

## **Indoor Air Quality in Knox County, Kentucky Hospitality Venues, 2010**

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

November 9, 2010

Funding for the study was provided by the Knox County Health Department 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.

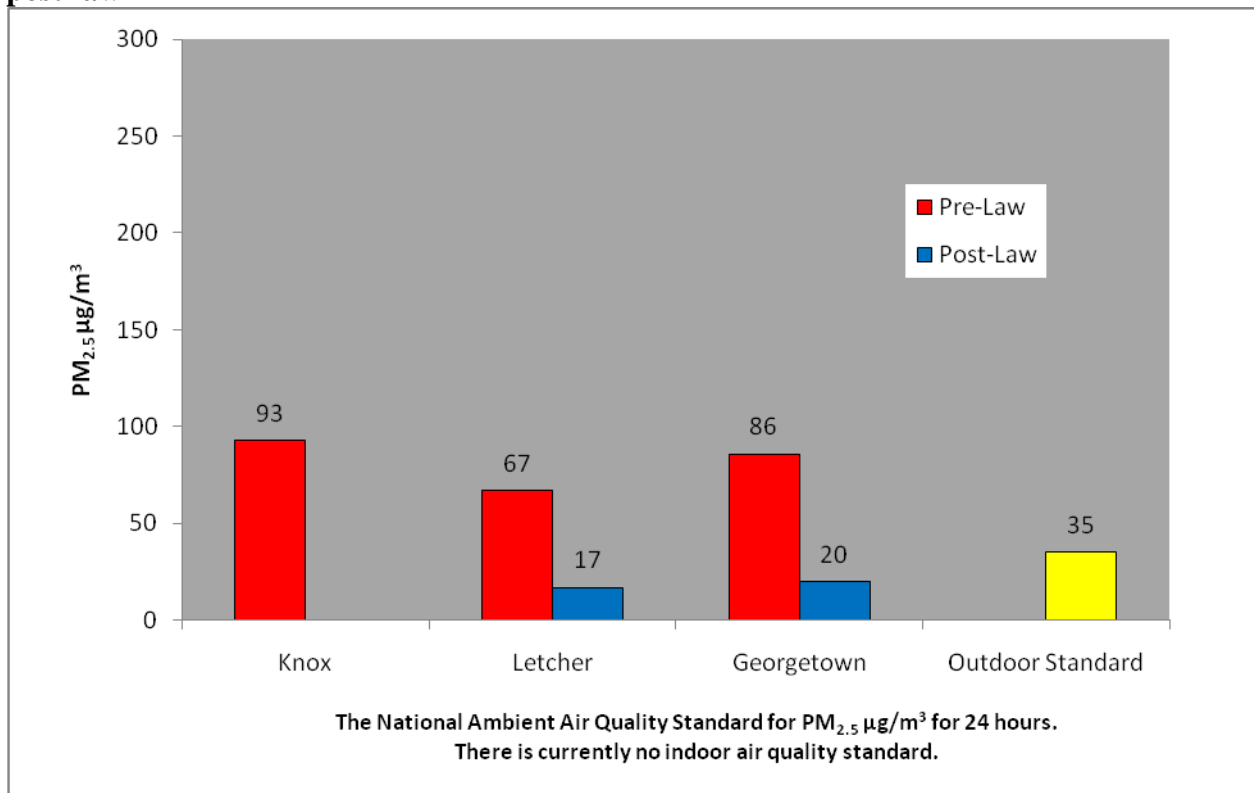
## Executive Summary

Indoor air quality was assessed in nine hospitality venues in Knox County, Kentucky. Fine particulates were measured from August 22 to August 30, 2010, using the TSI SidePak AM510 Personal Aerosol Monitor. The average PM<sub>2.5</sub> level from the nine locations was compared to the average PM<sub>2.5</sub> levels in Georgetown and Letcher County, Kentucky before and after implementation of their smoke-free laws, as well as the outdoor National Ambient Air Quality Standard (NAAQS; 35µg/m<sup>3</sup>) for 24 hours.

