

Jefferson City Air Quality Monitoring Study


C A S E

Campus-Community Alliances for Smoke-Free Environments



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June 2011

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 4,800 chemicals of which more than 250 are known to be toxic. 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 that have smokefree policies and those that permit smoking, and compare results to the EPA Air Quality Index. Indoor air quality for fine particulate matter pollution (PM_{2.5} particles) was sampled for 13 Jefferson City restaurants, bars and public entertainment venues in May and June of 2009 before the city smokefree ordinance was in place; and again, the same 13 public places were sampled in May of 2011, after the city's ordinance was in effect for at least three months. Eleven of the places originally allowed smoking indoors while two originally had smokefree policies.

Key findings of this study include:

- Before the ordinance was in effect:
 - Particulate matter air pollution for the 11 public places that allowed smoking averaged 111 $\mu\text{g}/\text{m}^3$ (EPA rating of "unhealthy") even though an average of only 2.2 cigarettes were being smoked at any given time. The two public places that did not allow smoking averaged 7 $\mu\text{g}/\text{m}^3$ (EPA rating of "good"). The level of particulate matter air pollution was almost 16 times higher in places that allowed smoking compared to those that were smokefree.
 - Due solely to their occupational exposure, a full-time employee in one of these public places that allowed smoking would exceed the EPA's average annual limit for particulate matter air pollution by 170%.
 - On average, fewer than 8% of people were actively smoking in the public places where smoking was permitted. This is less than half the 16% adult smoking prevalence in Jefferson City, and refuted the commonly held misperception that a high percent of employees or customers in bars or public recreational venues smoke.
 - In two places, three or less burning cigarettes created levels of pollution to the degree to be classified as "hazardous" by EPA standards.
- After the ordinance was in effect:
 - Particulate matter air pollution for the 11 public places that previously allowed smoking averaged 8 $\mu\text{g}/\text{m}^3$ (EPA rating of "good") and represents a 88% reduction for this pollutant.
 - No smoking was observed in any of the 11 public places, indicating high compliance with the ordinance.

The findings of this study are consistent with those of similar previous studies that found that about 90% 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 toxic or carcinogenic, and by itself was classified in 1992 by the U.S. Environmental Protection Agency as a human carcinogen. Exposure to SHS is responsible for an estimated 35,000 deaths per year from heart disease and lung cancer in nonsmokers.^{1,2} 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.^{3,4}

Current Missouri law allows for smoking in most indoor workplaces. 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, 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,⁵ but a majority of Missouri municipalities remain without comprehensive smokefree laws.

Jefferson City voters passed a smokefree ordinance on November 2, 2010 with an effective date of January 31, 2011. With few exceptions, this ordinance required public places and workplaces to be smokefree.

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_{2.5}) 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/m³. 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/m³). EPA assigned levels for PM_{2.5} ranging from "good" to "hazardous" with accompanying health advisories as presented in Table 1.⁶ 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.

The Jefferson City Air Quality Monitoring Study examined indoor air quality in a sampling of smokefree and smoking-permitted public places to assess the relation between smoking and indoor air pollution. Air quality findings were compared to the EPA Air Quality Index.

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

Air Quality	PM _{2.5} (µg/m ³)	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.

The Jefferson City Air Quality Monitoring Study examined indoor air quality in a sampling of smokefree and smoking-permitted public places in Jefferson City, Missouri, to assess the relation between smoking and indoor air pollution. Air quality findings were compared to the EPA Air Quality Index.

Methods

Overview

Indoor air quality for fine particulate matter pollution was sampled for 13 Jefferson City restaurants, bars and public entertainment venues between May 20 and June 26, 2009 before the city's smokefree ordinance was in effect. Eleven of the places allowed smoking while two did not. A follow-up sampling of the same places was conducted between May 13 and 19, 2011 after the city's smokefree ordinance had been in effect for approximately three and one-half months.

Particulate matter smaller than 2.5 micrograms ($PM_{2.5}$) was measured. The $PM_{2.5}$ particles are easily inhaled deep into the lungs, are associated with pulmonary and cardiovascular disease and mortality, and are a major source of $PM_{2.5}$ pollution. These venues provide variation in type of public place, size of venue, and location.

