

**Indoor Air Quality Before and After Implementation of
Bardstown's Smoke-free Ordinance**

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October 12, 2010

Funding for the study was provided by the Community Prevention Center, City of Bardstown, through a contract with the University of Kentucky and funded by the National Heart, Lung, and Blood Institute (R01 HL086450-01) Rural Smoke-free Communities Project.

The project described was supported by Award Number R01HL086450 from the National Heart, Lung, And Blood Institute. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung And Blood Institute or the National Institutes of Health.

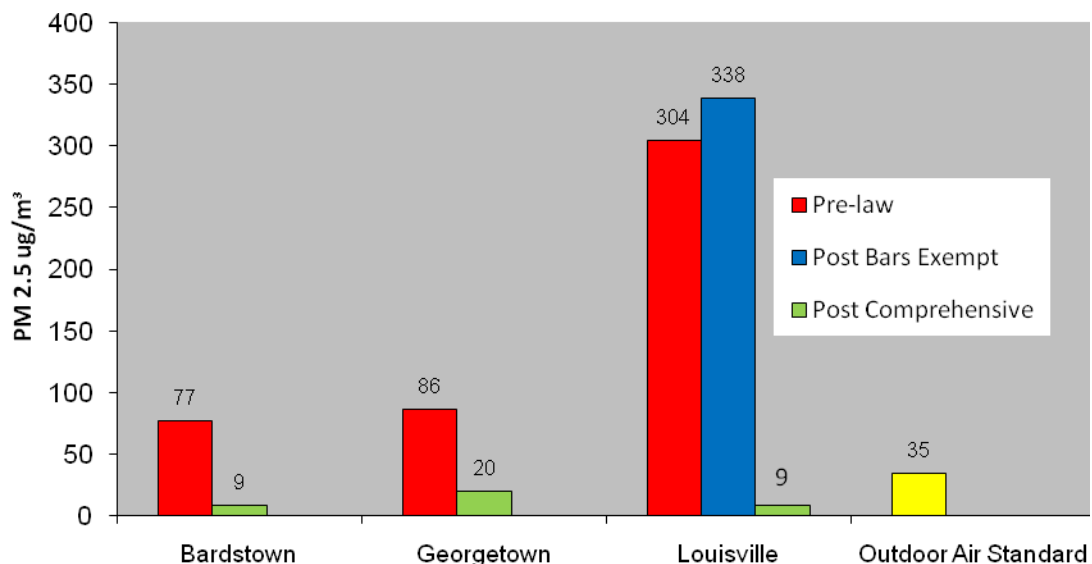
Executive Summary

Indoor air quality was assessed in eight locations before and after Bardstown's smoke-free ordinance was implemented on June 17, 2010. Locations were sampled using the TSI SidePak AM510 Personal Aerosol Monitor from August 15 to August 29, 2008 for pre-ordinance air quality measurements. Post-ordinance measurements were obtained from August 20 to August 27, 2010. The average PM_{2.5} levels in Bardstown establishments are compared to the average PM_{2.5} levels in Georgetown 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 eight venues located in Bardstown decreased from 77 $\mu\text{g}/\text{m}^3$ before the ordinance to 9 $\mu\text{g}/\text{m}^3$ following implementation of the ordinance. There was an 88% decline in indoor air pollution as a result of compliance with Bardstown's smoke-free ordinance.
- After the ordinance took effect, average PM_{2.5} levels in the eight hospitality venues ranged from 4 $\mu\text{g}/\text{m}^3$ to 18 $\mu\text{g}/\text{m}^3$. The average PM_{2.5} in the eight venues post-ordinance (9 $\mu\text{g}/\text{m}^3$) was lower than the National Ambient Air Quality Standard (35 $\mu\text{g}/\text{m}^3$), similar to Georgetown (20 $\mu\text{g}/\text{m}^3$) and Louisville (9 $\mu\text{g}/\text{m}^3$) post-ordinance.

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



The National Ambient Air Quality Standard of PM 2.5 $\mu\text{g}/\text{m}^3$ for 24 hours. There is currently no indoor air quality standard.

Note. Bardstown averages based on the same 8 venues tested pre- and post-ordinance

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 40% of nonsmokers in the United States have biological evidence of SHS exposure.⁶

Currently in the U.S., 21,838 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 48% of the U.S. population is protected by clean indoor air regulations that cover virtually all indoor worksites including bars and restaurants. There are 3,173 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 varies widely from community to community.

