

**Indoor Air Quality Before and After Implementation of
Madison County's Clean Indoor Air Board of Health Regulation**

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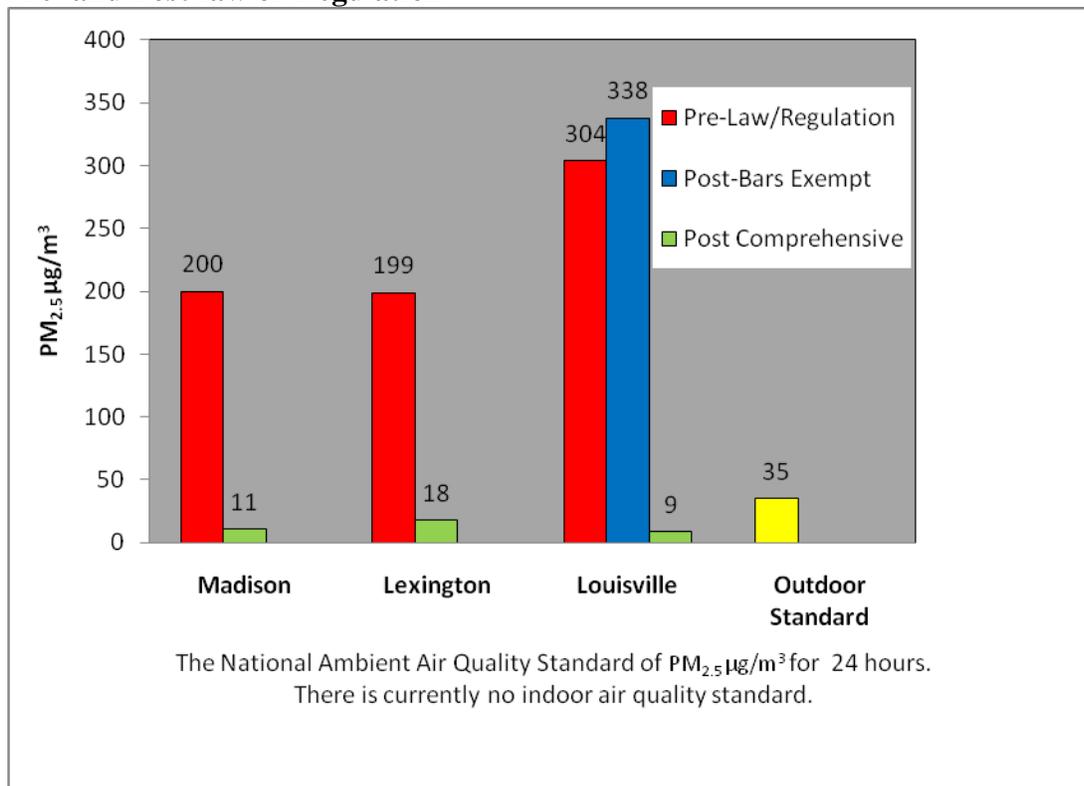
Executive Summary

Indoor air quality was assessed in eleven locations before and after Madison County's clean indoor air regulation was implemented on June 12, 2007. Locations were sampled using the TSI SidePak AM510 Personal Aerosol Monitor from September 9, 2005 to September 30, 2005 for pre-regulation air quality measurements. Post-regulation measurements were obtained from October 23, 2009 to May 8, 2010. The average PM_{2.5} levels in Madison County establishments are compared to the average PM_{2.5} levels in Lexington and Louisville pre- and post-law, as well as to the National Ambient Air Quality Standard (NAAQS) for 24 hours.

Key findings of the study are:

- The average PM_{2.5} in the eleven venues located in Madison County decreased from 200 µg/m³ before the regulation to 11 µg/m³ following implementation of the regulation. There was a 95% decline in indoor air pollution as a result of compliance with Madison County's clean indoor air regulation.
- After the regulation took effect, average PM_{2.5} levels in the eleven hospitality venues ranged from 2 µg/m³ to 54 µg/m³. The average PM_{2.5} in the eleven venues post-regulation (11 µg/m³) was lower than the National Ambient Air Quality Standard (35 µg/m³), similar to Lexington (18 µg/m³) and Louisville (9 µg/m³) post-regulation.

