

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

Ellen J. Hahn, PhD, RN, FAAN
Kiyoung Lee, ScD, CIH
Heather E. Robertson, MPA
Hilarie Sidney

University of Kentucky, College of Nursing
Clean Indoor Air Partnership

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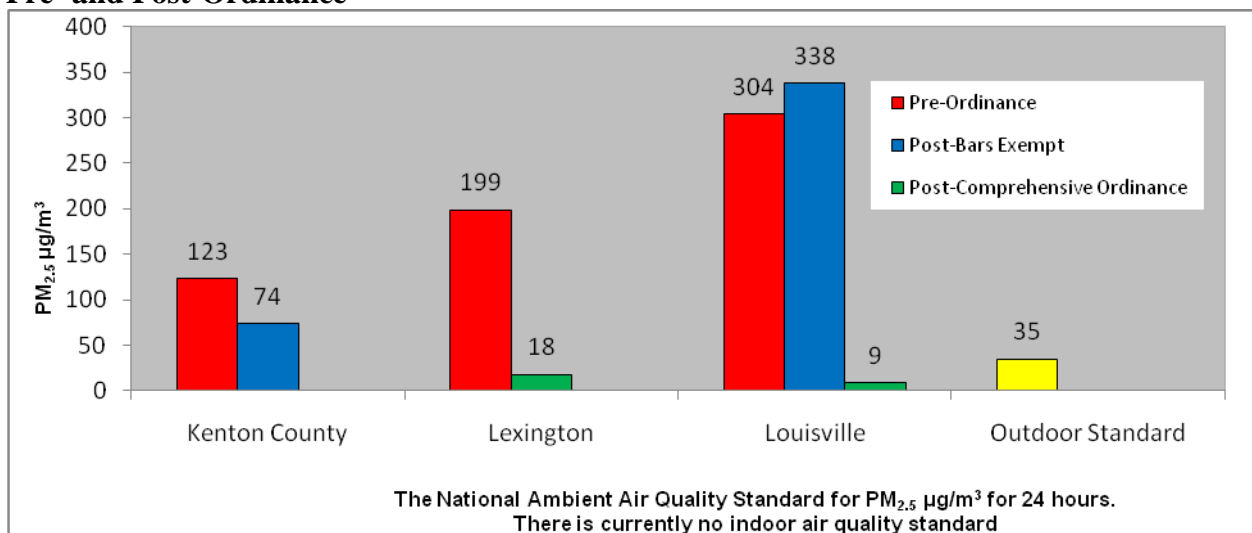
Executive Summary

Indoor air quality was assessed in nine locations before and after Kenton County's partial smoke-free ordinance was implemented on April 15, 2011. An additional 10 venues were tested post-ordinance. Kenton County's law exempts bars, and venues may adopt a 'split shift' exemption, allowing smoking after 4:00 PM. Locations were sampled using the TSI SidePak AM510 Personal Aerosol Monitor from April 8 to April 10, 2011 (pre-ordinance) and from May 13 to June 21, 2011 (post-ordinance). The average PM_{2.5} levels in Kenton 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 *outdoor air* for 24 hours (35 µg/m³).

Key findings of the study are:

- After the ordinance took effect, the average PM_{2.5} level in the nine hospitality venues was 74µg/m³, 2.1 times higher than the NAAQS. Kenton County PM_{2.5} levels post-ordinance were 4.1 times higher than Lexington (18 µg/m³) and 8.0 times higher than Louisville (9 µg/m³) after their comprehensive laws. The higher average PM_{2.5} in the Kenton County venues was due to exemptions allowing for smoking either all or some of the time.
- Of the 19 venues tested post-ordinance, the average PM_{2.5} level in 11 nonsmoking venues was 13 µg/m³. The PM_{2.5} levels in three split shift venues averaged 63 µg/m³ (37 µg/m³ during the non-smoking periods and 104 µg/m³ when smoking was allowed), nearly 2 times higher than the NAAQS. The PM_{2.5} level in the five venues that allowed smoking was 147 µg/m³, 4.2 times higher than the NAAQS.

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



Note. Kenton County levels based on the same nine venues pre-and post-ordinance.