As of October 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 Bardstown, Kentucky hospitality venues before and after implementation of their smoke-free ordinance on June 17, 2010; and (b) compare the results to Georgetown 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-ordinance in Bardstown venues would be significantly lower than pre-ordinance levels and lower than the National Ambient Air Quality Standard (NAAQS).

Methods

Between August 15 and August 29, 2008, before the smoke-free ordinance took effect, indoor air quality was assessed in 12 hospitality venues in Nelson 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 Bardstown's ordinance went into effect. Four of the original 12 venues tested pre-ordinance were not tested post-ordinance either because they had closed or because they were not located in the city. Only the eight remaining Bardstown venues were considered in this analysis. Between August 20 and August 27, 2010, two months after Bardstown's ordinance took effect, indoor air quality was assessed in eight Bardstown venues that remained from the original sample. No new businesses were tested. To evaluate the effect of Bardstown's ordinance, we compared air quality data before and after the ordinance from these eight venues.

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 Clean Indoor Air Partnership (CIAP) staff trained researchers from Smoke Free Nelson County who conducted the sampling. CIAP 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 smoke-free ordinance, Bardstown hospitality venues were visited from August 15 to August 29, 2008 (Monday through Sunday). The average size of the eight venues analyzed for this study was 1657 m³ (range 71-9302 m³). On average, 34 patrons were present per venue and two burning cigarettes (bc) per venue were observed. The smoker density was 0.31 #bc/100 m³. The average PM_{2.5} level before the ordinance was 77 µg/m³. Descriptive statistics for the eight venues are shown in Table 1.

Table 1. Air Quality Data for Eight Venues in Bardstown, Kentucky, Before the Ordinance, August 2008

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	8/27/2008	544	25	5.5	1.01	273
Restaurant B	8/29/2008	1224	109	1.9	0.16	30
Restaurant C	8/16/2008	340	29	0	0	14
Restaurant D	8/22/2008	287	6	0.4	0.14	29
Restaurant E	8/23/2008	490	27	1	0.2	35
Restaurant F	8/25/2008	71	5	0.3	0.42	67
Entertainment A	8/15/2008	9302	21	1.3	0.01	29
Entertainment B	8/27/2008	996	51	5.7	0.57	141
Averages		1657	34	2	0.31	77

Post-ordinance measurements were obtained from August 20 to August 27, 2010, in the same eight Bardstown venues after the smoke-free ordinance took effect. Venues were visited Friday through the following Friday for an average of 58 minutes (range 45-83 minutes) per venue. Visits occurred at various times of the day from 8:40 AM to 9:30 PM. On average, 34 people were present per venue. The average PM_{2.5} level post-ordinance was 9µg/m³. Descriptive statistics for each venue after the implementation of Bardstown's ordinance are shown in Table 2.

