

St. Louis County 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 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 St. Louis County and compare results to the EPA Air Quality Index. Indoor air quality for fine particulate matter pollution (PM_{2.5} particles) was sampled in nine various locations in St. Louis County on the evenings of November 19, 2010 before the county's smokefree ordinance went into effect and June 24 and July 18, 2011 after the ordinance was in effect for several months. Two locations did not allow smoking, while seven locations allowed smoking indoors with five of these to be included in the ordinance and two of these to be exempt from the ordinance.

Key findings of this study include:

- Before the ordinance was in effect:
 - Particulate matter air pollution for –
 - The seven smoking-allowed locations averaged 72 $\mu\text{g}/\text{m}^3$ (EPA rating of “unhealthy”).
 - The two no smoking-allowed locations averaged 12 $\mu\text{g}/\text{m}^3$ (EPA rating of “good”).
 - The level of particulate matter air pollution was over 6 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 a St. Louis County public place would be exposed to 110% the EPA's average annual limit for particulate matter air pollution during an 8-hour workshift.
 - On average, less than 4% of people were actively smoking in the locations where smoking was permitted. This is about one-fifth the adult smoking prevalence of 18.6% for St. Louis County and refutes the commonly held misperception that a higher percent of restaurant and bar customers or employees smoke.
- After the ordinance was in effect:
 - Particulate matter air pollution for the five public places that previously allowed smoking and were then included in the smokefree ordinance averaged 7 $\mu\text{g}/\text{m}^3$ (EPA rating of “good”) and represents an 91% reduction for this pollutant.
 - Particulate matter air pollution for the two public places that previously allowed smoking and were then exempted from the smokefree ordinance averaged 32 $\mu\text{g}/\text{m}^3$ (EPA rating of “moderate”).
 - No smoking was observed in any of the public places covered by the ordinance, indicating high compliance with the ordinance.

The 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.¹ Exposure to SHS is responsible for an estimated 35,000 deaths per year from heart disease and lung cancer in nonsmokers.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.^{1,3,4}

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. Note is made that casinos are not exempted, however it is doubtful the St. Louis casinos are in compliance with this state law.

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,⁵ but a majority of Missouri municipalities remain without comprehensive smokefree laws.

The St. Louis County Council placed a smokefree ordinance on the November 3, 2009 ballot, which was then overwhelmingly passed by voters 65% to 35%. This ordinance went into effect on January 1, 2011. The ordinance exempted casino gaming floors and bars where food sales are less than 25% of total sales.

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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_{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 1.⁷ 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_{2.5} (µg/m³)	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 nine locations in St. Louis County before and after the smokefree workplace ordinance went into effect. Seven of the locations allowed smoking indoors while two locations did not allow smoking. 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.

Measurement Protocol

An average of 54 minutes before the ordinance and an average of 49 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 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_{2.5}. The concentrations of particulate matter were recorded as micrograms per cubic meter (µg/m³). 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_{2.5} concentration within the location.

Descriptive data including the location volume in cubic meters (m³), number of people, number of burning cigarettes, and smoker density (number of burning cigarettes per 100 m³) 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 evenings of September 19, 2010 before the smokefree ordinance was in effect; and again on June 24 and July 18, 2011 after the ordinance was in effect.. The average time spent per location was 54 minutes before the ordinance and 49 minutes after the ordinance.

Prior to the effective date of the smokefree ordinance, the seven public places that allowed smoking had an average PM_{2.5} level of 72.5 µg/m³ (range: 6.1 – 193.0 µg/m³). The two smokefree venues had an average PM_{2.5} level of 11.8 µg/m³ (range 7.6 – 15.9 µg/m³). The level of particulate matter air pollution was 6.2 times higher in those public places that allowed smoking compared to the smokefree venue. On average, 3.0 cigarettes (range: 0.2 – 9.8 cigarettes) were burning during the monitoring timeframe at smoking venues. This represented an overall average of 3.9% of patrons smoking at any observed time.

After the implementation of the smokefree ordinance, the five sampled public places that previously allowed smoking and was subsequently covered by the smokefree ordinance had an average PM_{2.5} level of 6.8 µg/m³ (range: 2.5 – 12.0 µg/m³). This represents a 90.6% reduction for this pollutant. At no time was smoking was observed at any of these places.

Reductions were also seen in the two exempted places that were sampled. The average number of cigarettes burning decreased from 7.6 to 2.9; the average smoking density decreased from 0.72 burning cigarettes per 100 cubic meters to 0.17; consequently the average PM_{2.5} level decreased by 56.3% from 72.5 µg/m³ to 31.6 µg/m³ (range: 8.9 – 54.4 µg/m³).

