Boonville
Air Quality Monitoring Study

School of Medicine
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CASE
Campus-Community Alliances for Smoke-Free Environments

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January 2012

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 Boonville public places and workplaces and compare results to the EPA Air Quality Index. Indoor air quality for fine particulate matter pollution ($PM_{2.5}$ particles) was sampled in 13 public places on November 4 and 18, 2011. Eight locations allowed smoking indoors; one location did not allow smoking but was connected to a smoking allowed venue; and four locations were smokefree.

Key findings of this study include:

- Particulate matter air pollution for –
    - The 8 smoking-allows locations averaged 166 $\mu g/m^3$ (EPA rating of "unhealthy").
    - The 1 non-smoking location connected to a smoking-allowed location averaged 30 $\mu g/m^3$ (EPA rating of "moderate").
    - The 4 smokefree locations averaged 8 $\mu g/m^3$ (EPA rating of "good").

  The level of particulate matter air pollution was nearly 20 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 Boonville public place that allows smoking would be exposed to 250% the EPA's average annual limit for particulate matter air pollution during an 8-hour workshift.
- On average, only 7% of people were actively smoking in the locations where smoking was permitted. This is about 1/3rd the adult smoking prevalence of 20.8% for Cooper County, and refutes the commonly held misperception that a higher percent of hospitality industry customers or employees smoke.

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. Missouri state law does not preempt local governments from enacting more stringent smokefree ordinances. The current Boonville ordinance addressing smoking in public places is limited to Article IV, Division 2, Section 2-151 "It shall be unlawful for any person to smoke in the council chamber during a council meeting," which apparently was codified over a half century ago in 1958.

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 (including restaurants, bars, 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 and populations remain without comprehensive smokefree laws.

To protect public health, the U.S. Environmental Protection Agency (EPA) issued National Ambient Air Quality Standards which include fine particulate matter as one of the criteria pollutants. The EPA first issued standards for daily exposure to pollution consisting of particulate matter of 2.5 microns in size ($PM_{2.5}$) 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 $\mu g/m^3$. 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 ($\mu g/m^3$). 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.

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

Air Quality	$PM_{2.5}$ ($\mu g/m^3$)	Health Advisory
Good	$\leq$ 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 13 public places in Boonville on November 4 and 18, 2011. Eight of the locations allowed smoking indoors, one location did not allow smoking but was readily open to a location that allowed smoking, and four locations were smokefree. Particulate matter smaller than 2.5 micrograms ($PM_{2.5}$) was measured. The $PM_{2.5}$ particles are easily inhaled deep into the lungs and can pass into the bloodstream, and are associated with pulmonary and cardiovascular disease and mortality.

Measurement Protocol

An average of 54 minutes was spent in each location to monitor air for data collection. The number of people at the location and the observed number of burning cigarettes were recorded during the air quality sampling period. A sonic measuring device was used to measure room dimensions, enabling unobtrusive calculation of the volume of each location. Active smoker density was calculated by dividing the average number of burning cigarettes by the volume of the room in meters. The number of burning cigarettes was divided by the number of people at the location to determine the percent of people smoking.

A TSI Sidepak AM510 Personal Aerosol Monitor (TSI, Inc., St. Paul, MN) was used to sample and record the levels of particulate matter pollution in the air. The Sidepak uses a built-in sampling pump to draw air through the device, where the particulate matter in the air scatters the light from a laser to assess the real-time concentration of particulate matter smaller than 2.5 micrograms to be recorded as $PM_{2.5}$. 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 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 (m^3), number of people, number of burning cigarettes, and smoker density (number of burning cigarettes per 100 m^3) were recorded for each location and averaged for all locations. Additionally, the results are compared to the EPA Air Quality Index.