Introduction

Secondhand smoke (SHS) contains at least 250 chemicals that are known to be toxic.¹ There is no safe level of exposure to SHS.^{2,3} SHS damages the DNA, blood vessels, and lung tissue, causing cancer, heart, and lung disease.³ SHS exposure is the third leading cause of preventable death in the United States.² SHS is a mixture of the smoke from the burning end of tobacco products (sidestream smoke) and the smoke exhaled by smokers (mainstream smoke). An estimated 3,000 nonsmokers die from lung cancer and over 46,000 nonsmokers die from heart disease² every year in the U.S due to SHS exposure. It is estimated that 40.1% of nonsmokers in the United States have biological evidence of SHS exposure.⁴

Currently in the U.S., 21,884 local municipalities are covered by either local or state 100% smoke-free laws in workplaces and/or restaurants and/or bars.⁵ 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 3,487 local ordinances or regulations that restrict smoking to some extent in workplaces across the United States and Washington D.C.⁵ The extent of protection provided by these laws varies widely from community to community.

As of January 2, 2012, 31 Kentucky communities had implemented 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 implemented in 19 communities: Ashland, Bardstown, Bowling Green, Campbellsville, Clark County (Board of Health regulation), Corbin, 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. Bullitt County's Board of Health has adopted a comprehensive regulation but it is delayed pending court action. Manchester, KY passed a comprehensive smoke-free law which will go into effect January 29, 2012. The next most comprehensive ordinances, 100% smoke-free enclosed public place laws, have been implemented in three communities: Frankfort, Letcher County, and Paducah. Nine communities have enacted partial smoke-free laws, protecting workers and patrons in some public venues: Beattyville, Daviess County, Henderson, Hopkins County, Kenton County, Oak Grove, 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 nine Kenton County, Kentucky hospitality venues before and after implementation of their partial smoke-free ordinance on April 15, 2011; (b) compare the results to Lexington and Louisville, Kentucky air quality data before and after their smoke-free laws took effect; and (c) compare air quality in 19 venues after the ordinance including nonsmoking, smoking, and split-shift locations. We hypothesized that the average level of indoor air pollution sampled post-ordinance in nonsmoking Kenton County

venues would be significantly lower than pre-ordinance levels and lower than the National Ambient Air Quality Standard (NAAQS). We also expected that the indoor air pollution in the exempt venues (allowing smoking all the time or at certain times of the day) would be higher than the NAAQS and higher than the nonsmoking venues.

Methods

Between April 8 and April 10, 2011 before the smoke-free ordinance took effect, indoor air quality was assessed in nine hospitality venues in Kenton 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-ordinance allowed smoking before Kenton County's ordinance went into effect.

Between May 13 and June 21, 2011 after Kenton County's ordinance took effect, indoor air quality was assessed in 19 Kenton County venues. To evaluate the effect of Kenton County's ordinance, we compared air quality data before and after the ordinance from nine of these 19 venues. Of the nine venues tested at both time periods, five no longer allowed smoking and 4 operated under an exemption. Of the four with exemptions, three allowed smoking only after 4:00 PM (split shift) and one venue allowed smoking all the time.

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 the Northern Kentucky District Health Department 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

The average size of the nine venues analyzed for this study was 830 m³ (range 325-1421 m³). On average, 120 patrons were present per venue and 3.2 burning cigarettes (bc) per venue were observed. The smoker density was 0.35 #bc/100 m.³ The average PM_{2.5} level before the ordinance was 123µg/m.³ Descriptive statistics for the nine venues before the smoke-free ordinance are shown in Table 1.

Table 1. Air Quality Data for Nine Venues in Kenton County, Kentucky, Before the Ordinance, April 2011.

