

Indoor Air Quality in Bracken County, Kentucky Workplaces, 2018

Ellen J. Hahn, PhD, RN, FAAN
Kiyoun Lee, ScD, CIH
Amanda Bucher, BA

December 13, 2018

Funding for this study provided by the Bracken County Health Department.

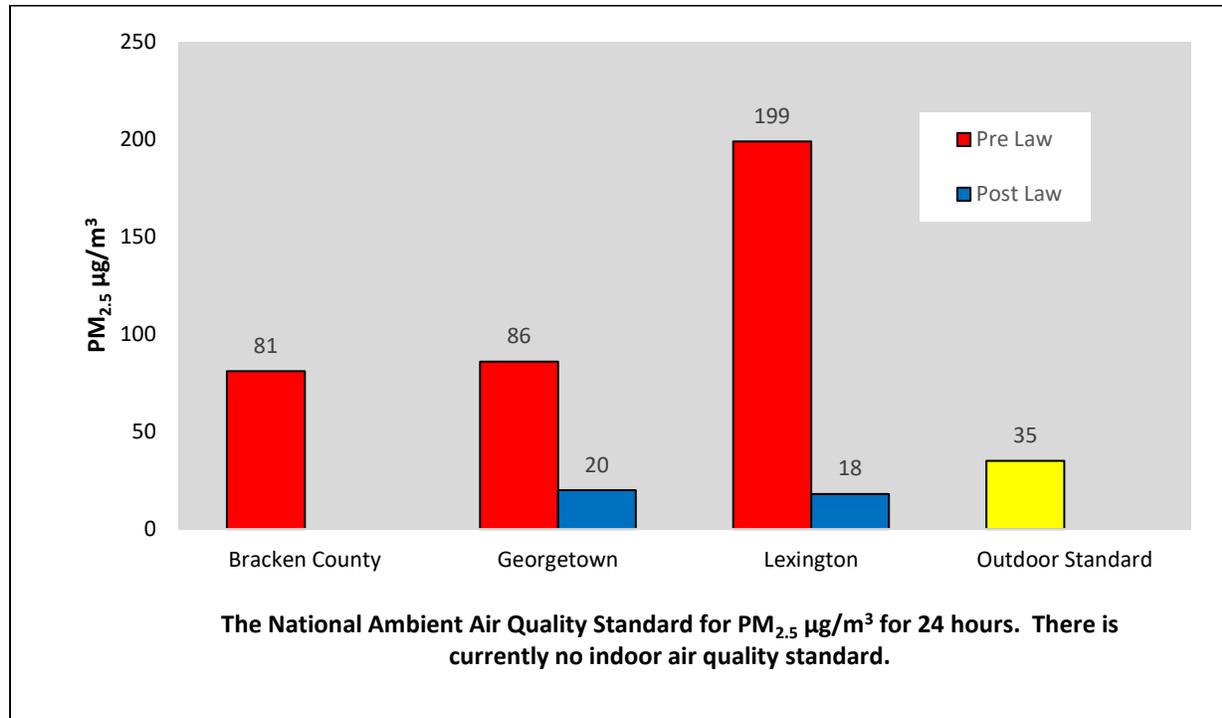
Executive Summary

Indoor air quality was assessed in five workplaces in Bracken County, Kentucky. Fine particulates were measured from August 10-28, 2018, using the TSI SidePak AM510 Personal Aerosol Monitor. The average PM_{2.5} level from the five workplaces 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:

- The level of indoor air pollution in workplaces measured in Bracken County (average PM_{2.5} = 81 µg/m³) was approximately 4.1 times higher than Georgetown and 4.5 times higher than Lexington after implementation of their smoke-free laws (see Figure 1). Further, the level of indoor air pollution in Bracken County workplaces was 2.3 times higher than the National Ambient Air Quality Standard for *outdoor* air.
- The five workplaces had average PM_{2.5} levels ranging from 16 to 338 µg/m³ (see Figure 2). Air pollution in one of the five workplaces 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.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 and stroke.⁴ 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 7,333 nonsmoking adults in the U.S. died from lung cancer and an estimated 33,951 from heart disease in 2006⁵ due to SHS exposure. It is estimated that 40.1% of nonsmokers in the United States have biological evidence of SHS exposure.⁶

Currently in the U.S., 22,678 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 58.9% of the U.S. population is protected by clean indoor air regulations that cover virtually all indoor worksites including bars and restaurants. There are 5,004 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 varies widely from community to community.