Key findings of the study are:

- The level of indoor air pollution in hospitality venues measured in Knox County (average PM<sub>2.5</sub> = 93µg/m<sup>3</sup>) was approximately 4.7 times higher than Georgetown and 5.5 times higher than Letcher County after implementation of their smoke-free laws (see Figure 1). Further, the level of indoor air pollution in Knox County's public venues was 2.7 times higher than the National Ambient Air Quality Standard for *outdoor* air.
- The nine hospitality venues had average PM<sub>2.5</sub> levels ranging from 16 to 242µg/m<sup>3</sup> (see Figure 2). Air pollution in 7 of the 9 venues equaled or exceeded the National Ambient Air Quality Standard for *outdoor* air.

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



## Introduction

Secondhand smoke (SHS) contains at least 250 chemicals that are known to be toxic.<sup>1,2</sup> There is no safe level of exposure to SHS.<sup>2</sup> SHS exposure is the third leading cause of preventable death in the United States.<sup>3</sup> 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.<sup>1,2,3</sup> SHS exposure is a cause of heart disease and lung cancer in nonsmoking adults.<sup>1-4</sup> An estimated 3,000 nonsmokers die from lung cancer<sup>5</sup> annually and over 46,000 nonsmokers die from heart disease<sup>2</sup> every year in the U.S due to secondhand smoke exposure. It is estimated that 46.4% of people in the United States have biological evidence of SHS exposure.<sup>6</sup>

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.<sup>7</sup> 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.<sup>7</sup> The extent of protection provided by these laws varies widely from community to community.

As of October 1, 2010, 27 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 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.

The purpose of this study was to (a) assess air quality in Knox County, Kentucky hospitality venues; and (b) compare the results to Georgetown and Letcher County, Kentucky, air quality data before and after their smoke-free laws took effect.

## Methods

Between August 22, and August 30, 2010, indoor air quality was assessed in nine indoor hospitality venues located in Knox County. Sites were of various sizes; some sites were individually owned establishments and some were part of local or national chain entities.

TSI SidePak AM510 Personal Aerosol Monitor



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 PM<sub>2.5</sub>. 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.

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 PM<sub>2.5</sub> concentration within each venue. The Kentucky Center for Smoke-free Policy (KCSP) staff trained researchers from the Knox County 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<sup>3</sup>) were reported for each venue and averaged for all venues.

## **Results**

The hospitality venues were visited Sunday through Sunday for an average of 51 minutes (range 46-58 minutes). Visits occurred at various times of the day from 8:00 AM to 9:15 PM. The average size of the Knox County venues was 904 m<sup>3</sup> (range 265-2152 m<sup>3</sup>) and the average smoker density was 0.06/100 m<sup>3</sup>. On average, 23 patrons were present per venue and .4 burning cigarettes per venue were observed. Descriptive statistics for each venue are summarized in the Table.