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

Table 2. Air quality data before St. Louis County smokefree ordinance

Location	Average # burning cigarettes	Active smoker density	% burning cigarettes to # people	Average PM _{2.5} level (µg/m ³)	EPA Air Quality Index category
Rest/Bar A*	-	-	-	15.9	Moderate
Rest/Bar B*	-	-	-	7.5	Good
Average	-	-	-	-	-
Rest/Bar C	0.7	0.08	0.7	6.1	Good
Rest/Bar D	0.2	0.02	0.7	49.4	Unhealthy for Sensitive Groups
Rest/Bar E	0.8	0.67	5.6	164.6	Very Unhealthy
Rest/Bar F	1.4	0.26	1.9	23.4	Moderate
Rest/Bar G	2.4	0.22	6.4	193.0	Very Unhealthy
Rest/Bar H^	5.4	0.12	11.7	54.0	Unhealthy for Sensitive Groups
Rec A^	9.8	1.32	6.1	16.8	Moderate
Average	3.0	0.38	3.9	72.5	Unhealthy

*non-smoking venue

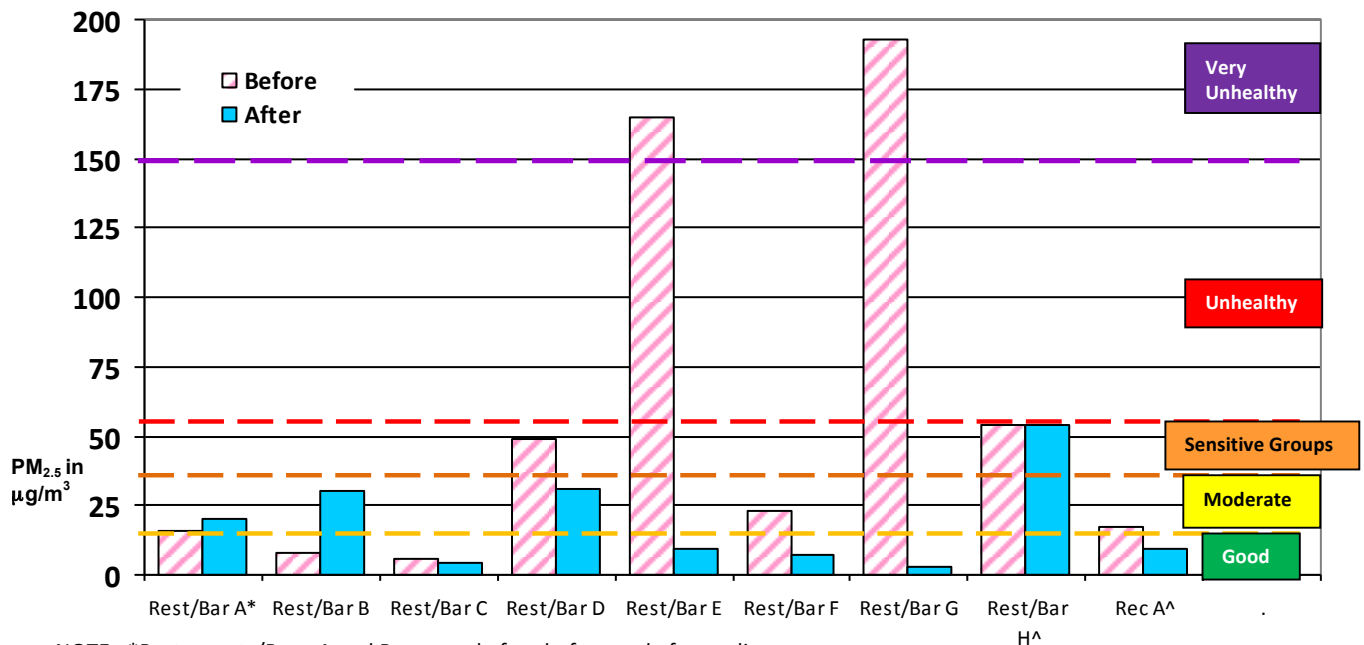
^will be exempt from ordinance

Table 3. PM_{2.5} levels in St. Louis County public places

Public Place	Before Ordinance		After Ordinance		% PM _{2.5} change
	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/Bar A*	15.9	Moderate	20.4	Moderate	-
Rest/Bar B*	7.6	Good	29.9	Moderate	-
Average	11.8	Good	25.2	Moderate	-
Rest/Bar C	6.1	Good	4.0	Good	-35%
Rest/Bar D	49.4	Unhealthy for Sensitive Groups	12.0	Good	-76%
Rest/Bar E	164.6	Very Unhealthy	9.0	Good	-95%
Rest/Bar F	23.4	Moderate	6.5	Good	-72%
Rest/Bar G	193.0	Very Unhealthy	2.5	Good	-99%
Average			10.6	Good	-91%
Rest/Bar H^	54.0	Unhealthy for Sensitive Groups	54.4	Good	0.8%
Rest/Bar I^	16.8	Moderate	8.9	Good	-47%
Average			31.6	Moderate	-56%
Average	72.5	Unhealthy			

Figure 1 is a presentation of the air quality data of outdoor, the two non-smoking and the seven smoking areas with comparison to the EPA Air Quality Index standards.