As of October 1, 2018, 50 Kentucky communities had implemented smoke-free laws. The most comprehensive ordinances/regulations, 100% smoke-free workplace and 100% smoke-free enclosed public place laws, have been implemented in 33 Kentucky communities: Ashland, Bardstown, Berea, Bowling Green, Campbellsville, Clarkson, Corbin, Danville, Elizabethtown, Georgetown, Glasgow, Hardin County (unincorporated areas), La Grange, Lexington-Fayette County, London, Louisville, Manchester, Martin, Middlesboro, Midway, Morehead, Murray, Oldham County, Paducah, Prestonsburg, Radcliff, Richmond, Salyersville, Somerset, Stanford, Versailles, Williamsburg, and Woodford County. Smoke-free enclosed public place laws, considered moderate in strength, have been implemented in three communities: Frankfort, Leitchfield, and Letcher County. Fourteen communities have enacted partial smoke-free laws, protecting workers and patrons in some public places or workplaces: Beattyville, Daviess County, Elkhorn City, Franklin County, Hazard, Henderson, Hopkins County, Hopkinsville, Kenton County, Mayfield, Oak Grove, Owensboro, Paintsville, and Kenton County.

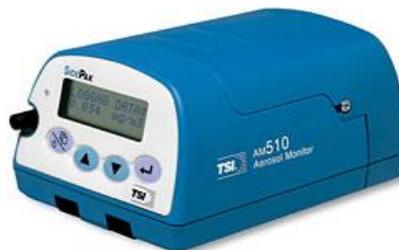
The purpose of this study was to (a) assess air quality in Bracken County, Kentucky workplaces; and (b) compare the results to Georgetown and Lexington, Kentucky air quality data before and after their smoke-free laws took effect.

Methods

Between August 10-28, 2018 indoor air quality was assessed in five indoor workplaces located in Bracken County, Kentucky. Of the five workplaces, sites were of various sizes and they were individually owned establishments.

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 Bracken County community advocates 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 were visited Monday through Friday for an average of 51 minutes (range 44-61 minutes). Visits occurred at various times of the day from 9:45 AM to 8:45 PM. The average size of the Bracken County workplaces was 903 m^3 (range $514\text{--}1,376\text{ m}^3$) and the average smoker density was $0.07/100\text{ m}^3$. On average, 14 patrons were present per workplace and 0.7 burning cigarettes per workplace were observed. Descriptive statistics for each workplace are summarized in the Table.

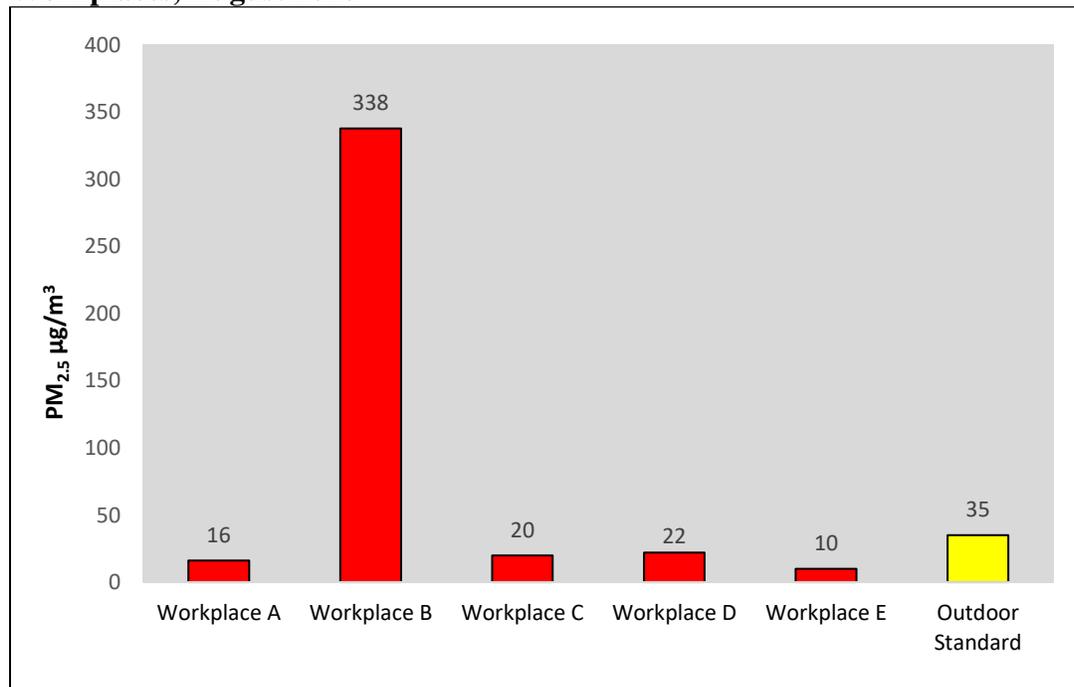
As depicted in Figure 1, the average level of indoor air pollution in the Bracken County workplaces ($81\text{ }\mu\text{g}/\text{m}^3$) was approximately 4.1 times higher than Georgetown and 4.5 times higher than Lexington after implementing their smoke-free laws. Further, the level of indoor air pollution in Bracken County workplaces was 2.3 times higher than the National Ambient Air Quality Standard ($35\mu\text{g}/\text{m}^3$) for *outdoor* air for 24 hours.

