

Fulton Area Air Quality Monitoring Study



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 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 eleven Fulton restaurants, bars and public entertainment venues on October 8, 2010. Nine of those places allowed smoking indoors while two had smokefree policies. Nine of these places were again sampled on March 25, 2011 after the city's smokefree ordinance had been in effect for slightly more than three months; seven places were those that previously allowed smoking.

Key findings of this study include:

- Before the ordinance was in effect:
 - Particulate matter air pollution for the nine public places that allowed smoking averaged 87 $\mu\text{g}/\text{m}^3$ (EPA rating of "unhealthy") even though an average of only 1½ cigarettes were being smoked at any given time. The two public places that did not allow smoking averaged 9 $\mu\text{g}/\text{m}^3$ (EPA rating of "good"). The level of particulate matter air pollution was over 9 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 132%.
 - On average, only 6% of people were actively smoking in the public places where smoking was permitted. This is less than one-fourth the 26.2% adult smoking prevalence for Callaway County, and refutes the commonly held misperception that a high percent of employees or customers in restaurants, bars or other public venues smoke.
 - An average of only 1½ burning cigarettes created levels of pollution to the degree to be classified as "Unhealthy" by the EPA.
- After the ordinance was in effect:
 - Particulate matter air pollution for the seven public places that previously allowed smoking averaged 21 $\mu\text{g}/\text{m}^3$ (EPA rating of "moderate") and represents a 76% reduction for this pollutant.
 - One brief incidence of smoking was observed, indicating fairly high compliance with the ordinance.

The findings of this study are consistent with those of similar previous studies that found the majority of fine particulate matter air pollution can 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.

Fulton voters passed a smokefree ordinance on November 2, 2010 with an effective date of December 3, 2010. 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 Fulton 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.

Methods

Overview

Indoor air quality for fine particulate matter pollution was sampled for eleven Fulton restaurants, bars and recreational venues on October 8, 2010 before the city's smokefree ordinance was in effect. Nine of the places allowed smoking while two did not. A follow-up sampling of nine of the eleven places was conducted on March 25, 2011 after the city's smokefree ordinance had been in effect for several months. Seven of the places previously allowed smoking.

Particulate matter smaller than 2.5 micrograms (PM_{2.5}) was measured. Because PM_{2.5} particles are easily inhaled deep into the lungs, they are associated with pulmonary and cardiovascular disease and mortality. The selected venues varied in type of public place, size of venue, and location. Nine of the places allowed smoking indoors while two had smokefree policies.

Measurement Protocol

An average of 55 minutes was spent before the ordinance and an average of 54 minutes after the ordinance for 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 ($\mu\text{g}/\text{m}^3$). 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. Study staff ordered food or beverages and assumed normal seating positions in a venue. 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

Locations were visited on Friday evenings from 6 p.m. – 10 p.m. The average time spent per location was 55 minutes (range 44-66 minutes).

Prior to the effective date of the smokefree ordinance, the nine public places that allowed smoking had an average PM_{2.5} level of 87.0 µg/m³ (range: 6.9 – 291.1 µg/m³). The two smokefree venues had an average PM_{2.5} level of 9.4 µg/m³ (range 6.9 – 11.8 µg/m³). The level of particulate matter air pollution was 9.3 times higher in those public places that allowed smoking compared to the smokefree venues. On average, 1.5 cigarettes (range: 0 – 5 cigarettes) were burning during the monitoring timeframe at smoking venues. This represented an overall average of 6.0% of patrons.

It is of note that no smoking was observed in one of the smoking-allowed places. If the public places were sorted by smoke exposure rather than smoking policy, the revised averages for the eight places where smoking was observed was PM_{2.5} level of 96.2 µg/m³ and for the one smoking-allowed place where smoking was not observed was PM_{2.5} level of 13.9 µg/m³. The level of particulate matter air pollution was 8.8 times higher in those public places where smoking was observed compared places where smoking was not observed.

After the implementation of the smokefree ordinance, the seven sampled public places that previously allowed smoking had an average PM_{2.5} level of 20.9 µg/m³ (range: 4.7 – 93.1 µg/m³). This represents a 76.0% reduction for this pollutant. One brief incident of smoking was observed at one of these places indicating that compliance with the ordinance is fairly high.