Results

The locations were visited from 3:45 p.m. to 10:00 p.m. The average time spent per location was 54 minutes (range 42-75 minutes). The average $PM_{2.5}$ levels for the 8 sampled locations that allowed smoking was 165.7 $\mu g/m^3$ (range: 28.8 – 434.8 $\mu g/m^3$). The one non-smoking location readily open to a smoking-allowed location had an average $PM_{2.5}$ level of 30.2 $\mu g/m^3$. The 4 smokefree locations had an average $PM_{2.5}$ level of 8.4 $\mu g/m^3$ (range: 7.5 – 10.5 $\mu g/m^3$). The level of particulate matter air pollution was 19.8 times higher in those locations that allowed smoking compared to those prohibiting smoking and not open to smoking-allowed locations. On average, 4.2 cigarettes (range: 0 – 25 cigarettes) were burning during the monitoring time frame at smoking venues. This represents an overall average of 7.3% of patrons smoking at any given time. Table 2 provides additional details of the monitored venues.

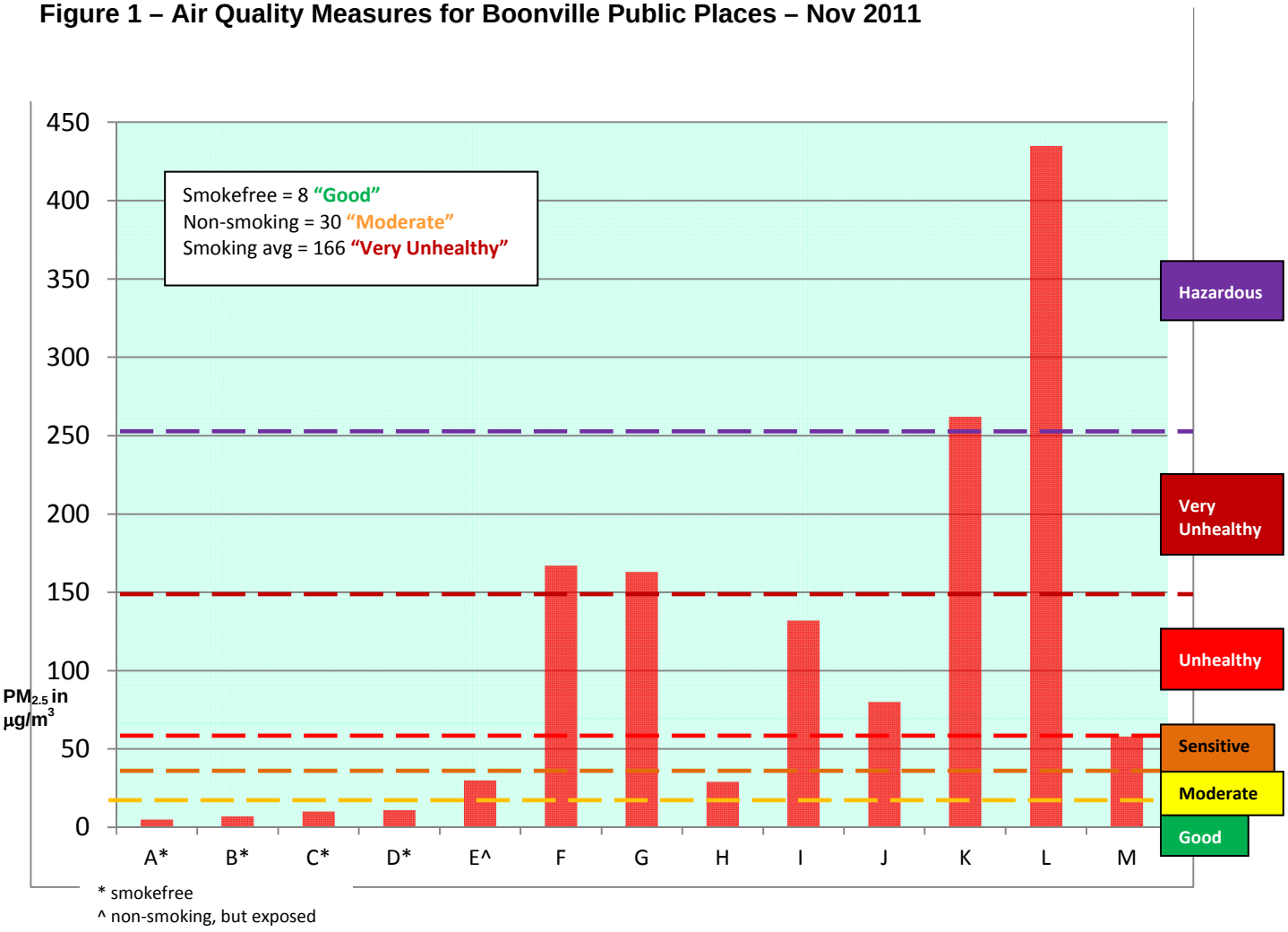
Table 2. Boonville Air Quality Data

Location	Average # burning cigarettes	Active smoker density	% burning cigarettes to # people	Average $PM_{2.5}$ level ($\mu g/m^3$)	EPA Air Quality Index category
A*	-	-	-	5.2	Good
B*	-	-	-	7.5	Good
C*	-	-	-	10.5	Good
D*	-	-	-	10.3	Good
Average	-	-	-	8.4	Good
E^	-	-	-	30.2	Moderate
F	0.8	0.08	2.1	166.6	Very Unhealthy
G	1.5	0.47	5.1	163.1	Very Unhealthy
H	0.8	0.19	5.6	28.8	Moderate
I	1.4	0.43	3.1	131.8	Unhealthy
J	1.0	0.09	22.0	80.1	Unhealthy
K	2.3	0.44	11.1	262.4	Hazardous
L	2.3	0.10	3.1	434.8	Hazardous
M	23.2	0.49	5.2	57.9	Unhealthy
Average	4.2	0.29	7.3	165.7	Very Unhealthy

*smokefree venues
^non-smoking, but exposed to smoking-allowed venue

Figure 1 is a presentation of the air quality data of outdoor, the four smokefree, one non-smoking exposed to smoking, and the eight smoking areas with comparison to the EPA Air Quality Index standards.

Figure 1 – Air Quality Measures for Boonville Public Places – Nov 2011



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. This study found $PM_{2.5}$ pollution to be 19.8 times higher in public places that permitted smoking compared to those that did not allow smoking (8.4 $\mu g/m^3$ vs. 165.7 $\mu g/m^3$). The average air quality in the four sampled smokefree locations not exposed to smoking-allowed areas was classified as "good" by the EPA Air Quality Index. The average air quality for the one non-smoking location open to a smoking-allowed location was classified as "moderate". The eight smoking-allowed locations had an average classification of "very unhealthy" with 1 classified as "moderate", 3 as "unhealthy", 2 as "very unhealthy", and 2 as "hazardous".

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.

Counts of the number of people and of the number of burning cigarettes revealed that on average 7.3% of the people in these public places were actively smoking, which is two-thirds that of the adult smoking prevalence of 20.8% for Cooper County.[7]

A relevant 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.[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]

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]

