

**Indoor Air Quality in Livingston, Lyon and Trigg Counties, Kentucky
Workplace Venues, 2011-12**

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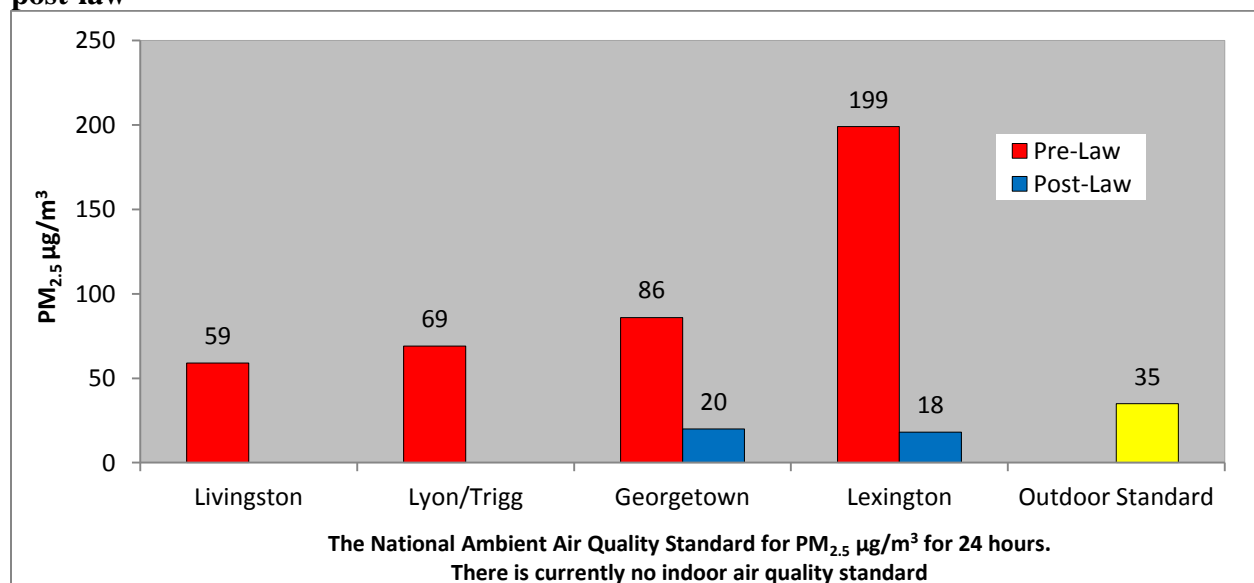
Executive Summary

Indoor air quality was assessed in six workplaces in Livingston County and nine workplace venues in Lyon and Trigg Counties, Kentucky. Fine particulates were measured from September 29, 2011 to January 12, 2012 in Livingston, and July 26 to August 22, 2012, in Lyon and Trigg using the TSI SidePak AM510 Personal Aerosol Monitor. The average PM_{2.5} level from the locations in these three counties was compared to the average PM_{2.5} levels in Georgetown and Lexington, Kentucky before and after implementation of their smoke-free laws, as well as the outdoor National Ambient Air Quality Standard (NAAQS; 35µg/m³) for 24 hours.

Key findings of the study are:

- On average, the level of indoor air pollution in workplace venues measured in Livingston, Lyon, and Trigg Counties (PM_{2.5} = 64 µg/m³) was approximately 3.2 times higher than Georgetown and 3.6 times higher than Lexington after implementation of their smoke-free laws (see Figure 1). Further, the level of indoor air pollution in Livingston, Lyon and Trigg Counties' workplaces was 1.9 times higher than the National Ambient Air Quality Standard for *outdoor* air.
- The six workplaces in Livingston County had average PM_{2.5} levels ranging from 3 to 131µg/m³ (see Figure 2). Air pollution in 3 of the 6 workplaces exceeded the National Ambient Air Quality Standard for *outdoor* air.
- The nine workplace venues in Lyon and Trigg Counties had average PM_{2.5} levels ranging from 10 to 179µg/m³ (see Figure 3). Air pollution in 7 of the 9 venues exceeded the National Ambient Air Quality Standard for *outdoor* air.