Figure 1 – Air Quality Measures for St Louis County public places – Nov 2010 & Jun-Jul 2011



NOTE: *Restaurants/Bars A and B are smokefree before and after ordinance
 ^Restaurant/Bar H and Recreation A allowed smoking before and 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_{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

Before the St. Louis County smokefree ordinance was in effect PM_{2.5} pollution was 6.2 times higher in public places that permitted smoking compared to a smokefree public place (72.5 µg/m³ vs. 11.8 µg/m³).

Of the seven smoking-allowed venues:

- 1 had air quality classified as “good”
- 2 as “moderate”
- 2 as “unhealthy for sensitive groups”
- 2 as “very unhealthy”

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 smoking-allowed public places was 110% 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 3.9% of the people in these public places were actively smoking at any given time, about 1/5th the 18.6% adult smoking prevalence in St. Louis.⁸ 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 3.0 cigarettes were actually smoked at any given time; and yet, these few cigarettes created levels of pollution to the degree to be rated as “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.⁹ 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).¹⁰ 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.¹¹ The current study in St. Louis 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 five public places that previously allowed smoking was 6.8 µg/m³, a decrease of 90.6% compared to the 72.5 µg/m³ average seen before the ordinance was in effect.

Likewise, particulate matter levels for the two places where smoking was allowed before and after the smokefree ordinance decreased 56.4% with an average of 31.6 µg/m³. Smoking was observed post-ordinance in both places, though at lower levels from an average of 7.6 burning

cigarettes to 2.9; and smoking density correspondingly decreased from 0.72 burning cigarettes per 100 cubic meters to 0.17.

Of the five previously smoking-allowed venues that were covered by the smokefree ordinance, four had air quality classified as “good” and one as “moderate”. Occupational exposure to this type of air pollution was found to be only 16% of the EPA average annual daily limit rather than the 110% noted prior to the implementation of the smokefree ordinance.

The two venues that were smoking-allowed before and after the ordinance had air quality classified as “moderate” and as “unhealthy for sensitive groups” before the ordinance and as “moderate” after the 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. It is of note that the two venues that still allowed smoking had a decrease in number of burning cigarettes after the ordinance was in effect. In particular, Rec A decreased from 9.8 cigarettes burning at any observed time before the ordinance to 1.8 cigarettes after the ordinance, an 81% decrease in number of cigarettes burning. The other smoking-permitted venue, Rest/Bar I also saw a decrease in the number of burning cigarettes, but not to the same degree, from 5.4 burning cigarettes to 4.0. It is not known if this decrease in smoking in these two smoking-permitted venues may be partially attributed to increased public awareness of the health harm of secondhand smoke or if this was just happenstance.

Counts of the number of people and of the number of burning cigarettes revealed that on average 3.9% of the people in these public places were actively smoking, which is about one-fifth the adult smoking prevalence of 18.6% for St. Louis, Missouri.¹² This finding is in agreement with a study of smoking prevalence at casinos in Las Vegas and Reno, Nevada which found smoking prevalence of gamblers did not exceed the national smoking prevalence.¹³ This counters the commonly held misperception that a high percent of employees or customers in hospitality venues smoke.

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.¹⁴ 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.¹⁵ 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.¹⁶

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.^{17,18,19} 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.^{20,21} 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.^{22,23}

A “66 casino” study by Repace found that incremental 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.¹³ This is of particular importance in that the EPA previously determined in a 2003 publication that even short term exposure to 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.²⁴

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.^{25,26} 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.²⁷

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.^{28,29,30,31,32,33,34,35,36,37,38} 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.^{39,40}

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.^{19,41} 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.⁴²

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With such evidence becoming more established and recognized by policymakers, a resolution was adopted on January 10, 2009 by the Executive Committee of the National Council of Legislators from Gaming States to support 100% smokefree gaming venues as a prerequisite for issuing/renewing gaming licenses (Note: Kansas is a member of this organization, Missouri and Illinois are not).⁴⁴ To date, 18 states have laws requiring non-tribal casinos to be smokefree.

The overwhelming 65% to 35% approval by voters for the county smokefree ordinance led some county council leaders in late January, 2011 to consider removal of all exemptions.⁴⁵ However, no tangible results have been produced.

Conclusions

Before the St. Louis County smokefree ordinance went into effect, public places that allowed smoking had over 6 times the fine particulate matter air pollution of 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 improved to a rating of “good”.

Before the ordinance, employees in public places that allowed smoking were exposed to 110% 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 11% the EPA exposure standard.

After implementation of the smokefree ordinance, particulate matter air pollutants for the five places that previously allowed smoking dropped an average 91% to come into the EPA rating of “good.” The two places that continued to allow smoking saw a decline of 56% in particulate matter air pollution and came into the EPA rating of “moderate”.

Hospitality workers and customers in St. Louis County smoking-allowed public places and workplaces 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. Unfortunately, exemptions in the ordinance allows some workers and customers in St. Louis County public places to continue to be exposed to this preventable source of disease.

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