Figure 1. Average Fine Particle Air Pollution in Three Kentucky Communities, Pre- and Post-law or Regulation



Note. Madison County averages based on 11 venues tested pre- and post-regulation

Introduction

Secondhand smoke (SHS) contains at least 250 chemicals that are known to be toxic.^{1,2} There is no safe level of exposure to SHS.² SHS exposure is the third leading cause of preventable death in the United States.³ SHS is a mixture of the smoke from the burning end of tobacco products (sidestream smoke) and the smoke exhaled by smokers (mainstream smoke) and is known to cause cancer in humans.^{1,2,3} SHS exposure is a cause of heart disease and lung cancer in nonsmoking adults.¹⁻⁴ An estimated 3,000 nonsmokers die from lung cancer⁵ annually and over 46,000 nonsmokers die from heart disease² every year in the U.S due to secondhand smoke exposure. It is estimated that approximately 46.4% of people in the United States have biological evidence of SHS exposure.⁶

Currently in the U.S., 17,628 local municipalities are covered by either local or state 100% smoke-free laws in workplaces and/or restaurants and/or bars.⁷ It is estimated that approximately 41% of the U.S. population is protected by clean indoor air regulations that cover virtually all indoor worksites including bars and restaurants. There are 3,117 local ordinances or regulations that restrict smoking to some extent in workplaces across the United States and Washington D.C.⁷ The extent of protection provided by these laws vary widely from community to community.

As of May 1, 2010, 27 Kentucky communities had enacted smoke-free laws or adopted smoke-free regulations. The most comprehensive ordinances/regulations, 100% smoke-free workplace *and* 100% smoke-free enclosed public place laws, have been enacted in 17 communities: Ashland, Bardstown, Campbellsville, Clark County (Board of Health regulation), Danville, Elizabethtown, Georgetown, Glasgow, Hardin County (unincorporated areas), Lexington-Fayette County, London, Louisville, Madison County (Board of Health regulation), Morehead, Prestonsburg, Radcliff, and Woodford County (Board of Health regulation), Kentucky. The next most comprehensive ordinances, 100% smoke-free enclosed public place laws, have been implemented in three communities: Frankfort, Letcher County, and Paducah. Seven communities have enacted partial smoke-free laws, protecting workers and patrons in some public venues: Beattyville, Daviess County, Henderson, Hopkins County, Oldham County, Paintsville, and Pikeville.

In Louisville, Kentucky, two different types of smoke-free laws have been enacted and implemented since 2005. In November 2005, a smoke-free law covering most buildings open to the public, but with significant exemptions (i.e., venues serving a certain amount of alcohol) was implemented in Louisville Metro. In July 2007, Louisville Metro strengthened their ordinance to cover all workplaces (including bars) and all buildings open to the public.

The purpose of this study was to (a) assess air quality in Madison County, Kentucky hospitality venues before and after implementation of their clean indoor air regulation on June 12, 2007; and (b) compare the results to Lexington and Louisville, Kentucky air quality data before and after their smoke-free laws took effect. It was hypothesized that the average level of indoor air pollution sampled post-regulation in Madison County venues would be significantly lower than pre-regulation levels and lower than the National Ambient Air Quality Standard (NAAQS).

Methods

Between September 9, 2005 and September 30, 2005, before the smoke-free regulation took effect, indoor air quality was assessed in fifteen hospitality venues in Madison County. Sites were of various sizes; some sites were individually owned establishments and some were part of local or national chain entities.

All venues tested pre-regulation allowed smoking before the policy went into effect. Four of the original fifteen venues tested pre-regulation closed during the four year interval between pre- and post-regulation testing dates. Only the eleven venues currently in operation were considered in this analysis. Between October 23, 2009 and May 8, 2010, after Madison County's regulation took effect, indoor air quality was assessed again in the eleven Madison County venues that remained in operation during this time. To evaluate the effect of Madison County's regulation, we compared air quality data before and after the regulation from eleven of the fifteen venues (four venues were no longer in operation during the post-testing period).