Figure 1. Average fine particle air pollution in four Kentucky communities, pre- and post-law



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., 22,465 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 48.9% of the U.S. population is protected by clean indoor air regulations that cover virtually all indoor worksites including bars and restaurants. There are 3,671 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 February 1, 2013, 35 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 21 Kentucky 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), Manchester, Morehead, Prestonsburg, Radcliff, Somerset, and Woodford County (Board of Health regulation). Bullitt County's Board of Health has adopted a comprehensive regulation but it is delayed pending court action (upheld by Kentucky Court of Appeals, 12/7/12). The next most comprehensive ordinances, 100% smoke-free enclosed public place laws, have been implemented in three communities: Frankfort, Letcher County, and Paducah. Eleven communities have enacted partial smoke-free laws, protecting workers and patrons in some public venues: Beattyville, Daviess County, Franklin County, Henderson, Hopkins County, Hopkinsville, Kenton County, Oak Grove, Oldham County, Paintsville, and Pikeville.

The purpose of the study was to (a) assess air quality in Livingston, Lyon, and Trigg Counties, Kentucky workplaces; and (b) compare the results from the three counties to Georgetown and Lexington, Kentucky air quality data before and after their smoke-free laws took effect.

Methods

Between September 29, 2011 and January 12, 2012, indoor air quality was assessed in six indoor workplace venues located in Livingston County. In addition, nine workplace venues were monitored in Lyon and Trigg Counties between July 26 and August 22, 2012. Sites were of various sizes; some sites were individually owned establishments and some were part of local or national chains.

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.

TSI SidePak AM510 Personal Aerosol Monitor



The equipment was set to a one-minute log interval, which averages the previous 60 one-second measurements. 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 Pennyriple District Health Department who did the sampling and sent the data to KCSP for analysis. Sampling was discreet in order not to disturb the occupants' normal behavior.

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 workplaces.

Results

The workplaces in Livingston County were visited Monday through Friday for an average of 52 minutes (range 47-62 minutes). Visits occurred at various times of the day from 11:15 AM to 7:00 PM. The average size of the Livingston County workplace venues was 244 m^3 (range $102\text{-}339\text{ m}^3$) and the average smoker density was $0.34/100\text{ m}^3$. On average, 13 patrons were present per workplace and 0.7 burning cigarettes per workplace were observed. Descriptive statistics for each Livingston County workplace are summarized in Table 1.

The workplaces in Lyon and Trigg Counties were visited Monday through Thursday for an average of 58 minutes (range 51-69 minutes). Visits occurred at various times of the day from 10:00 AM to 3:00 PM. The average size of the Lyon and Trigg County workplace venues was 1065 m^3 (range $135\text{-}5498\text{ m}^3$) and the average smoker density was $0.30/100\text{ m}^3$. On average, 15 patrons were present per workplace and 1.0 burning cigarette per workplace was observed. Descriptive statistics for each venue in Lyon and Trigg Counties are summarized in Table 2.

Table 1. Air Quality Data for Six Workplace Venues in Livingston County Kentucky, September 2011 – January 2012

Venue	Date Sampled	Size (m ³)	Average # people	Average # burning cigs	Smoker density (#bc/100m ³)	Average PM _{2.5} levels (µg/m ³)
Venue A	9/29/2011	230	11	0.2	0.07	20
Venue B	10/1/2011	102	19	0.6	0.59	3
Venue C	10/7/2011	305	14	2.0	0.66	131
Venue D	10/11/2011	216	9	1.0	0.46	102
Venue E	11/21/2011	339	18	0.0	0.00	12
Venue F	1/12/2012	271	8	0.7	0.24	86
Averages		244	13	0.7	0.34	59

Table 2. Air Quality Data for Nine Workplace Venues in Lyon and Trigg Counties Kentucky, July-August, 2012

Venue	Date Sampled	Size (m ³)	Average # people	Average # burning cigs	Smoker density (#bc/100m ³)	Average PM _{2.5} levels (µg/m ³)
Venue A	7/26/2012	447	37	0.0	0.00	50
Venue B	7/26/2012	677	13	0.5	0.07	95
Venue C	8/15/2012	5498	18	0.3	0.01	11
Venue D	8/15/2012	420	7	0.9	0.20	36
Venue E	8/20/2012	847	21	3.0	0.35	106
Venue F	8/20/2012	455	10	2.0	0.44	67
Venue G	8/21/2012	429	12	0.6	0.13	64
Venue H	8/21/2012	135	9	2.0	1.48	179
Venue I	8/22/2012	679	7	0.0	0.00	10
Average		1065	15	1.0	0.30	69

Note. There were no burning cigarettes observed in Venue A, but researchers were seated next to the kitchen.