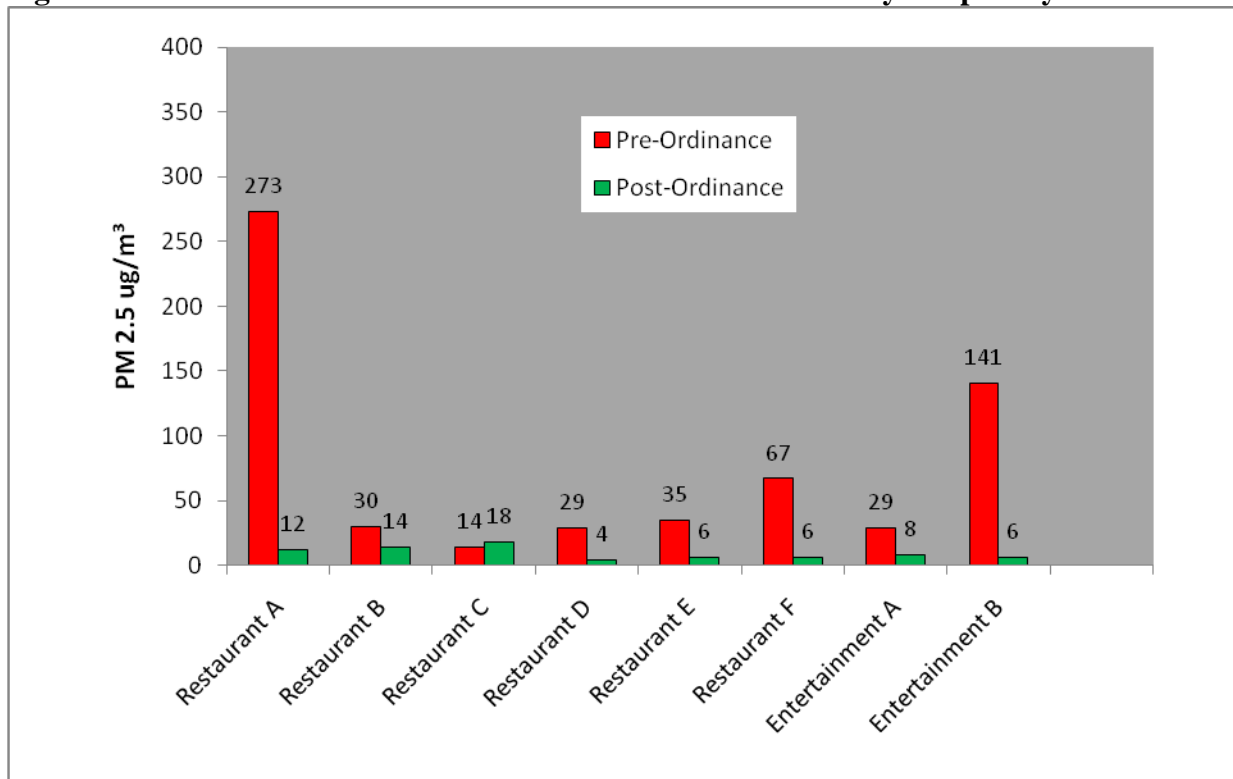
Figure 1 shows an 88% decline in fine particle air pollution from pre-ordinance (77µg/m³) to post-ordinance (9µg/m³) in the eight Bardstown venues. Before the ordinance took effect in Bardstown, the average level of indoor air pollution in the eight venues was approximately 2.2 times higher than the current NAAQS. After the smoke-free ordinance took effect, the indoor air pollution in Bardstown was lower than the NAAQS, similar to Georgetown and Louisville after their comprehensive laws took effect.

Figure 2 shows the average level of indoor air pollution in all eight venues from pre- to post-ordinance. The average PM_{2.5} levels in the eight Bardstown venues ranged from 14µg/m³ to 273µg/m³ pre-ordinance and from 4 to 18µg/m³ post-ordinance.

Table 2. Air Quality Data for Eight Venues in Bardstown, Kentucky After Implementation of the Ordinance, August 2010

Venue	Date Sampled	Size	Ave. # of People	Average # burning cigs	Smoker density	Average PM _{2.5} level
Restaurant A	8/23/2010	544	6	0	0	12
Restaurant B	8/27/2010	1224	124	0	0	14
Restaurant C	8/21/2010	340	10	0	0	18
Restaurant D	8/20/2010	287	26	0	0	4
Restaurant E	8/21/2010	490	12	0	0	6
Restaurant F	8/23/2010	71	10	0	0	6
Entertainment A	8/25/2010	9302	19	0	0	8
Entertainment B	8/27/2010	996	49	0	0	6
Averages		1657	34	0	0	9

Figure 2. Air Pollution in Bardstown Pre- and Post-Ordinance by Hospitality Venue



Discussion

The average PM_{2.5} in the venues in Bardstown, Kentucky decreased from 77µg/m³ before the smoke-free ordinance to 9µg/m³ after implementation. There was an 88% drop in indoor air pollution as a result of compliance with the smoke-free workplace ordinance in Bardstown. The average PM_{2.5} level (9µg/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. Four in 10 (40%) nonsmokers 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 Bardstown, Kentucky dropped from 77 $\mu\text{g}/\text{m}^3$ pre-ordinance to 9 $\mu\text{g}/\text{m}^3$ post-ordinance, indicating an 88% reduction in indoor air pollution. The level of indoor air pollution in Bardstown hospitality venues post-ordinance was similar to Georgetown and Louisville's post-law average PM_{2.5} levels. These findings show significant improvement in air quality after implementing a smoke-free ordinance in Bardstown.

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