A TSI SidePak AM510 Personal Aerosol Monitor (TSI, Inc., St. Paul, MN) was used to sample and record the levels of respirable suspended particles in the air. The SidePak uses a built-in sampling pump to draw air through the device and the particulate matter in the air scatters the light from a laser to assess the real-time concentration of particles smaller than $2.5\mu\text{m}$ in micrograms per cubic meter, or $\text{PM}_{2.5}$. The SidePak was calibrated against a light scattering instrument, which had been previously calibrated and used in similar studies. In addition, the SidePak was zero-calibrated prior to each use by attaching a HEPA filter according to the manufacturer's specifications.

Aerosol TSI SidePak AM510 Personal Monitor



The equipment was set to a one-minute log interval, which averages the previous 60 one-second measurements. Sampling was discreet in order not to disturb the occupants' normal behavior. For each venue, the first and last minute of logged data were removed because they are averaged with outdoor and entryway air. The remaining data points were summarized to provide an average $\text{PM}_{2.5}$ concentration within each venue. The Kentucky Center for Smoke-free Policy (KCSP) staff trained researchers from the Madison County Health Department who conducted the sampling along with KCSP staff. KCSP analyzed the data.

Statistical Analyses

Descriptive statistics including the venue volume, number of patrons, number of burning cigarettes, and smoker density (i.e., average number of burning cigarettes per 100 m^3) were reported for each venue and averaged for all venues.

Results

Before the clean indoor air regulation, Madison County hospitality venues were visited from September 9 to September 30, 2005 (Friday through Saturday). The average size of the eleven venues analyzed for this study was 2048 m³ (range 280-6743 m³). On average, 65 patrons were present per venue and 12 burning cigarettes per venue were observed. The smoker density was 0.80 #bc/100 m³. The average PM_{2.5} level before the regulation was 200 µg/m³. Descriptive statistics for the eleven venues are shown in Table 1.

Table 1. Air Quality Data for Eleven Venues in Madison County, Kentucky, Before the Regulation, September 2005

Venue	Date Sampled	Size (m ³)	Average # people	Average # burning cigs	Smoker density (#bc/100m ³)	Average PM _{2.5} level (µg/m ³)
Restaurant A	9/9/2005	280	4	0.3	0.09	68
Restaurant B	9/9/2005	3663	91	4.8	0.13	166
Restaurant C	9/10/2005	283	140	5.8	2.06	174
Restaurant D	9/30/2005	2294	70	1.2	0.05	71
Restaurant E	9/30/2005	425	19	0.4	0.09	21
Restaurant F	9/30/2005	531	6	1.0	0.19	125
Restaurant G	9/30/2005	2124	21	0.2	0.01	111
Bar A	9/9/2005	928	35	7.0	0.75	231
Bar B	9/10/2005	500	53	12.5	2.50	737
Entertainment A	9/9/2005	6743	104	15	0.22	124
Entertainment B	9/10/2005	4757	225	100	2.10	375
Averages		2048	65	12	0.8	200

Post-regulation measurements were obtained from October 23, 2009 to May 8, 2010, in eleven of the same Madison County venues after the clean indoor air regulation took effect. Venues were visited Friday through Saturday for an average of 69 minutes (range 48-123 minutes) per venue. Visits occurred at various times of the day from 1:10 PM to 11:57 PM. On average, 58 people were present per venue. The average PM_{2.5} level post-regulation was 11 µg/m³. Descriptive statistics for each venue after the implementation of Madison County's regulation are shown in Table 2.

Figure 1 shows a 95% decline in fine particle air pollution from pre-regulation (200 µg/m³) to post-regulation (11 µg/m³) in the 11 Madison County venues. Before the regulation took effect in Madison County, the average level of indoor air pollution in the 11 venues was approximately 5.7 times higher than the current NAAQS. After the clean indoor air regulation took effect, the indoor air pollution in Madison County was lower than the NAAQS, similar to Lexington and Louisville after their comprehensive laws took effect.