As depicted in Figure 1, the average level of indoor air pollution in Livingston County ($59\mu\text{g}/\text{m}^3$) was approximately 3 times higher than Georgetown and 3.3 times higher than Lexington after implementing their smoke-free laws. Further, the level of indoor air pollution in Livingston County workplaces was 1.7 times higher than the National Ambient Air Quality Standard ($35\mu\text{g}/\text{m}^3$) for outdoor air for 24 hours. In Lyon and Trigg County workplace venues, fine particulate air pollution ($69\mu\text{g}/\text{m}^3$) was approximately 3.5 times higher than Georgetown and 3.8 times higher than Lexington after implementing their smoke-free laws. Further, the level of indoor air pollution in Lyon and Trigg County workplaces was 2 times higher than the National Ambient Air Quality Standard ($35\mu\text{g}/\text{m}^3$) for *outdoor* air for 24 hours.

Figures 2 and 3 show the average level of indoor air pollution in each of the six tested workplaces in Livingston County and nine tested workplace venues in Lyon and Trigg Counties. In Livingston County, the average $\text{PM}_{2.5}$ levels ranged from 3 to $131\mu\text{g}/\text{m}^3$, and air pollution in three workplaces exceeded the National Ambient Air Quality Standard for *outdoor* air (NAAQS; $35\mu\text{g}/\text{m}^3$). In Lyon and Trigg Counties, the average $\text{PM}_{2.5}$ levels ranged from 10 to $179\mu\text{g}/\text{m}^3$. There were no burning cigarettes observed in Venue A (see Table 2), but researchers were seated next to the kitchen during monitoring. Air pollution in 7 workplaces exceeded the National Ambient Air Quality Standard for *outdoor* air (NAAQS; $35\mu\text{g}/\text{m}^3$) in Lyon and Trigg County.

Figure 2. Average Indoor Fine Particle Concentration in Six Livingston County Workplace Venues, 2011-2012