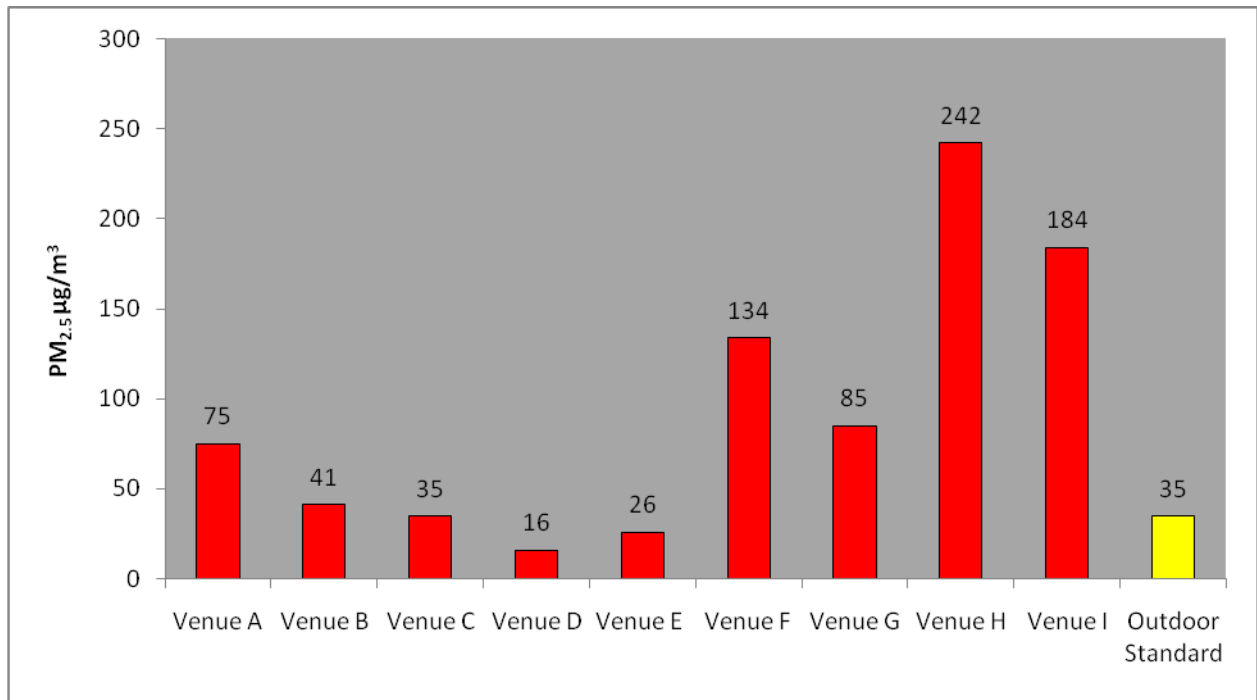
As depicted in Figure 1, the average level of indoor air pollution in the Knox County venues (93 $\mu\text{g}/\text{m}^3$ ) was approximately 4.7 times higher Georgetown and 5.5 times higher than Letcher County after implementing their smoke-free laws. Further, the level of indoor air pollution in Knox County public venues was 2.7 times higher than the National *outdoor* Ambient Air Quality Standard (35 $\mu\text{g}/\text{m}^3$ ) for 24 hours.

Figure 2 shows the average level of indoor air pollution in each of the nine tested venues in Knox County. The average PM<sub>2.5</sub> levels ranged from 16 $\mu\text{g}/\text{m}^3$  to 242 $\mu\text{g}/\text{m}^3$ . Air pollution in seven venues equaled or exceeded the National Ambient Air Quality Standard for *outdoor* air (NAAQS; 35 $\mu\text{g}/\text{m}^3$ ). Although no burning cigarettes were observed in Venue F, the smell of smoke was observed.

**Table. Air Quality Data for Nine Venues in Knox County, Kentucky, August 2010**

Venue	Date Sampled	Size (m <sup>3</sup> )	Average # people	Average # burning cigs	Smoker density (#bc/100m <sup>3</sup> )	Average PM <sub>2.5</sub> levels (µg/m <sup>3</sup> )
Venue A	8/22/2010	476	37	0.7	0.14	75
Venue B	8/24/2010	442	7	0.8	0.19	41
Venue C	8/24/2010	2152	15	0	0	35
Venue D	8/25/2010	272	15	0	0	16
Venue E	8/26/2010	412	26	0	0	26
Venue F	8/28/2010	805	20	0	0	134
Venue G	8/29/2010	1911	53	0.6	0.03	85
Venue H	8/30/2010	265	15	0.4	0.16	242
Venue I	8/30/2010	1404	21	0.7	0.05	184
<b>Averages</b>		<b>904</b>	<b>23</b>	<b>0.4</b>	<b>0.06</b>	<b>93</b>

**Figure2. Average Indoor Fine Particle Concentration in nine Knox County Venues, August 2010**



## Discussion

The average PM<sub>2.5</sub> level in nine Knox County, Kentucky venues was 93µg/m<sup>3</sup>, which is 2.7 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.<sup>8</sup> To protect the public's health, the EPA set a new limit of 35 µg/m<sup>3</sup> 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.<sup>9</sup> The average level of indoor air pollution was 199 µg/m<sup>3</sup> pre-law and dropped to 18 µg/m<sup>3</sup> post-law. Average levels of indoor air pollution dropped from 86 µg/m<sup>3</sup> to 20 µg/m<sup>3</sup> after Georgetown, Kentucky implemented a comprehensive smoke-free law on October 1, 2005.<sup>10</sup> 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.<sup>11</sup> 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.<sup>12</sup>