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

Table 2. Smokefree and Smoking Establishments in Fulton before 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
Venue A	39.6	-	-	-	6.9	Good
Venue B	18.3	-	-	-	11.8	Good
Average	29.0	-	-	-	9.4	Good
Venue C	35.0	2.4	0.41	8.5	104.0	Unhealthy
Venue D	32.2	4.0	0.50	12.3	97.1	Unhealthy
Venue E	19.6	0.0	0.00	0.0	13.9	Good
Venue F	66.7	0.5	0.04	0.7	28.4	Moderate
Venue G	9.0	0.4	0.09	4.9	27.5	Moderate
Venue H	9.4	1.4	0.68	13.9	101.3	Unhealthy
Venue I	27.2	1.0	0.71	3.2	113.0	Unhealthy
Venue J	10.0	2.7	0.78	26.7	291.1	Hazardous
Venue K	11.0	0.7	0.14	4.2	6.9	Good
Average	24.5	1.5	0.37	6.0	87.0	Unhealthy

Table 3. PM_{2.5} Levels in Fulton 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	
Venue A*	6.9	Good	4.7	Good	-32%
Venue B*	11.8	Good	6.1	Good	-49%
Average*	9.4	Good	5.4	Good	- 42%
Venue C	104.0	Unhealthy	6.3	Good	- 94%
Venue D	97.1	Unhealthy	10.9	Good	- 86%
Venue E^	13.9	Good	17.5	Moderate	+ 26%
Venue F	28.4	Moderate	5.7	Good	- 80%
Venue G	27.5	Moderate	93.1	Unhealthy	+239%
Venue H	101.3	Unhealthy	-	Good	
Venue I	113.0	Unhealthy	7.4	Good	- 94%
Venue J	291.1	Hazardous	5.1	Good	- 98%
Venue K ^x	6.9	Good	-		
Average	87.0	Unhealthy	14.1	Good	- 76%

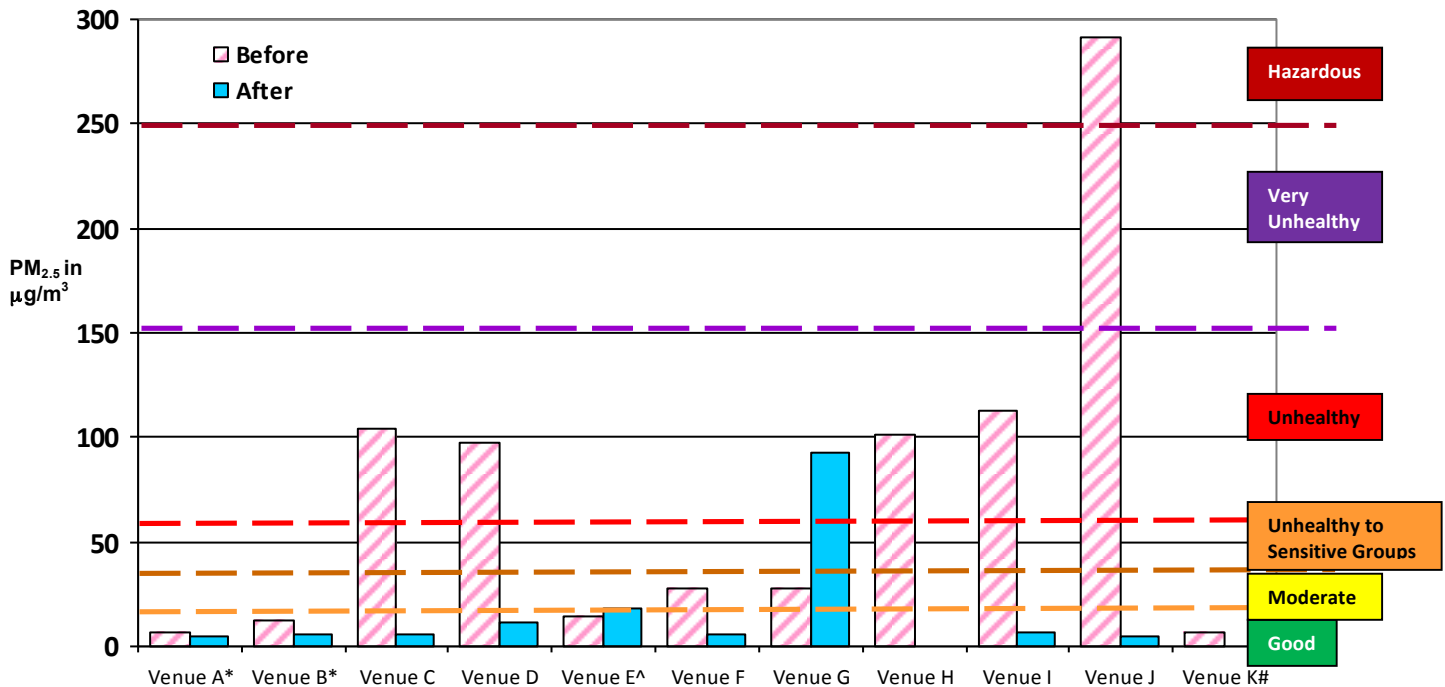
* Smokefree before the ordinance

^ No smoking observed

^x No smoking observed until the last few minutes of observation period

Figure 1 is a presentation of the air quality data of the two smokefree and nine/seven smoking venues before and after Fulton’s smokefree ordinance with comparison to the EPA Air Quality Index standards.

