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

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Executive Summary

Indoor air quality was assessed in 13 hospitality venues in Danville, Kentucky before and after Danville's smoke-free ordinance was implemented on August 8, 2008. Locations were sampled from August 25 to August 27, 2005 for pre-law air quality measurements and from October 9 to October18, 2008 for post-law measurements, using the TSI SidePak AM510 Personal Aerosol Monitor. The average $PM_{2.5}$ levels in Danville establishments are compared to the average $PM_{2.5}$ levels in Lexington and Louisville pre- and post-law, as well as the National Ambient Air Quality Standard (NAAQS) for 24 hours. Key findings of the study are:

- There were no burning cigarettes observed in any of the 13 hospitality venues at the post-law period. The average $PM_{2.5}$ in the 13 venues decreased from 126 $\mu g/m^3$ before the law to 21 $\mu g/m^3$ after implementation of the law. There was an 84% decline in indoor air pollution as a result of compliance with the smoke-free law.

- After the law took effect, average $PM_{2.5}$ levels in the 13 hospitality venues ranged from 3 $\mu g/m^3$ to 94 $\mu g/m.^3$ The average $PM_{2.5}$ in the 13 venues post-law (21 $\mu g/m^3$) was lower than the National Ambient Air Quality Standard (35 $\mu g/m^3$), similar to Lexington (18 $\mu g/m^3$) and Louisville (9 $\mu g/m^3$) post-law.

- Post-law, three hospitality venues in Danville had $PM_{2.5}$ levels higher than the National Ambient Air Quality Standard of 35 $\mu g/m^3$. Enforcement of smoke-free laws is essential to promoting public health for workers and patrons.

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 cancer[5] annually and over 46,000 nonsmokers die from heart disease[2] 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., 17,059 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 40.3% of the U.S. population is protected by clean indoor air regulations that cover virtually all indoor worksites including bars and restaurants. There are 3,091 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 August 10, 2009, 24 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 14 communities: Georgetown, Morehead, Ashland, Elizabethtown, Hardin County (unincorporated areas), Madison County (Board of Health regulation), Louisville, Danville, Woodford County (Board of Health regulation), Lexington-Fayette County, Clark County (Board of Health regulation), Campbellsville, London, and Prestonsburg, Kentucky. The next most comprehensive ordinances, 100% smoke-free enclosed public place laws, have been implemented in three communities: Letcher County, Frankfort and Paducah. Seven communities have enacted partial smoke-free laws/regulations, protecting workers and patrons in some public venues: Daviess County, Henderson, Oldham County, Paintsville, Pikeville, Beattyville, and Hopkins County.

The purpose of this study was to (a) assess air quality in 13 Danville, Kentucky hospitality venues before and after implementation of Danville's smoke-free ordinance on **August 8, 2008**; 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-law in Danville venues would be significantly lower than pre-law levels and lower than the National Ambient Air Quality Standard (NAAQS).

Methods

Between August 25 and August 27, 2005, before the smoke-free law took effect, indoor air quality was assessed in 13 hospitality venues in Danville. Sites were of various sizes; some sites were individually owned establishments and some were part of local or national chain entities. All venues except one allowed smoking before the law went into effect. Between October 9 and October 18, 2008, two months after Danville's law took effect indoor air quality was assessed again in the same 13 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 2.5µm in micrograms per cubic meter, or $PM_{2.5}$. 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. 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 $PM_{2.5}$ concentration within each venue. The Kentucky Center for Smoke-free Policy (KCSP) staff trained researchers from *Smoke-free Danville, Boyle County,* who did the sampling and sent the data to KCSP for analysis.

Statistical Analyses

Descriptive statistics including the venue size (i.e., 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

For the first phase (before the smoke-free law), 13 hospitality venues were visited from August 25 to 27, 2005 (Thursday through Saturday) for an average of 41 minutes (range 27-50 minutes) per venue. Visits occurred at various times of the day from 8:12 AM to 8:40 PM. The average size of the Danville venues was 429 m^3 (range 152-1,864 m^3). On average, 26 patrons were present per venue and 1.3 burning cigarettes per venue were observed. The smoker density was 0.47 #bc/100 m^3. Descriptive statistics for each venue are shown in Table 1.