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.<sup>13</sup> 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.<sup>14</sup> 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.<sup>15</sup>

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."<sup>2</sup> 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.<sup>6</sup> 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."<sup>3</sup>

## Conclusions

This study demonstrated that workers and patrons in Knox County hospitality venues are exposed to harmful levels of SHS. On average, workers and patrons in Knox County were exposed to indoor air pollution levels approximately 2.7 times the National Ambient Air Quality Standard, and the level of indoor air pollution in these venues was 4.7 times higher than Georgetown and 5.5 times higher than Letcher County's average PM<sub>2.5</sub> levels after implementation of their smoke-free laws. When smoking is completely prohibited, air quality significantly improves.

## References

1. National Toxicology Program. *10<sup>th</sup> Report on Carcinogens*. Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, December 2002.
2. Centers for Disease Control and Prevention. "Vital signs: Nonsmokers' exposure to secondhand smoke---United States, 1999-2008." *MMWR*, 2010;59(35): 1141-1146.
3. National Cancer Institute. *Health Effects of Exposure to Environment Tobacco Smoke*. Smoking and Tobacco Control Monograph No. 10 (PDF – 71k). Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute; 1999. NIH Pub. No. 99-4645.
4. U.S. Environmental Protection Agency. *Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders*. Washington, DC: U.S. Environmental Protection Agency; 1992. Pub. No. EPA/600/6-90/006F.
5. Centers for Disease Control and Prevention. Annual smoking-attributable mortality, years of potential life lost, and economic costs—United States, 1995-1999, *MMWR*, 2002;51(14):300-320.
6. Centers for Disease Control and Prevention. Disparities in Secondhand Smoke Exposure -- United States, 1988-1994 and 1999-2004, *MMWR*, 2008; 57(27): 744-747.
7. Americans for Nonsmokers' Rights. *Overview list: How many smoke-free laws*. October 1, 2010. Retrieved October 5, 2010 from <http://no-smoke.org/pdf/mediaordlist.pdf>.
8. U.S. Environmental Protection Agency. National Ambient Air Quality Standards for Particulate Matter; Final Rule. *Federal Register* 1997; 62(138): 38651-38701.
9. Hahn, E, Lee, K, Okoli, Z, Troutman, A, Knox, R. Smoke-free Laws and Indoor Air Pollution in Lexington and Louisville. *Louisville Medicine*, 2005; 52(10): 391-392.

10. Lee, K., Hahn, E.J., Riker, C., Head, S. Seithers, P. Immediate impact of smoke-free laws on indoor air quality. *Southern Medical Journal*, 2007; 100(9): 885-889.
11. Ott, W, Switzer, P, Robinson, J. Particle concentrations inside a tavern before and after prohibition of smoking: Evaluating the performance of an indoor air quality model. *Journal of the Air Waste Management Association*, 1996; 46:1120-1134.
12. Centers for Disease Control and Prevention. Indoor air quality in hospitality venues before and after implementation of a clean indoor air law—Western New York, *MMWR*, 2003, November 12, 2004, 53(44); 1038-1041.
13. Hahn, E.J., Rayens, M.K., York, N., Okoli, C.T.C., Zhang, M., Dignan, M., Al-Delaimy, W.K. Effects of a smoke-free law on hair nicotine and respiratory symptoms of restaurant and bar workers. *Journal of Occupational and Environmental Medicine*, 2006; 48(9): 906-913
14. Farrelly, M, Nonnemaker, J, Chou, R, Hyland, A, Peterson, K, Bauer, U. Change in hospitality workers' exposure to secondhand smoke following the implementation of New York's smoke-free law. *Tobacco Control*, 2005; 14: 236-241.
15. Menzies, D, Nair, A, Williamson, P, Schembri, S, Al-Khairalla, M, Barnes, M, Fardon, T, McFarlane, L, Magee, G, Lipworth, B. Respiratory symptoms, pulmonary function, and markers of inflammation among bar workers before and after a legislative ban on smoking in public places. *JAMA*, 2006; 296: 1742-1748.