Table. Air Quality Data for Five Workplaces in Bracken County, Kentucky, August 2018

Venue	Date Sampled	Size (m ³)	Average # people	Average # burning cigs	Smoker density (#bc/100m ³)	Average PM _{2.5} levels (µg/m ³)
Workplace A	8/10/2018	1376	38	2.4	0.17	16
Workplace B	8/14/2018	514	20	1.0	0.19	338
Workplace C	8/27/2018	412	4	0.0	0.00	20
Workplace D	8/27/2018	990	6	0.0	0.00	22
Workplace E	8/28/2018	1221	2	0.0	0.00	10
Averages		903	14	0.7	0.07	81

Figure 2 shows the average level of indoor air pollution in each of the five tested workplaces in Bracken County. The average PM_{2.5} levels ranged from 16 to 338 µg/m³. Air pollution in one workplaces exceeded the National Ambient Air Quality Standard for *outdoor* air (NAAQS; 35µg/m³).

Figure 2. Average Indoor Fine Particle Concentration in Five Bracken County, Kentucky Workplaces, August 2018



Discussion

The average PM_{2.5} level in five Bracken County, Kentucky workplaces was 81 µg/m³, which is 2.3 times higher than the National Ambient Air Quality Standard (NAAQS) for *outdoor* air set by the EPA. There were over 80 EPA cited epidemiologic studies in creating a particulate air pollution standard in 1997.⁸ 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, 2004.⁹ 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 implemented a comprehensive smoke-free law on October 1, 2005.¹⁰ 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 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.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."² Tobacco smoke causes immediate blood vessel, lung tissue, and DNA damage, causing heart disease, lung disease, cancer,³ and stroke.⁴

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.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 The 2014 Surgeon General's report recommends that comprehensive smoke-free indoor protections be extended to the entire U.S. population.⁴

Conclusions

This study demonstrated that workers and patrons in Bracken County workplaces are exposed to harmful levels of SHS. On average, workers and patrons in Bracken County were exposed to indoor air pollution levels approximately 2.3 times the National Ambient Air Quality Standard for *outdoor* air, and the level of indoor air pollution in these workplaces was 4.1 times higher than Georgetown and 4.5 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 for all workers and patrons.

References

1. National Toxicology Program. *10th Report on Carcinogens*. Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program;2002.
2. U.S. Department of Health and Human Services. *The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General*. Atlanta, GA: Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Center for Chronic Disease and Prevention and Promotion, Office of Smoking and Health;2006.
3. U.S. Department of Health and Human Services. *How Tobacco Smoke Causes Disease: The Biology and Behavioral Basis for Smoking-Attributable Disease: A Report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health;2010.
4. U.S. Department of Health and Human Services. *The health consequences of smoking--50 years of progress. A report of the surgeon general*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health;2014.
5. Max W, Sung HY, Shi Y. Deaths from secondhand smoke exposure in the United States: economic implications. *Am J Public Health*. Nov 2012;102(11):2173-2180.
6. Centers for Disease Control and Prevention. Vital signs: Nonsmokers' exposure to secondhand smoke---United States, 1999-2008. *Morbidity and Mortality Weekly Report (MMWR)*. 2010;59(35):1141-1146.
7. Americans for Nonsmokers' Rights Foundation. Overview list--how many smokefree laws? 2014; <http://www.no-smoke.org/pdf/mediaordlist.pdf>. Accessed October 1, 2018.
8. U.S. Environmental Protection Agency National Ambient Air Quality Standards (NAAQS). 2006. Accessed June 20, 2009.
9. Hahn E, Lee K, Okoli C, Troutman A, Powell R. Smoke-free laws and indoor air pollution in Lexington and Louisville. *Louisville Medicine*. 2005;52(10):391-394, 409, 415.
10. Lee K, Hahn EJ, 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. 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, 2003. *MMWR Morb Mortal Wkly Rep*. Nov 12 2004;53(44):1038-1041.
13. Hahn E, Rayens M, York N, et al. Effects of a smoke-free law on hair nicotine and respiratory symptoms in restaurant and bar workers. *Journal of Occupational and Environmental Medicine*. 2006;48(9):906-913.
14. Farrelly MC, Nonnemaker JM, Chou R, Hyland A, Peterson KK, Bauer UE. Changes 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, et al. 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.