The second phase, conducted two months after Danville's smoke-free law took effect, assessed the same 13 venues. Venues were visited October 9 to 18, 2008 (Thursday through Saturday) for an average of 61 minutes (range 48-73 minutes) per venue. Visits occurred at various times of the day from 7:41 AM to 8:39 PM. On average, 54 people were present per venue. No burning cigarettes were observed in any of the 13 hospitality venues post-law as shown Table 2.

Table 1. Air Quality Data for 13 Venues in Danville, Kentucky, Pre-Law 2005

Venue	Date sampled	Size (m^3)	Average # people	Average # burning cigs	Smoker density (#bc/100m^3)	Average $PM_{2.5}$ level ($\mu g/m^3$)
Hospitality Venue A*	8/25/05	180	9	0	0	20
Hospitality Venue B	8/25/05	165	13	1.3	0.79	136
Hospitality Venue C	8/25/05	152	17	0.7	0.46	72
Hospitality Venue D	8/25/05	238	14	3.7	1.55	312
Hospitality Venue E	8/25/05	252	21	1.0	0.40	101
Hospitality Venue F	8/25/05	867	100	0	0	60
Hospitality Venue G	8/26/05	230	25	0.3	0.13	65
Hospitality Venue H	8/26/05	326	29	5.0	1.53	320
Hospitality Venue I	8/26/05	1864	61	1.7	0.09	78
Hospitality Venue J	8/26/05	726	18	0.3	0.04	115
Hospitality Venue K	8/27/05	179	6	0	0	135
Hospitality Venue L	8/27/05	295	17	0.7	0.24	72
Hospitality Venue M	8/27/05	258	18	3.3	1.28	156
Averages			26	1.3	0.50	126

^*Note:* One of the original 14 venues tested pre-law closed during the three year interval between testing dates. Only the 13 venues currently in operation are considered in this analysis.
**Note*: Venue was voluntarily smoke-free pre-law.

