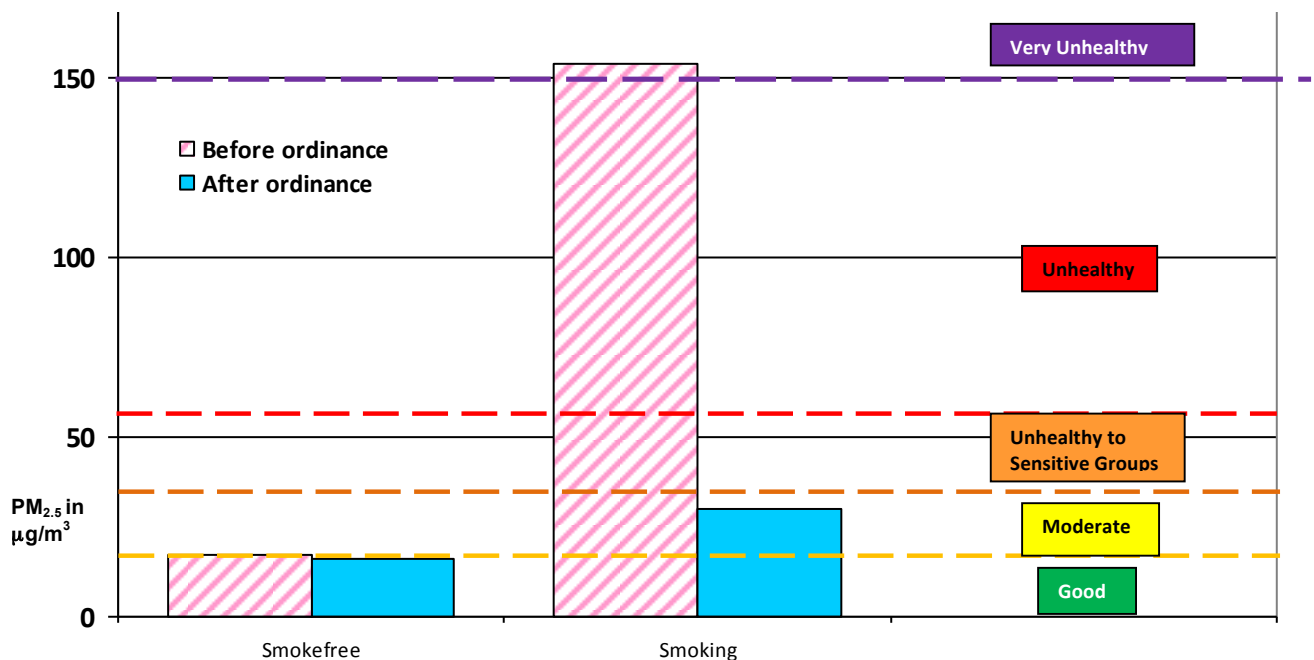
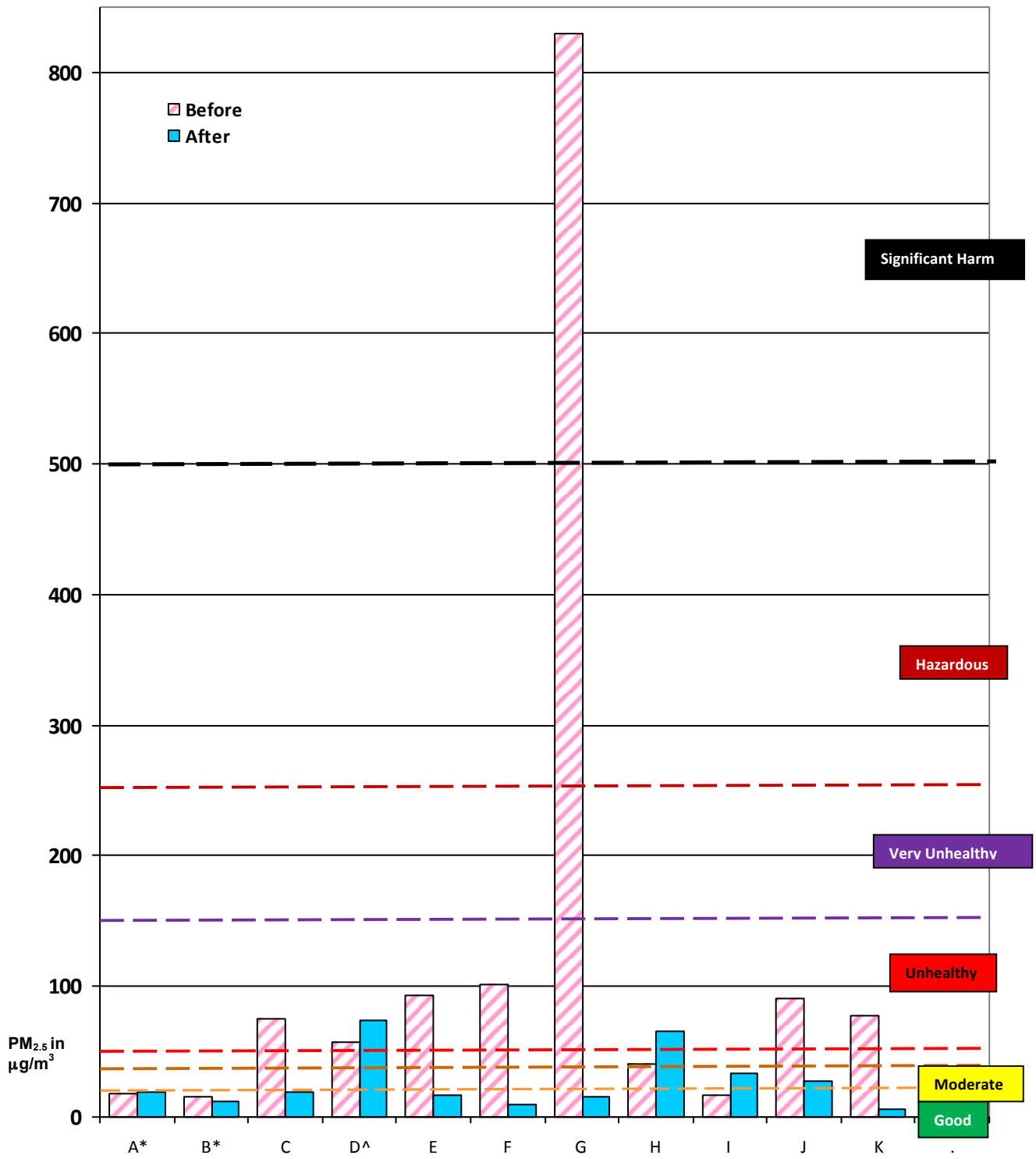