Measurement Protocol

An average of 61 minutes before the ordinance and an average of 51 minutes after the ordinance were 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 Stanley IntelliMeasure ultrasonic distance estimator (The Stanley Works, New Britain, CT) was used to measure room dimensions, enabling unobtrusive calculation of the volume of each venue. 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 venue in 10-minute intervals to determine the percent of people smoking within a venue at any particular time.

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 $PM_{2.5}$. The concentrations of particulate matter were recorded as micrograms per cubic meter ($\mu g/m^3$). 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 other patrons. Study staff ordered food or beverages and assumed standard seating positions in a venue. If a venue had both smoking and nonsmoking sections, the air monitoring was conducted in the smoking section. The monitor was generally located on a table so the air being sampled was within the sitting occupants' normal breathing zone. For each public place, the first and last minute of logged data were removed because they were averaged with outdoor and entryway air. The remaining data points were averaged to provide an average $PM_{2.5}$ concentration within the public place.

Descriptive data including the venue volume in cubic meters (m^3), number of people, number of burning cigarettes, and smoker density (number of burning cigarettes per $100 m^3$) were recorded for

each public place and averaged for all public places. Additionally, the results are compared to the EPA Air Quality Index.

Results

The locations were visited one time on various evenings of the week (Monday, Wednesday, Thursday and Friday; 5:30 p.m. to 11:00 p.m.). The average time spent per location was 61 minutes before the ordinance and 51 minutes after the ordinance.

Prior to the effective date of the smokefree ordinance, eleven public places that allowed smoking had an average PM_{2.5} level of 111.4 µg/m³ (range: 17.5 – 310.4 µg/m³). The two smokefree venues had an average PM_{2.5} level of 7.2 µg/m³ (range 4.1 – 10.2 µg/m³). The level of particulate matter air pollution was 15.5 times higher in those public places that allowed smoking compared to the smokefree venues. On average, 2.2 cigarettes (range: 0 – 8.3 cigarettes) were burning during the monitoring timeframe at smoking venues. This represented an overall average of 7.9% of patrons.

After the implementation of the smokefree ordinance, the eleven sampled public places that previously allowed smoking had an average PM_{2.5} level of 8.1 µg/m³ (range: 2.6 – 20.3 µg/m³). This represents an 87.5% reduction for this pollutant. At no time was smoking was observed at any of these places indicating that compliance with the ordinance is high.

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

Table 2. Air Quality Data before Jefferson City ordinance

Public Place	Average # people	Average # burning cigarettes	Active smoker density	% burning cigarettes to # people	Average PM _{2.5} level (µg/m ³)	EPA Air Quality Index category
SMOKEFREE ESTABLISHMENTS						
Rest A	52.0	0	0	0	4.1	Good
Rec C	98.0	0	0	0	10.2	Good
Average	75	0	0	0	7.2	Good
SMOKING ESTABLISHMENTS						
Rest B*	21.5	0.8	0.19	3.7	30.2	Moderate
Rest C	19.2	0.5	0.14	2.6	17.5	Moderate
Rest D	10.8	0.4	0.33	3.7	136.2	Very Unhealthy
Rest E [†]	28.0	0	0	0	28.5	Moderate
Bar A	15.0	2.0	0.76	13.3	46.8	Unhealthy for Sensitive Groups
Bar B	10.7	2.5	0.27	23.4	257.7	Hazardous
Bar C	9.0	1.0	0.26	8.7	37.5	Unhealthy for Sensitive Groups
Bar D	26.0	2.8	0.27	10.1	141.1	Unhealthy
Bar E	27.2	3.0	0.61	10.9	310.4	Hazardous
Rec A	74.6	2.8	0.05	3.8	98.4	Unhealthy
Rec B	133.0	8.3	1.14	6.3	120.8	Unhealthy
Average	34.1	2.2	0.36	7.8	111.4	Unhealthy

