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

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Executive Summary

Indoor air quality was assessed in nine locations in McCracken County, Kentucky before and after Paducah's smoke-free ordinance was implemented on April 1, 2007. One of the locations was outside the city limits and not covered by the smoke-free ordinance. Locations were sampled using the TSI SidePak AM510 Personal Aerosol Monitor from August 25, 2005 to August 27, 2005 for pre-law air quality measurements. Post-law measurements were obtained over a two-year period from October 2007 to January 2009. The average $PM_{2.5}$ levels in Paducah 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 24 hours.

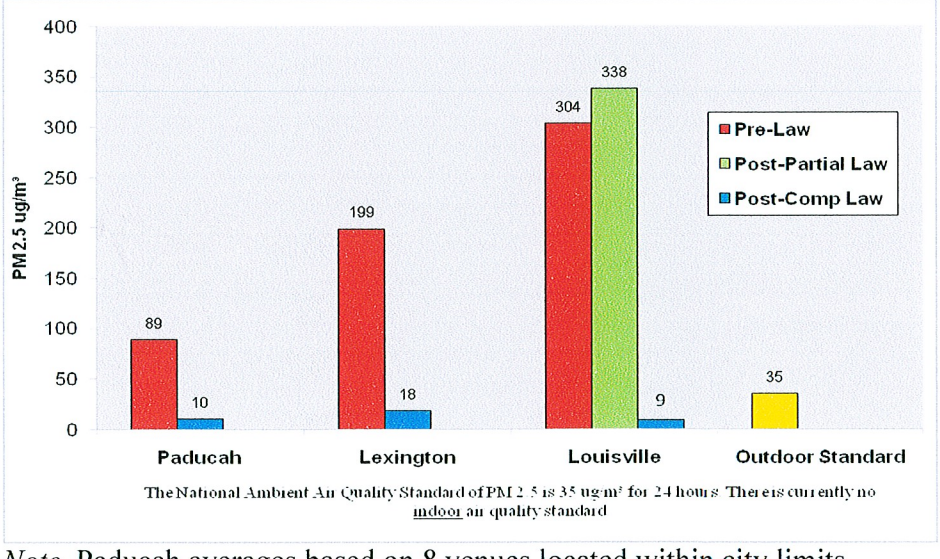
Key findings of the study are:

- The average $PM_{2.5}$ in the eight venues located in Paducah decreased from 89 $\mu g/m^3$ before the law to 10 $\mu g/m^3$ following implementation. There was an 89% decline in indoor air pollution as a result of compliance with Paducah's smoke-free law.

- After the law took effect, average $PM_{2.5}$ levels in the eight hospitality venues ranged from 3 $\mu g/m^3$ to 23 $\mu g/m.^3$ The average $PM_{2.5}$ in the eight venues post-law (10 $\mu g/m^3$) 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.

- Air quality in the one venue located outside the Paducah city limits and not covered by the smoke-free law was dangerously high; nearly 15 times higher than in Paducah post-law.

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



Note. Paducah averages based on 8 venues located within city limits

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., 17,068 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 41.2% of the U.S. population is protected by clean indoor air regulations that cover virtually all indoor worksites including bars and restaurants. There are 3,052 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 October 1, 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, protecting workers and patrons in some public venues: Daviess County, Henderson, Oldham County, Paintsville, Pikeville, Beattyville, and Hopkins County.

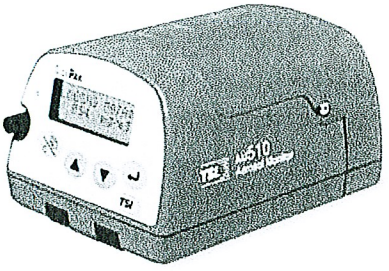
In Louisville, Kentucky, two different types of smoke-free laws have been enacted and implemented since 2005. In November 2005, a smoke-free law covering most buildings open to the public, but with significant exemptions was implemented in Louisville Metro. In July 2007, Louisville Metro strengthened their ordinance to cover all workplaces and all buildings open to the public.

The purpose of this study was to (a) assess air quality in nine McCracken County, Kentucky hospitality venues before and after implementation of Paducah's smoke-free ordinance on April 1, 2007; 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 Paducah venues would be significantly lower than pre-law levels and lower than the National Ambient Air Quality Standard (NAAQS).