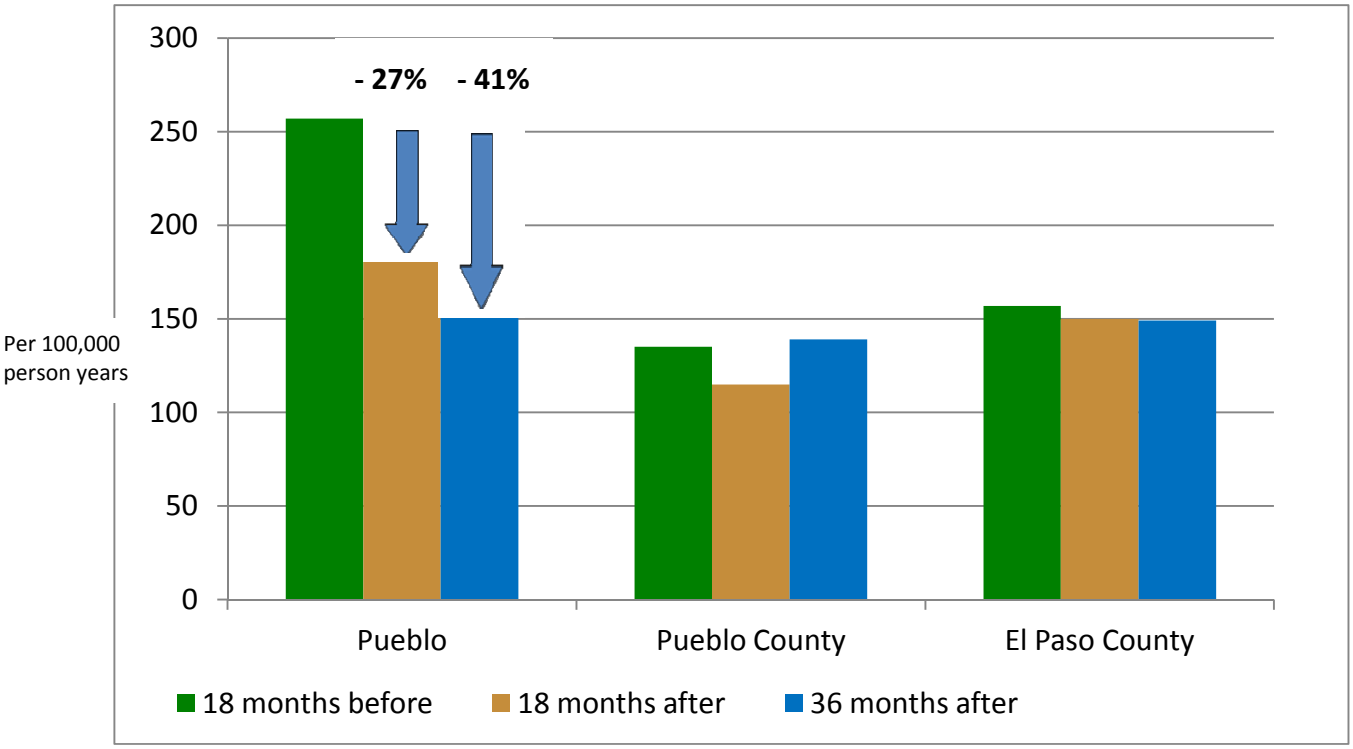
A "66 casino" study by Repace found that incremental $PM_{2.5}$ pollution from secondhand smoke in approximately half of the smoking-allowed casinos exceeded a level known to impact cardiovascular health in nonsmokers after less than 2 hours of exposure, posing acute health risks to patrons and workers.[13] 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.[18]

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.[19,20,21] 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.[22]

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 is are not).[23] To date, 18 states have laws requiring non-tribal casinos to be smokefree.

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.[24,25,26,27,28,29,30,31,32,33,34] Of note in Figure 2 are reports in which hospitalizations for heart attacks were reduced by 28% in Pueblo, Colorado, within the first 18 months after their smokefree ordinance was implemented; and that the decline continued to a 41% reduction within the first 36 months after the time the ordinance was implemented. However, rates in surrounding Pueblo County and adjacent El Paso County, which had no smokefree ordinances, remained virtually flat for the same periods.[35,36]

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



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.[19,37] A 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.[38]

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Conclusions

Smoking-allowed public places in Boonville had nearly 20 times the fine particulate matter air pollution of the smokefree public places. Average air quality for a smokefree public place was rated “good” by EPA standards, while that of smoking-allowed locations was “very unhealthy”.

Separation of smoking and non-smoking sections is ineffective in preventing infiltration of fine particulate matter into non-smoking areas. The non-smoking location that had open exposure to a smoking-allowed location had a level of fine particulate matter over 3½ times that for the smokefree locations. The air quality was rated as “moderate” and was close to the advisory level for people with asthma or other respiratory conditions.

Full-time employees in public places that allow smoking are exposed to 250% the established annual EPA exposure limit to protect human health from fine particle air pollution.

Employees and patrons in public places in Boonville where smoking is allowed are 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.

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