Figure 2 – Air Quality Measures for Springfield – before and after ordinance



\*Smokefree before the ordinance

^Smoking observed after the 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 Springfield smokefree ordinance was in effect PM<sub>2.5</sub> pollution was 9.1 times higher in public places that permitted smoking compared to a smokefree public place (153.6 µg/m<sup>3</sup> vs. 17.0 µg/m<sup>3</sup>).

The average air quality in the sampled smoking-allowed public places was classified as “very unhealthy” by the EPA Air Quality Index; while the average air quality for the smokefree public place was classified as “moderate”.

Due solely to their occupational exposure, a full-time employee in one of these smoking-allowed public places was 230% 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 conducted every 10 minutes revealed that on average 7.6% of the people in these public places were actively smoking at any given time, about 1/3<sup>rd</sup> the 28.0% adult smoking prevalence in Springfield.<sup>8</sup> Despite commonly held misperceptions that a high percent of employees or customers in bars or other public hospitality venues smoke, this study finds only an average of 4.7 cigarettes were actually smoked at any given time; and yet, these few cigarettes created levels of pollution to the degree to be rated as “very unhealthy” by the EPA standards.

The findings of this study are consistent with those of similar previous studies. 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>9</sup> Similarly, a study of 22 hospitality venues in western New York found a 90% reduction in PM<sub>2.5</sub> levels in bars and restaurants and an 84% reduction in large recreation venues (e.g., bingo halls, bowling alleys).<sup>10</sup> Similar findings of reductions of more than 90% of PM<sub>2.5</sub> levels in public places were reported after several communities in Kentucky implemented smokefree workplace ordinances.<sup>11</sup> The current study in Springfield finds 89.5% lower particulate matter pollution in the smokefree public venue compared to public venues that allowed smoking.

### Post-Ordinance

Average particulate matter air pollution for the nine public places that previously allowed smoking was 30.0 µg/m<sup>3</sup>, a decrease of 80.5% compared to the 153.6 µg/m<sup>3</sup> average seen before the ordinance was in effect.

Occupational exposure to this type of air pollution was found to be half (50%) of the EPA average annual daily limit rather than the 230% noted prior to the implementation of the smokefree ordinance.

Most of the findings of this study are consistent with those of similar previous studies regarding numbers of smokers among customers and employees, and levels of particulate matter air pollution.

Smoking was directly observed in one of the places and the pollution level was rated as “unhealthy” in both pre- and post-ordinance samplings. An “unhealthy” level was also detected in



another place, though no direct observation of smoking was made, it is suspected smoking may have occurred in an area not accessible to the public, such as an employee break area.

### 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>12,13,14</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>15,16</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>17,18</sup>

A “66 casino” study by Repace found that incremental PM<sub>2.5</sub> 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 PM<sub>2.5</sub> 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>19</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>20,21</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>22</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>23,24,25,26,27,28,29,30,31,32,33</sup> Of note 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>34,35</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>19,36</sup> Further, a recent 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>37</sup>

## Conclusions

Before the Springfield smokefree ordinance went into effect, public places that allowed smoking had over 9 times the fine particulate matter air pollution of smokefree public places. Average air quality in smokefree places was rated “moderate” by EPA standards, while the average air quality in places where smoking was allowed was rated “very unhealthy”. After the ordinance, average air quality for places that previously allowed smoking improved to a rating of “moderate”.

Before the ordinance, employees in public places that allowed smoking were exposed to 230% the established annual EPA exposure standard to protect human health from fine particle air pollution; after the ordinance these same places that became smokefree saw a decline to 50% the EPA exposure standard.

After implementation of the smokefree ordinance, particulate matter air pollutants for the nine places that previously allowed smoking dropped an average 80% to come into the EPA rating of “moderate.”

Hospitality workers and customers in Springfield smoking-allowed public places and workplaces had been exposed to very unhealthy levels of an air pollutant known to cause heart disease, respiratory diseases, cancer and other diseases. Peer-reviewed studies have demonstrated that policies prohibiting smoking in public places and workplaces dramatically reduce SHS exposure and improve employee and public health.

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