Venue	Date Sampled	Size (m ³)	Average # people	Average # burning cigs	Smoker density (#bc/100m ³)	Average PM _{2.5} level (µg/m ³)
Venue A	4/8/2011	604	149	3.2	0.52	95
Venue B	4/8/2011	915	34	1.9	0.20	51
Venue C	4/9/2011	338	16	0.3	0.10	66
Venue D	4/9/2011	325	47	1.8	0.56	182
Venue E	4/9/2011	815	27	2.0	0.25	44
Venue F	4/9/2011	811	290	2.3	0.28	84
Venue G	4/9/2011	977	71	0.5	0.05	20
Venue H	4/9/2011	1266	289	2.8	0.22	188
Venue I	4/9/2011	1421	158	14.0	0.99	377
Averages		830	120	3.2	0.35	123

Although Figure 1 shows a 40% decline in fine particle air pollution from pre-ordinance (123µg/m³) to post-ordinance (74µg/m³) in the nine Kenton County venues, fine particle air pollution was approximately 2.1 times higher than the NAAQS. Kenton County PM_{2.5} levels after the law took effect were higher than those in Lexington (18µg/m³) and Louisville (9µg/m³) after their comprehensive ordinances.

After the smoke-free ordinance took effect, measurements were obtained in a total of 19 Kenton County venues (including the nine venues measured pre-ordinance). Venues were visited for an average of 53 minutes (range 46-89 minutes) per venue. On average, 55 people were present per venue. Descriptive statistics for each venue after the implementation of Kenton County's ordinance are shown in Table 2.

Of the 19 venues tested, the average PM_{2.5} in the 11 nonsmoking venues was 13 µg/m,³ as shown in Figure 2. The PM_{2.5} levels in three split shift venues averaged 63 µg/m³ (37 µg/m³ when smoking not allowed and 104 µg/m³ when smoking allowed). The PM_{2.5} in the five smoking venues was 147 µg/m³ which was 4.2 times above the outdoor NAAQS standard. Figure 3 displays air quality measurements for all 19 venues, comparing pre- and post-levels for the nine venues and the levels for those measured during split-shift conditions.

Table 2. Air Quality Data for 19 Venues in Kenton County After Implementation of the Partial Smoke-free Ordinance, May – June 2011

Venue	Date Sampled	Size	Ave. # of People	Average # burning cigs	Smoker density	Average PM _{2.5} level
Venue A	5/23/2011	604	73	0.0	0.00	15
Venue B	5/29/2011	915	21	0.0	0.00	18
Venue B	6/17/2011	915	68	1.0	0.11	74
Venue C	6/2/2011	338	11	0.0	0.00	75
Venue C	6/15/2011	338	8	0.5	0.15	69
Venue D	5/28/2011	325	22	0.0	0.00	18
Venue D	6/4/2011	325	46	2.2	0.66	169
Venue E	6/10/2011	815	23	0.0	0.00	11
Venue F	5/13/2011	811	231	0.0	0.00	34
Venue G	5/13/2011	977	85	0.0	0.00	10
Venue H	5/28/2011	1266	36	0.0	0.00	11
Venue I	5/28/2011	1421	62	5.2	0.36	400
Venue J	5/24/2011	1184	67	0.0	0.00	3
Venue K	5/26/2011	671	102	0.0	0.00	6
Venue L	5/28/2011	1185	129	0.0	0.00	11
Venue M	5/31/2011	488	45	0.0	0.00	14
Venue N	6/1/2011	2213	65	0.0	0.00	4
Venue O	6/4/2011	452	34	0.0	0.00	26
Venue P	6/9/2011	458	24	1.9	0.40	44
Venue Q	6/10/2011	271	17	0.8	0.31	127
Venue R	6/16/2011	916	18	2.0	0.22	96
Venue S	6/19/2011	122	14	1.7	1.36	67

Note. Venues A-I also measured pre-ordinance (see Table 1).

Non-smoking Venues
Split-shift non-smoking periods
Split-shift smoking periods
Smoking Venues

Figure 2. Average Fine Particle Air Pollution in Kenton County Venues, Pre-Ordinance and Nonsmoking, Split-shift Non-smoking, Split-shift Smoking, and Smoking Venues Post-Ordinance, May-June, 2011