Table 2. Air Quality Data for 13 Venues in Danville, Kentucky, Post-Law 2008

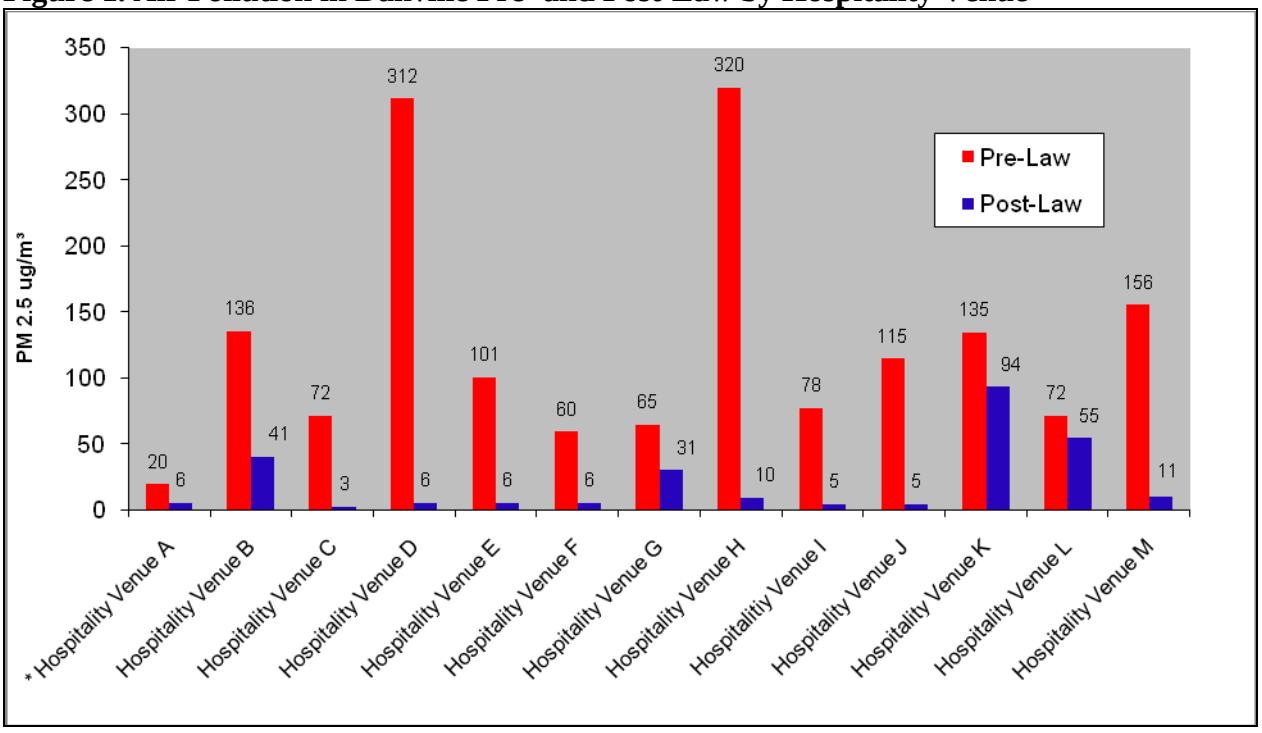
Venue	Date sampled	Size (m^3)	Average # people	Average # burning cigs	Smoker density (#bc/100m^3)	Average $PM_{2.5}$ level ($\mu g/m^3$)
Hospitality Venue A*	10/9/08	180	21	0	0	6
Hospitality Venue B	10/9/08	165	17	0	0	41
Hospitality Venue C	10/9/08	152	15	0	0	3
Hospitality Venue D	10/10/08	238	14	0	0	6
Hospitality Venue E	10/10/08	252	114	0	0	6
Hospitality Venue F	10/17/08	867	160	0	0	6
Hospitality Venue G	10/17/08	230	50	0	0	31
Hospitality Venue H	10/11/08	326	25	0	0	10
Hospitality Venue I	10/11/08	1864	52	0	0	5
Hospitality Venue J	10/18/08	726	11	0	0	5
Hospitality Venue K	10/18/08	179	15	0	0	94
Hospitality Venue L	10/10/08	295	24	0	0	55
Hospitality Venue M	10/11/08	258	122	0	0	11
Averages			54	0	0	21

**Note*: Venue was voluntarily smoke-free pre-law

Figure 1 shows the average level of indoor air pollution in each of the 13 sampled venues from pre- to post-law. After the law took effect, three of the venues still exceeded the NAAQS for 24 hours (35 µg/m^3) with air quality values of 41 µg/m^3, 55 µg/m^3, and 94 µg/m^3 respectively. The average $PM_{2.5}$ levels ranged from 20 µg/m^3 to 320 µg/m^3 pre-law and from 3 to 94 µg/m^3 post-law.