Figure 1 – Air Quality Measures for Fulton – before and after ordinance



NOTE: *Venues A & B were smokefree

^ Venue E had no observed smoking

Venue K had no pre-ordinance observed smoking until last few minutes

Venues H & K do not have post-ordinance data

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 Fulton smokefree ordinance was in effect PM_{2.5} pollution was 9.3 times higher in public places that permitted smoking compared to a smokefree public place (87.0 µg/m³ vs. 9.4 µg/m³).

Of the nine smoking-allowed venues:

- 2 had air quality classified as “good”
- 2 as “moderate”
- 4 as “unhealthy”
- 1 as “hazardous”

Of those smoking places with “good” air quality – one did not have any observed smoking; the other had cigarettes lit near the end of the observation period and the level of particulate matter increased notably.

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 132% 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 only 6.0% of the people in these public places were actively smoking at any given time, less than one-fourth the adult smoking prevalence of 26.2% for Callaway County.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 1.5 cigarettes were actually smoked at any given time; and yet, these few cigarettes create levels of pollution to the degree to be rated as “unhealthy” per the EPA index.

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 Fulton finds 89% lower particulate matter pollution in the smokefree public venue compared to those public venues that allow smoking.

Post-Ordinance

Average particulate matter air pollution for the seven public places that previously allowed smoking was $20.9 \mu\text{g}/\text{m}^3$, a decrease of 76.0% 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 42.2%, from an average $9.4 \mu\text{g}/\text{m}^3$ to an average $5.4 \mu\text{g}/\text{m}^3$.

Of the seven previously smoking-allowed venues:

- 5 had air quality classified as “good”
- 1 as “moderate”
- 1 as “unhealthy”

Occupational exposure to this type of air pollution was found to be only 32% of the EPA average annual daily limit rather than the 132% noted prior to the implementation of the smokefree ordinance.

While there was an overall decrease of 76% of $\text{PM}_{2.5}$ pollution among places that previously allowed smoking, two places actually saw an increase:

- Venue E saw a rise from $13.9 \mu\text{g}/\text{m}^3$ to $17.5 \mu\text{g}/\text{m}^3$, an increase of 26%. However, with an increase of only $3.6 \mu\text{g}/\text{m}^3$ this is not considered significant and well within bounds of variance. It is also noted this place had no observed smoking during the pre-ordinance sampling period
- Venue G saw a rise from $27.5 \mu\text{g}/\text{m}^3$ to $93.1 \mu\text{g}/\text{m}^3$, an increase of 239%. This is a significant increase in pollution from previously being classified as “moderate” to now classified as “unhealthy”. Sampling occurred during the last hour before the business closed for the day. The air quality for the first 25 minutes averaged $4.5 \mu\text{g}/\text{m}^3$ whereas for the last 20 minutes, when the sampling team members were the only people in the place except for employees, the $\text{PM}_{2.5}$ pollution quickly rose to an average of $181.7 \mu\text{g}/\text{m}^3$. It is speculated one or more employees may have lit cigarettes in a back area as closing time approached and no additional customers were needing attention.

When results for Venue G are not included, the overall $\text{PM}_{2.5}$ pollution among places that previously allowed smoking decrease by 89.9%; have a $\text{PM}_{2.5}$ level of $8.8 \mu\text{g}/\text{m}^3$, considered “good” in the EPA Air Quality Index; and presents only 13% the EPA average daily limit for exposure to this pollutant.

One brief incident of smoking was observed at one place during the post-ordinance observations. The smoker appeared to attempt to conceal his smoking. After several puffs and realizing there were no ashtrays, the smoker went outside to finish the cigarette. He re-entered a few minutes later without the cigarette. This sole observed incident indicates fairly high compliance with the ordinance. The average $\text{PM}_{2.5}$ level prior to this cigarette being lit was $4.5 \mu\text{g}/\text{m}^3$, well within the EPA classification of “good” air quality.

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 Fulton's smokefree ordinance went into effect, public places that allowed smoking had more than 9 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". Before the ordinance, employees in public places that allow smoking are exposed to 132% the established annual EPA exposure standard to protect human health from fine particle air pollution; after the ordinance this exposure declined to 32% the EPA standard.

After implementation of the smokefree ordinance, particulate matter air pollutants for seven places that previously allowed smoking dropped an average 76% to come into the EPA rating of "moderate."

Hospitality workers and customers in Fulton 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. This is consistent with peer-reviewed studies that demonstrated that policies prohibiting smoking in public places and workplaces dramatically reduce SHS exposure and improve employee and public health.

The incident of observed smoking indicates that removal of ashtrays is an effective method of encouraging smokers to not smoke inside the facility or, as in this case, once the cigarette is lit, to soon take it outside. That this was the only incident of observed smoking indicates fairly high compliance with the smokefree ordinance. It is anticipated compliance will increase as customers and employees become more accustomed to the ordinance.

The sudden increase in PM_{2.5} pollution in Venue G indicates that city officials need to be vigilant for signs of smoking (e.g. ashtrays with cigarette butts) during routine inspections of businesses or when responding to complaints.

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