Methods

Between August 25, 2005 and August 27, 2005, before the smoke-free law took effect, indoor air quality was assessed in eleven hospitality venues in McCracken 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



All venues tested pre-law, except one, allowed smoking before the law went into effect. Two of the original 11 venues tested pre-law closed during the three year interval between pre- and post-law testing dates. Only the nine venues currently in operation were considered in this analysis. Between October 6, 2007 and January 24, 2009, after Paducah's law took effect, indoor air quality was assessed again in the nine McCracken County venues that were in operation both pre- and post-law. To evaluate the effect of Paducah's law, we compare data pre- and post-law from eight of the nine venues (one venue is located outside the city limits and not covered by the smoke-free law).

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.

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 the Clean Air McCracken County Coalition who conducted the sampling and sent the data to KCSP for analysis.

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 law, McCracken County hospitality venues were visited from August 25 to 27, 2005 (Thursday through Saturday). The average size of the eight venues located within the

city limits was 3301 m^3 (range 41-18,689 m^3). On average, 101 patrons were present per venue and 15 burning cigarettes per venue were observed. The smoker density was 0.58 #bc/100 m^3. One venue was voluntarily smoke-free at that time and indoor $PM_{2.5}$ in the venue was 3 $\mu g/m^3$. The average $PM_{2.5}$ level for the eight venues located in the city limits was 89 $\mu g/m^3$, 2.5 times higher than NAAQS. Descriptive statistics for all nine venues are shown in Table 1.

Table 1. Air Quality Data for Nine Venues in McCracken County, Kentucky, 2005 (before Paducah's smoke-free law)

Venue	Date Sampled	Size (m^3)	Average # people	Average # burning cigs	Smoker density (#bc/100m^3)	Average $PM_{2.5}$ level ($\mu g/m^3$)
Restaurant A*	8/25/2005	2141	26	3.3	0.2	84
Restaurant B	8/25/2005	1055	25	6	0.6	112
Restaurant C	8/26/2005	911	31	7.3	0.8	152
Restaurant D	8/26/2005	1414	176	10	0.7	28
Restaurant E	8/27/2005	2294	80	11.3	0.5	53
Restaurant F	8/27/2005	1957	131	14.7	0.8	124
Restaurant G^	8/27/2005	283	13	0	0	3
Other Enter.	8/26/2005	18689	350	70	0.4	157
Other Enter.	8/25/2005	41	5	0.3	0.8	82
Averages		3301	101	15	.58	89

*Venue outside Paducah city limits
^Venue voluntarily smoke-free pre-law
Note: The averages reflect only the eight venues located inside Paducah city limits.

Post-law measurements were obtained from October 6, 2007 to January 24, 2009, in nine of the same McCracken County venues after Paducah's smoke-free law took effect. Only the eight venues located within the city limits were compared pre- and post-law. Venues were visited Tuesday through Saturday for an average of 57 minutes (range 31-77 minutes) per venue. Visits occurred at various times of the day from 8:05 AM to 9:16 PM. On average, 90 people were present per venue. The average $PM_{2.5}$ level post-law was 10 $\mu g/m^3$. Smoking was observed in the one venue that was located outside the city limits and not covered by Paducah's smoke-free ordinance; $PM_{2.5}$ in the venue was 147 $\mu g/m^3$. The average $PM_{2.5}$ level in the eight smoke-free Paducah venues was 10 $\mu g/m^3$. Descriptive statistics for each venue after the implementation of Paducah's law are shown in Table 2.

Table 2. Air Quality Data for Nine Venues in McCracken County, Kentucky (after Paducah's smoke-free law)

Venue	Date Sampled	Size (m3)	Average # people	Average # burning cigs	Smoker density (#bc/100m3)	Average PM2.5 level
Restaurant A*	10/6/2007	2141	73	23	1.1	147
Restaurant B	10/082007	1055	49	0	0	11
Restaurant C	1/24/2009	911	56	0	0	4
Restaurant D	11/23/2008	1414	121	0	0	13
Restaurant E	1/25/2009	2294	264	0	0	6
Restaurant F	11/25/2008	1957	66	0	0	23
Restaurant G^	10/5/2007	283	19	0	0	3
Other Ent. A	10/6/2007	41	26	0	0	11
Other Ent. B	1/2/2009	18689	115	0	0	9
Averages		3301	90	0	0	10