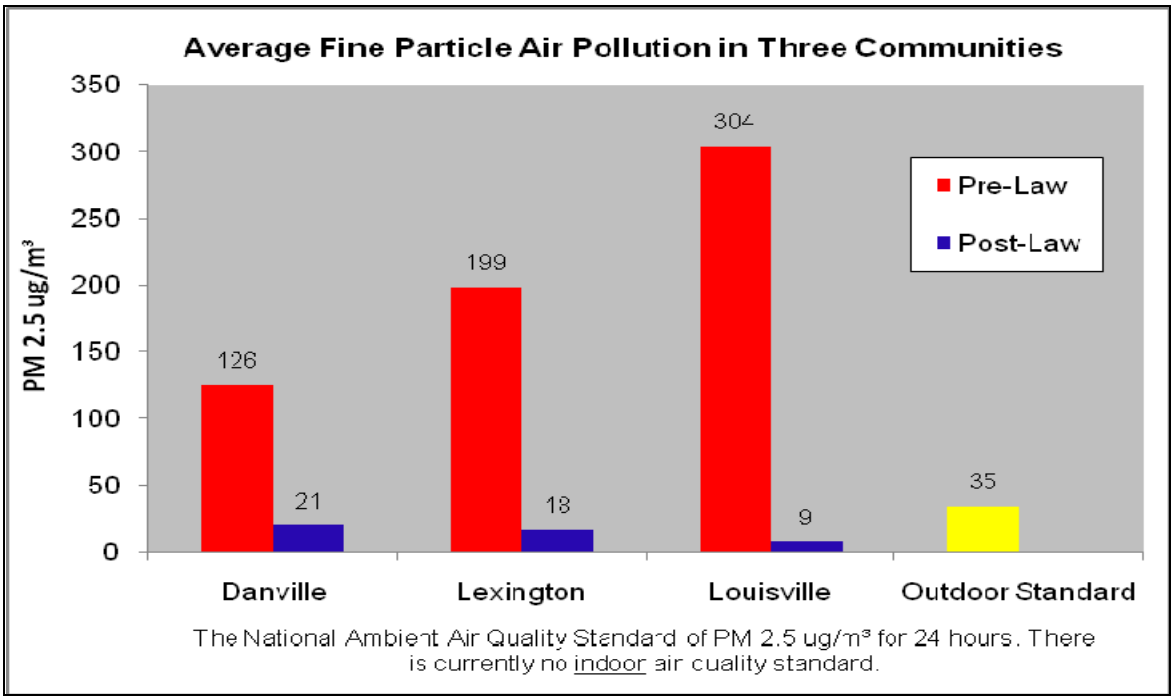
Figure 2 shows that there was an 84% decline in fine particle air pollution from pre-law (126 µg/m^3) to post-law (21 µg/m^3) in the 13 Danville venues. Before the law took effect in Danville, the average level of indoor air pollution in the venues was approximately 4 times higher than the NAAQS. After their smoke-free laws took effect, the indoor air pollution in Danville was lower than the NAAQS, similar to Lexington and Louisville after their comprehensive laws took effect.

Figure 1. Air Pollution in Danville Pre- and Post-Law by Hospitality Venue



**Note*: Venue was voluntarily smoke-free pre-law.

Figure 2. Average Fine Particle Air Pollution in Three Communities Before and After the Smoke-free Laws



Discussion

The average $PM_{2.5}$ in the 13 hospitality venues in Danville, Kentucky decreased from 126 µg/m^3 before Danville's smoke-free law to 21 µg/m^3 after implementation of the law. There was an 84% drop in indoor air pollution as a result of compliance with the 100% smoke-free public places law. The average $PM_{2.5}$ level (21 µg/m^3) was lower than the NAAQS (35 µg/m^3). There were over 80 EPA cited epidemiologic studies in creating a particulate air pollution standard in 1997.[9] To protect the public's health, the EPA set a new limit of 35 µg/m^3 for $PM_{2.5}$ 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.[10] The average level of indoor air pollution was 199 µg/m^3 pre-law and dropped to 18 µg/m^3 post-law. Average levels of indoor air pollution dropped from 86 µg/m^3 to 20 µg/m^3 after Georgetown, Kentucky implemented a comprehensive smoke-free law on October 1, 2005. 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 been conducted to assess 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." 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."

Conclusions

The average level of indoor air pollution in Danville, Kentucky was 126 $\mu g/m^3$ pre-law and dropped to 21 $\mu g/m^3$ post-law, indicating an 84% reduction in indoor air pollution. The level of indoor air pollution in Danville hospitality venues post-law was similar to Lexington's and Louisville's post-law average $PM_{2.5}$ levels. This finding showed significant improvements in air quality after implementing a smoke-free law in Danville. However, three venues still showed higher levels of indoor air pollution than the NAAQS. Enforcement of smoke-free laws is essential to promoting public health for workers and patrons.

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