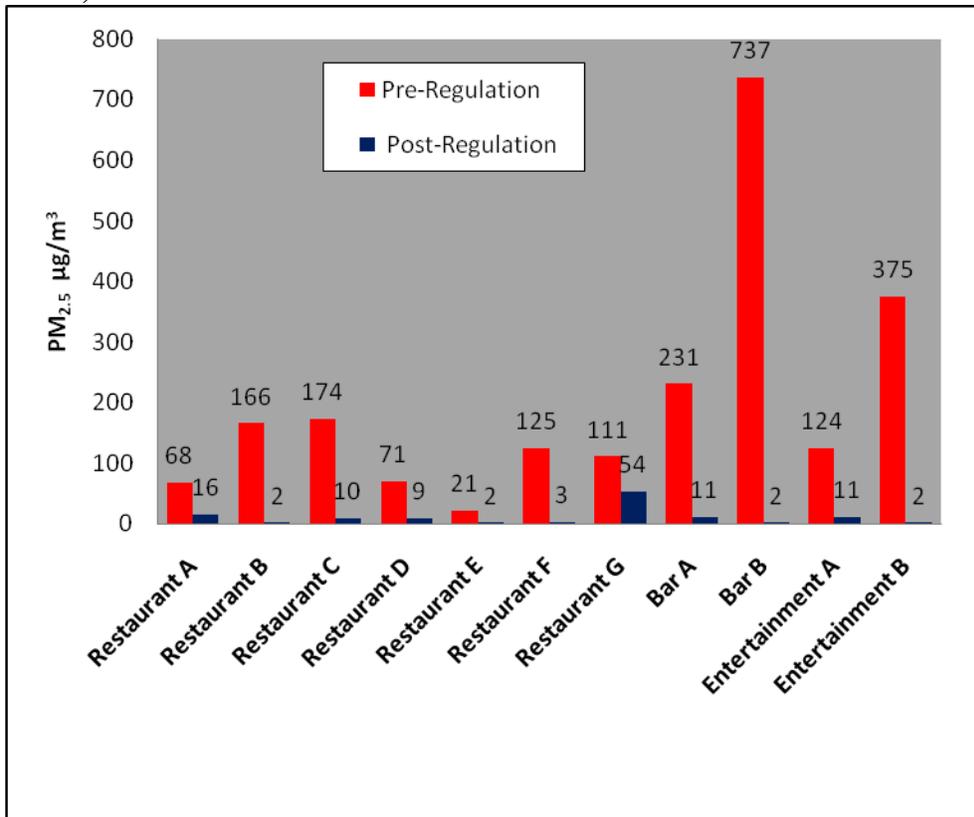
Figure 2 shows the average level of indoor air pollution in all eleven venues from pre- to post-regulation. The average PM_{2.5} levels in the eleven Madison County venues ranged from 21 µg/m³ to 737 µg/m³ pre-regulation and from 2 to 54 µg/m³ post-regulation. After the regulation took

effect, one of the venues had a $PM_{2.5}$ of $54\mu g/m^3$, exceeding the NAAQS for 24 hours ($35\mu g/m^3$). People were observed smoking right outside this venue.

Table 2. Air Quality Data for Eleven Venues in Madison County, Kentucky After Implementation of the Regulation, 2009-2010

Venue	Date Sampled	Size	Ave. # of People	Average # burning cigs	Smoker density	Average $PM_{2.5}$ level
Restaurant A	5/7/2010	280	13	0	0	16
Restaurant B	10/23/2009	3663	74	0	0	2
Restaurant C	5/8/2010	283	162	0	0	10
Restaurant D	5/7/2010	2294	148	0	0	9
Restaurant E	10/31/2009	425	25	0	0	2
Restaurant F	10/31/2009	531	16	0	0	3
Restaurant G	10/31/2009	2124	45	0	0	54
Bar A	5/7/2010	928	17	0	0	11
Bar B	11/7/2009	500	39	0	0	2
Entertainment A	5/7/2010	6743	47	0	0	11
Entertainment B	11/7/2009	4757	52	0	0	2
Averages		2048	58	0	0	11