[†] Restaurant E had no observed cigarettes burning at any observed time

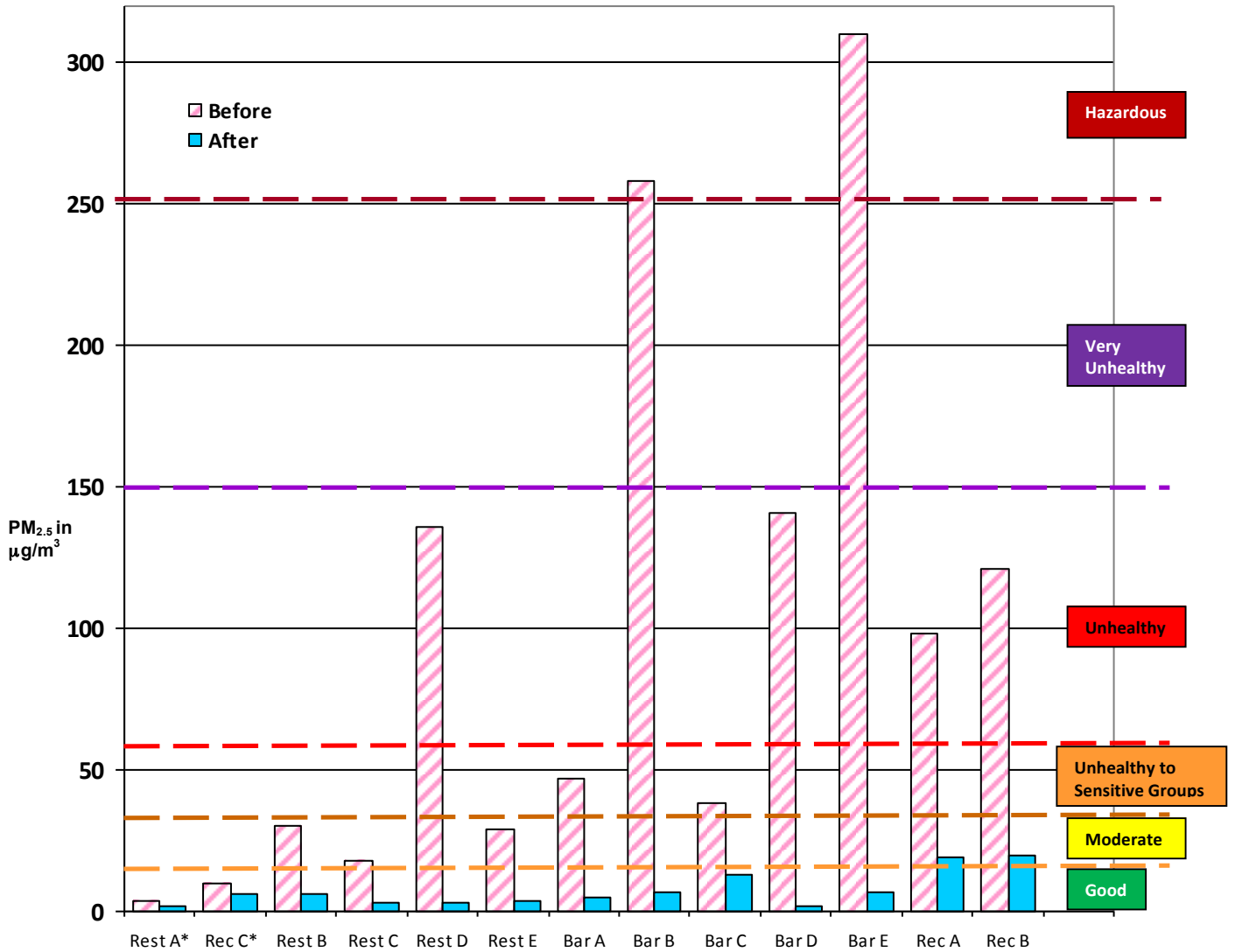
Table 3. PM_{2.5} Levels in Jefferson City Public Places

Public Place	Before Ordinance		After Ordinance		% PM _{2.5} reduction
	Average PM _{2.5} level (µg/m ³)	EPA Air Quality Index category	Average PM _{2.5} level (µg/m ³)	EPA Air Quality Index category	
Rest A*	4.1	Good	2.3	Good	-44%
Rec C*	10.2	Good	5.8	Good	-43%
Average*	7.2	Good	4.1	Good	- 44%
Rest B	30.2	Moderate	5.8	Good	- 81%
Rest C	17.5	Moderate	2.6	Good	- 85%
Rest D	136.2	Unhealthy	3.3	Good	- 98%
Rest E	28.5	Unhealthy for Sensitive Groups	4.1	Good	- 86%
Bar A	46.8	Moderate	4.7	Good	-90%
Bar B	257.7	Hazardous	7.1	Good	-97%
Bar C	37.5	Unhealthy	12.7	Good	- 66%
Bar D	141.1	Unhealthy	2.4	Good	- 98%
Bar E	310.4	Hazardous	6.8	Good	- 98%
Rec A	98.4	Unhealthy	19.0	Moderate	- 81%
Rec B	120.8	Unhealthy	20.3	Moderate	- 83%
Average	111.7	Unhealthy	8.1	Good	- 88%

* Smokefree before the ordinance

Figure 1 presents air quality data of the two smokefree and eleven smoking venues before and after Jefferson City’s smokefree ordinance with comparison to the EPA Air Quality Index standards.