*Venue outside city limits

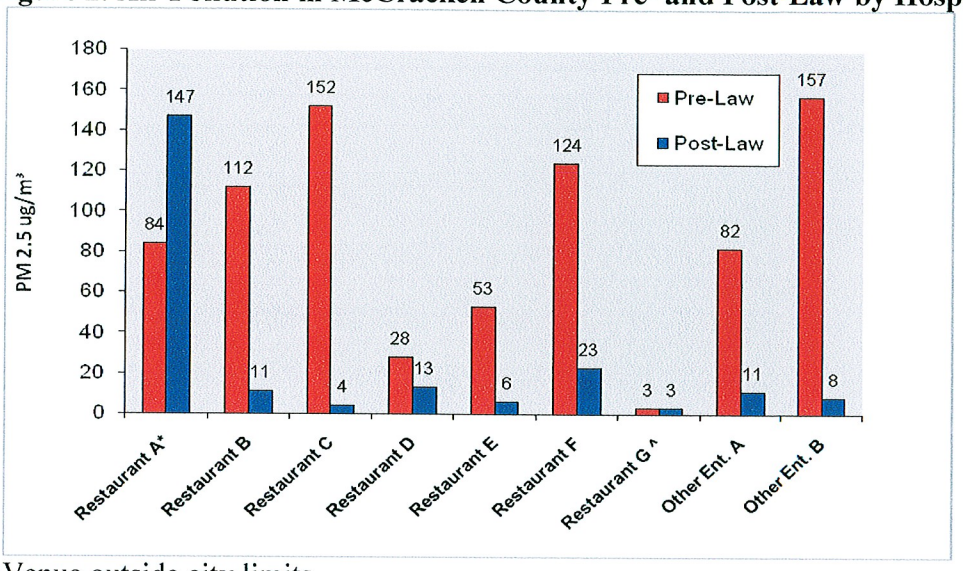
^Venue voluntarily smoke-free pre-law

Note: The averages only reflect the eight venues located inside Paducah city limits.

Figure 1 shows an 89% decline in fine particle air pollution from pre-law (89 $\mu g/m^3$) to post-law (10 $\mu g/m^3$) in the eight Paducah venues. Before the law took effect in Paducah, the average level of indoor air pollution in the venues was approximately 2.5 times higher than the NAAQS. After the smoke-free law took effect, the indoor air pollution in Paducah was lower than the NAAQS, similar to Lexington and Louisville after their comprehensive laws took effect.

Figure 2 shows the average level of indoor air pollution in all nine venues from pre- to post-law. The average $PM_{2.5}$ levels in the eight Paducah venues ranged from 3 $\mu g/m^3$ to 157 $\mu g/m^3$ pre-law and from 3 to 23 $\mu g/m^3$ post-law. After the law took effect, one of the venues, located outside the city limits, had a $PM_{2.5}$ of 147 $\mu g/m^3$, exceeding the NAAQS for 24 hours (35 $\mu g/m^3$).

Figure 2. Air Pollution in McCracken County Pre- and Post-Law by Hospitality Venue



*Venue outside city limits
^Venue voluntarily smoke-free pre-law

Discussion

The average PM2.5 in the eight venues in Paducah, Kentucky decreased from 89 μg/m3 before the smoke-free law to 10 μg/m3 after implementation of the law. There was an 89% drop in indoor air pollution as a result of compliance with the smoke-free public places law in Paducah. The average PM2.5 level (10 $\mu g/m^3$) was lower than the National Ambient Air Quality Standard (35 ug/m3) for *outdoor* air set by the EPA. A previously published study of Paducah's indoor public spaces reported data from 11 venues pre-law[8]. 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 $\mu g/m^3$ 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.

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 $\mu g/m^3$ pre-law and dropped to 18 $\mu g/m^3$ post-law. Average levels of indoor air pollution dropped from 86 $\mu g/m^3$ to 20 $\mu g/m^3$ after Georgetown, Kentucky implemented a comprehensive smoke-free law on October 1, 2005.[11] 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.[12] 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.[13]

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.[14] 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.[15] 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.[16]

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. 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."[2]

Conclusions

The average level of indoor air pollution in Paducah, Kentucky dropped from 89 $\mu g/m^3$ pre-law to 10 $\mu g/m^3$ post-law, indicating an 89% reduction in indoor air pollution. The level of indoor air pollution in Paducah hospitality venues post-law was similar to Lexington's and Louisville's post-law average $PM_{2.5}$ levels. These findings show significant improvement in air quality after implementing a smoke-free law in Paducah. Air quality in the one venue located outside the Paducah city limits and not covered by the smoke-free law was dangerously high; nearly 15 times higher than in Paducah post-law. Extending Paducah's law to all McCracken County would improve air quality in all county venues.

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