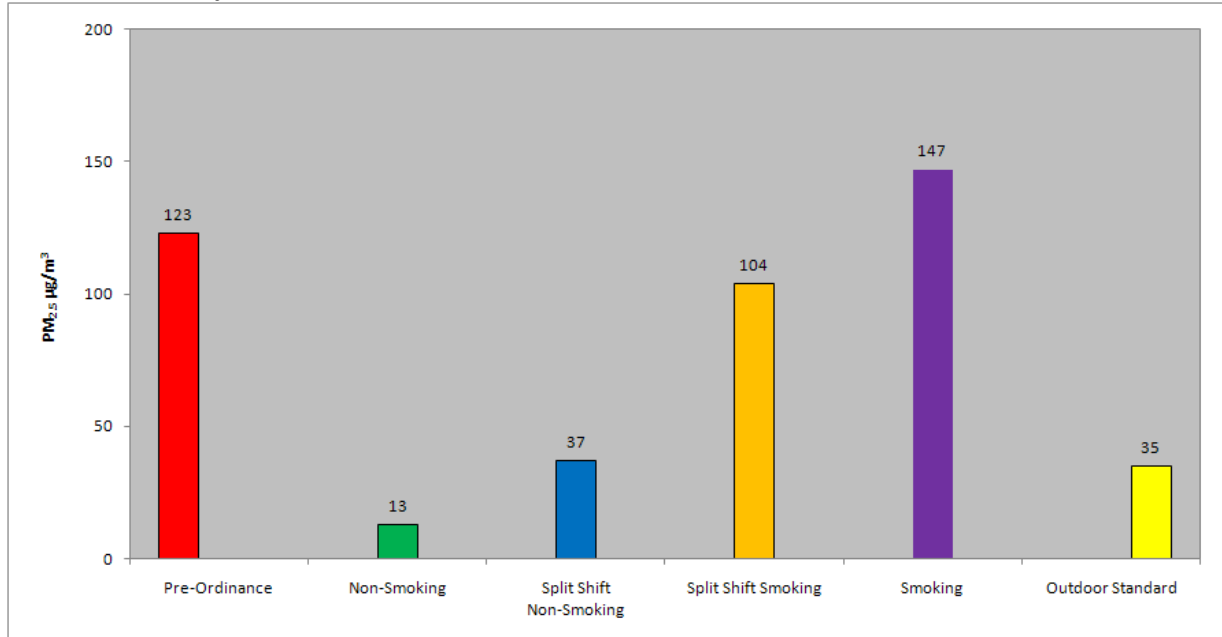
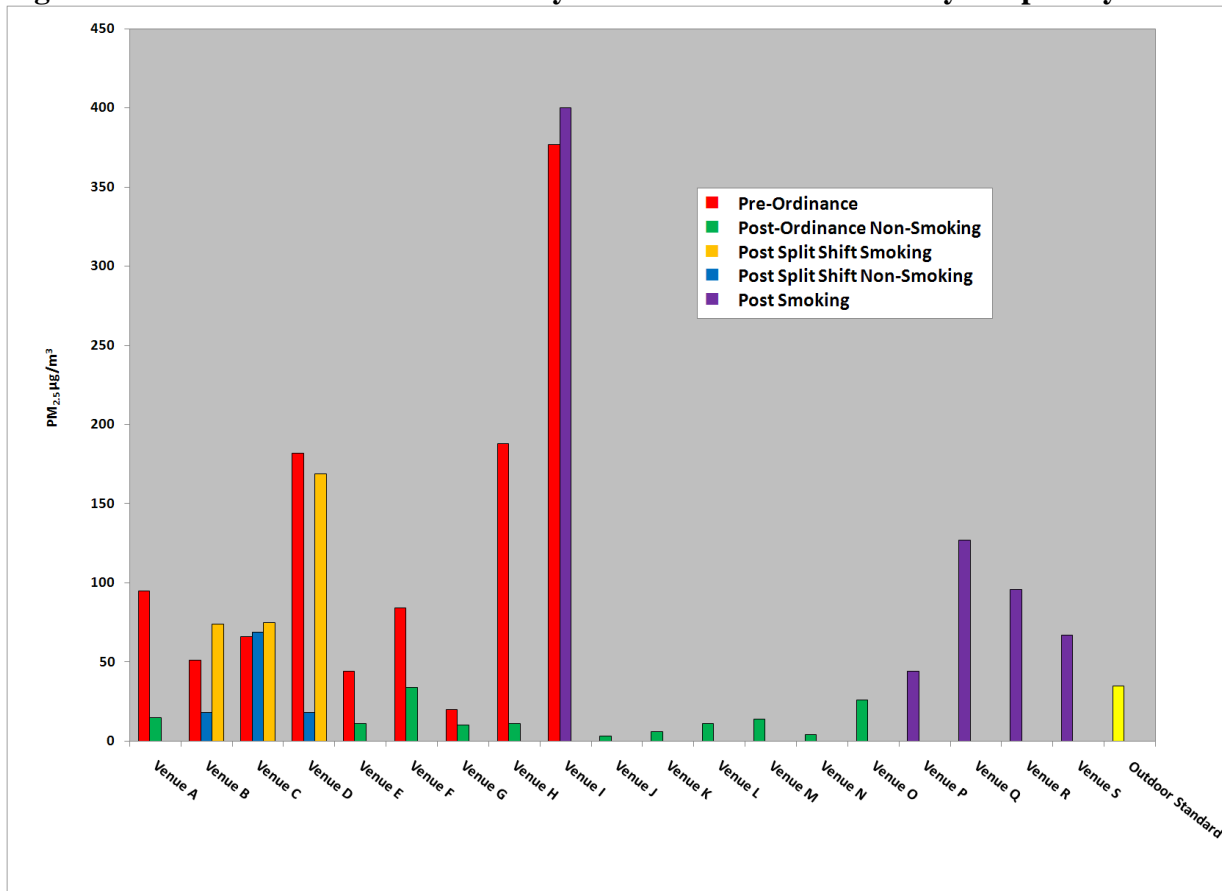