Figure 1 – Air Quality Measures for Jefferson City – before and after ordinance



NOTE: *Rest A and Rec C were smokefree before 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_{2.5} 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

This study found before the Jefferson City smokefree ordinance was in effect PM_{2.5} pollution was 15.5 times higher in public places that permitted smoking compared to a smokefree public place (111.4 µg/m³ vs. 7.2 µg/m³).

Of the eleven smoking-allowed venues:
3 had air quality classified as “moderate”
1 as “unhealthy for sensitive groups”
5 as “unhealthy”
2 as “hazardous”

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

Due solely to their occupational exposure, a full-time employee in one of these public places that allowed smoking was 170% 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 less than 8% of the people in these public places were actively smoking at any given time, less than half the 16% adult smoking prevalence in Jefferson City.⁷ Despite commonly held misperceptions that a high percent of employees or customers in bars or public recreational venues smoke, this study finds only an average of 2.2 cigarettes were actually smoked at any given time; and yet, these few cigarettes created levels of pollution to the degree in some places to be rated as “hazardous” 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.⁸ Similarly, a study of 22 hospitality venues in western New York found a 90% reduction in PM_{2.5} levels in bars and restaurants and an 84% reduction in large recreation venues (e.g., bingo halls, bowling alleys).⁹ Similar findings of reductions of more than 90% of PM_{2.5} levels in public places were reported after several communities in Kentucky implemented smokefree workplace ordinances.¹⁰ The current study in Jefferson City finds 94% lower particulate matter pollution in smokefree public venues compared to public venues that allow smoking.

Post-Ordinance

Average particulate matter air pollution for the eleven public places that previously allowed smoking was 8.1 µg/m³, a decrease of 87.5% compared to the average seen before the ordinance was in effect. Likewise, particulate matter levels for the two places that were smokefree before the ordinance also decreased 43.5%, from an average 7.2 µg/m³ to an average 4.1 µg/m³.

Of the eleven previously smoking-allowed venues:
9 had air quality classified as “good”
2 as “moderate”

Occupational exposure to this type of air pollution was found to be only 10% of the EPA average annual daily limit rather than the 170% noted prior to the implementation of the smokefree ordinance.

Health Considerations

Other 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.^{11,12,13} 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.^{14,15} 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.^{16,17}

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.^{18,19,20,21,22,23,24,25,26,27,28} 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.^{29,30}

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.^{19,31} Further, a recent Swiss study found a 50% reduction for such hospitalizations among people previously diagnosed with coronary heart disease.³⁰ 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.³²

Conclusions

Before Jefferson City's smokefree ordinance went into effect, public places that allowed smoking had more than 15 times the fine particulate matter air pollution of the smokefree public places. Average air quality in smokefree places was rated "good" by EPA standards, while the average air quality in places where smoking was allowed was rated "unhealthy". After the ordinance, average air quality for places that previously allowed smoking was rated as "good".

Before the ordinance, employees in public places that allow smoking were exposed to 170% the established annual EPA exposure standard to protect human health from fine particle air pollution; after the ordinance this exposure declined to 10% the EPA standard.

After implementation of the smokefree ordinance, particulate matter air pollutants for eleven places that previously allowed smoking dropped an average 88% to come into the EPA rating of "good."

Hospitality workers and customers in Jefferson City public places and workplaces where smoking was allowed were exposed to unhealthy levels of an air pollutant known to cause heart disease, 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.

Soon after the ordinance went into effect, the city government received complaints that two bars were violating the ordinance. A letter from the city attorney informing the owners of the need to comply at the risk of fines or loss of licenses brought immediate promises of compliance.³³ Indeed, the monitoring teams saw "no smoking" signs at each place visited, did not see ashtrays, and did not observe any smoking during the sampling periods. It is anticipated future incidents of non-compliance will become rare to non-existent as owners, customers and employees become more accustomed to the ordinance.

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