Figure 2. Air Pollution in Madison County Pre- and Post-Regulation by Hospitality Venue ($n = 11$)



Discussion

The average PM_{2.5} in the venues in Madison County, Kentucky decreased from 200µg/m³ before the clean indoor air regulation to 11µg/m³ after implementation. There was a 95% drop in indoor air pollution as a result of compliance with the clean indoor air public places regulation in Madison County. The average PM_{2.5} level (11µg/m³) was lower than the National Ambient Air Quality Standard (35 ug/m³) for *outdoor* air set by the EPA. There were over 80 EPA cited epidemiologic studies in creating a particulate air pollution standard in 1997.⁸ To protect the public's health, the EPA set a new limit of 35 µg/m³ on December 17, 2006 as the average level of exposure over 24-hours in *outdoor environments*. There is no EPA standard for indoor air quality.

Two Kentucky air quality studies have demonstrated significant improvements in air quality as a result of implementing a comprehensive smoke-free law. Hahn et al. showed a 91% decrease in indoor air pollution after Lexington, Kentucky implemented a comprehensive smoke-free law on April 27, 2004.⁹ The average level of indoor air pollution was 199µg/m³ pre-law and dropped to 18µg/m³ post-law. Average levels of indoor air pollution dropped from 86µg/m³ to 20µg/m³ after Georgetown, Kentucky implemented a comprehensive smoke-free law on October 1, 2005.¹⁰ Similarly, other studies show significant improvements in air quality after implementing a smoke-free law. One California study showed an 82% average decline in air pollution after smoking was prohibited.¹¹ When indoor air quality was measured in 20 hospitality venues in western New York, average levels of respirable suspended particle (RSP) dropped by 84% after a smoke-free law took effect.¹²

Other studies have assessed the effects of SHS on human health. Hahn et al. found a 56% drop in hair nicotine levels in a sample of workers after Lexington implemented a smoke-free law, regardless of whether workers were smokers or nonsmokers.¹³ Workers were also less likely to report colds and sinus infections after the law went into effect. Similarly, Farrelly et al. also showed a significant decrease in both salivary cotinine concentrations and sensory symptoms in hospitality workers after New York State implemented a smoke-free law in their worksites.¹⁴ Smoke-free legislation in Scotland was associated with significant improvements in symptoms, spirometry measurements, and systemic inflammation of bar workers. The significant improvement of respiratory health was reported in only one month after smoke-free law.¹⁵

There is no longer any doubt in the medical or scientific communities that SHS is a significant public health problem. In 2006, U.S. Surgeon General Carmona, said "The scientific evidence is now indisputable: secondhand smoke is not a mere annoyance. It is a serious health hazard that can lead to disease and premature death in children and nonsmoking adults."² SHS causes coronary heart disease, lung cancer, other cancers, and lung disease in nonsmoking adults.

Many millions of Americans, both children and adults, are still exposed to secondhand smoke in their homes and workplaces. Approximately 46.4% of people in the United States have biological evidence of SHS exposure.⁶ U.S. Surgeon General Carmona said, "Eliminating smoking in indoor spaces fully protects nonsmokers from exposure to secondhand smoke. Separating smokers from nonsmokers, cleaning the air, and ventilating buildings cannot eliminate exposure of nonsmokers to secondhand smoke."²

Conclusions

The average level of indoor air pollution in Madison County, Kentucky dropped from 200 $\mu\text{g}/\text{m}^3$ pre-regulation to 11 $\mu\text{g}/\text{m}^3$ post-regulation, indicating a 95% reduction in indoor air pollution. The level of indoor air pollution in Madison County hospitality venues post-regulation was similar to Lexington's and Louisville's post-law average PM_{2.5} levels. These findings show significant improvement in air quality after implementing a clean indoor air regulation in Madison County. However, one venue post-law still showed higher levels of indoor air pollution than the National Ambient Air Quality Standard. Enforcement of smoke-free laws and ensuring reasonable distance from entrances and windows is essential to promoting public health for workers and patrons.

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