Figure 3. Air Pollution in Kenton County Pre- and Post-Ordinance by Hospitality Venue



Discussion

The average PM_{2.5} in nine Kenton County venues decreased from 123µg/m³ before the smoke-free ordinance to 74µg/m³ after implementation. However, the average PM_{2.5} after the law took effect was 2.1 times higher than the National Ambient Air Quality Standard (35µg/m³) for *outdoor* air set by the EPA. Of the 19 venues tested post-ordinance, the average PM_{2.5} level in 11 nonsmoking venues was 13 µg/m³. The PM_{2.5} levels in three split shift venues averaged 63 µg/m³ (37 µg/m³ during the non-smoking periods and 104 µg/m³ when smoking was allowed), nearly 2 times higher than the NAAQS. The PM_{2.5} level in the five venues that allowed smoking was 147 µg/m³, 4.2 times higher than the NAAQS. There were over 80 EPA cited epidemiologic studies in creating a particulate air pollution standard in 1997.⁶ 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.

At least 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 smoke-free law on April 27, 2004.⁷ The average level of indoor air pollution was 199 µg/m³ pre-law and dropped to 18 µg/m³ post-law. Average levels of indoor air pollution dropped from 86 µg/m³ to 20 µg/m³ after Georgetown, Kentucky implemented a comprehensive smoke-free law on October 1, 2005.⁸ 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.⁹ 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.¹⁰

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.¹¹ 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.¹² 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.¹³

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 In 2010, U.S. Surgeon General Benjamin reported that tobacco smoke causes immediate blood vessel, lung tissue, and DNA damage causing heart disease, lung disease, and cancer.³

Many millions of Americans, both children and adults, are still exposed to secondhand smoke in their homes and workplaces. Approximately 40.1% nonsmokers in the United States have biological evidence of SHS exposure.⁴ 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 Kenton County, Kentucky dropped from 123 $\mu\text{g}/\text{m}^3$ pre-ordinance to 74 $\mu\text{g}/\text{m}^3$ post-ordinance, but air quality remained dangerously high and above the National Ambient Air Quality Standard for *outdoor air*. While the nonsmoking venues fell below the outdoor standard, the split shift and smoking venues exceeded the National Ambient Air Quality Standard (35 $\mu\text{g}/\text{m}^3$) by 1.8 and 4.2 times, respectively. These findings show significant improvement in air quality in the nonsmoking venues but workers in the exempt venues remain exposed to toxic levels of secondhand smoke. Given these findings, the indoor air pollution could improve significantly if Kenton County had a comprehensive smoke-free ordinance.

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