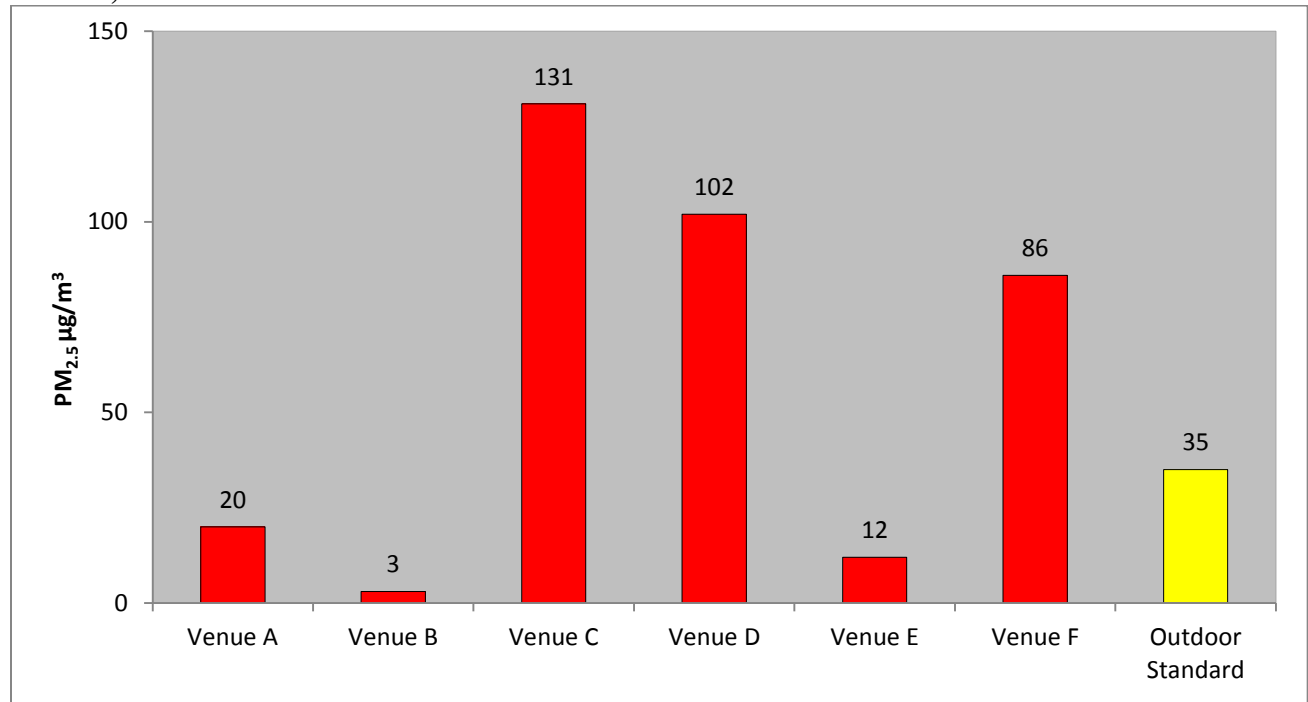
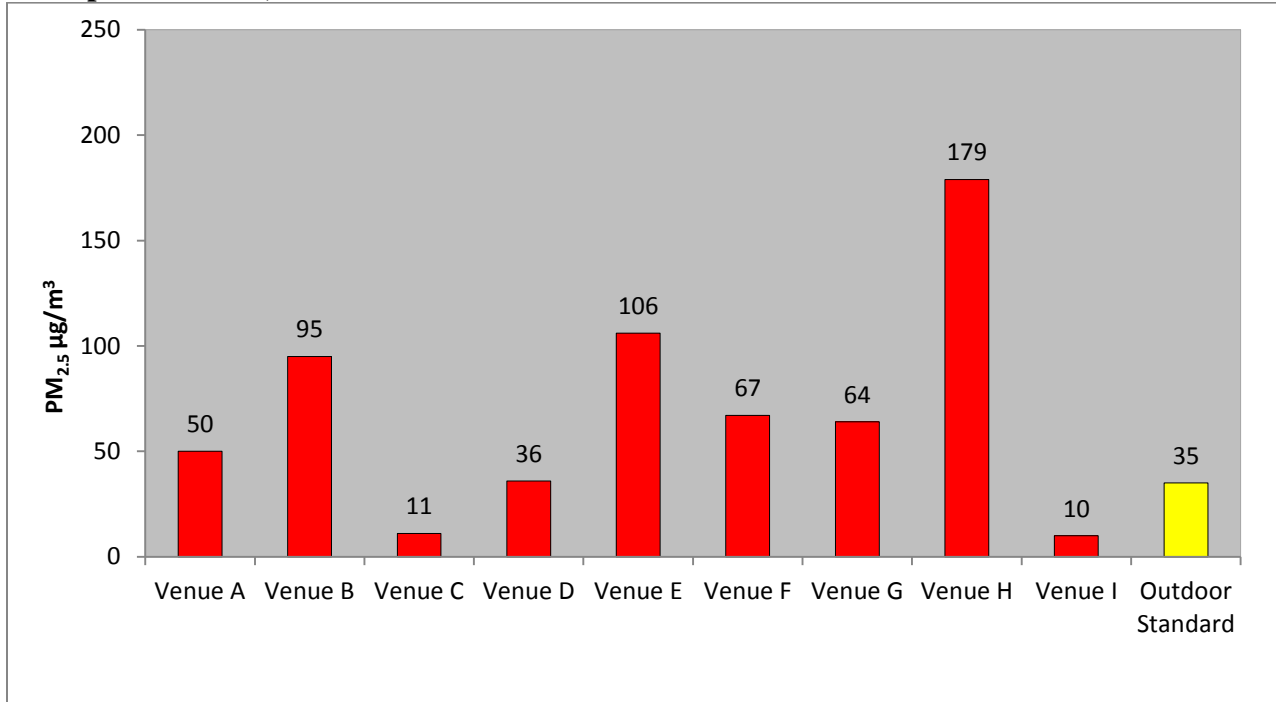


Figure 3. Average Indoor Fine Particle Concentration in Nine Lyon and Trigg County Workplace Venues, 2012



Discussion

On average, the level of indoor air pollution in workplace venues measured in Livingston, Lyon, and Trigg Counties ($PM_{2.5} = 64 \mu\text{g}/\text{m}^3$) was approximately 3.2 times higher than Georgetown and 3.6 times higher than Lexington after implementation of their smoke-free laws. The average $PM_{2.5}$ level was nearly 2 times higher than the National Ambient Air Quality Standard for *outdoor* air set by the EPA. 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 $35 \mu\text{g}/\text{m}^3$ 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 $199 \mu\text{g}/\text{m}^3$ pre-law and dropped to $18 \mu\text{g}/\text{m}^3$ post-law. Average levels of indoor air pollution dropped from $86 \mu\text{g}/\text{m}^3$ to $20 \mu\text{g}/\text{m}^3$ 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

This study demonstrated that workers and patrons in Livingston, Lyon, and Trigg County workplaces are exposed to harmful levels of SHS. On average, workers and patrons in Livingston, Lyon, and Trigg Counties were exposed to indoor air pollution levels approximately 2 times higher than the National Ambient Air Quality Standard. Further, the level of indoor air pollution in these workplaces was 3.2 times higher than Georgetown and 3.6 times higher than Lexington’s average PM_{2.5} levels after implementation of their smoke-free laws. When smoking is completely prohibited, air quality significantly improves.

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