Fort Wayne Air Monitoring Study

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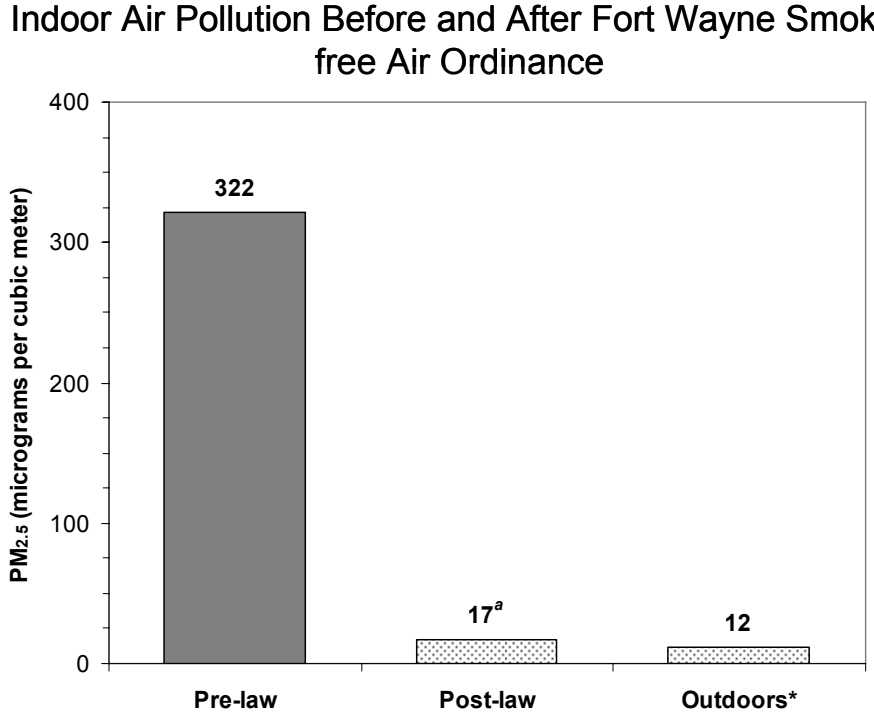
Executive Summary

Indoor air quality was assessed in 14 Fort Wayne hospitality venues including bars, restaurants, bowling alleys and pool halls both before and after the implementation of the new Fort Wayne smoke-free air law on June 1, 2007. The concentration of fine particle air pollution, $PM_{2.5}$, was measured with a TSI SidePak AM510 Personal Aerosol Monitor. $PM_{2.5}$ is particulate matter in the air smaller than 2.5 microns in diameter. Particles of this size are released in significant amounts from burning cigarettes, are easily inhaled deep into the lungs, and cause a variety of adverse health effects including cardiovascular and respiratory morbidity and death.

Key findings of the study include:

- The average level of fine particle indoor air pollution declined 94% after the Fort Wayne ordinance went into effect in those venues that went smoke-free as a result of the law.
- Compliance with the law in the fourteen places visited was 100%. There was no smoking observed in any location after the law went into effect.
- Before the law, employees in sampled locations were exposed to unhealthy air according to U.S. Environmental Protection Agency (EPA) standards. They now work in environments with safe levels of fine particle air pollution.

Before implementation of the Fort Wayne smoke-free air ordinance, locations allowing indoor smoking were significantly more polluted than indoor smoke-free sites and than outdoor air in Fort Wayne, with levels of pollution in excess of EPA standards. As a result of the Fort Wayne ordinance, air quality is dramatically improved for workers and patrons of those hospitality venues where indoor smoking became prohibited.



[a] p≤0.001 for comparison of pre-law and post-law values (Paired t-test of log-transformed values)

* Used for comparison purposes. Based on the 2006 average $PM_{2.5}$ level at Fort Wayne EPA monitoring sites. http://www.epa.gov/air/data/

Introduction

Secondhand smoke (SHS) contains at least 250 chemicals that are known to be toxic or carcinogenic, and is itself a known human carcinogen,[1] responsible for an estimated 3,000 lung cancer deaths annually in *never smokers* in the U.S., as well as more than 35,000 deaths annually from coronary heart disease in *never smokers,* and respiratory infections, asthma, Sudden Infant Death Syndrome, and other illnesses in children.[2] Although population-based data show declining SHS exposure in the U.S. overall, SHS exposure remains a major public health concern that is entirely preventable.[3, 4] Because requiring smoke-free environments is the most effective method for reducing SHS exposure in public places,[5] Healthy People 2010 Objective 27-13 encourages all states and the District of Columbia to establish and to enforce smoke-free air laws in public places and worksites.[6]

Currently in the U.S., 22 states, Washington, DC, and Puerto Rico have enacted strong smoke-free laws that include restaurants and bars. The states are Arizona, California, Colorado, Connecticut, Delaware, Hawaii, Illinois, Maine, Maryland, Massachusetts, Minnesota, Montana, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oregon, Rhode Island, Utah, Vermont, and Washington (Montana and Utah laws include bars in 2009; Illinois, Maryland, and Oregon laws go into effect in Jan. 2008, Feb. 2008, and Jan. 2009 respectively). Well over 50% of the U.S. population is now protected from secondhand smoke in all public places.[7] Florida, Idaho, Louisiana, Nevada, and North Dakota have smoke-free laws that exempt stand-alone bars. Nine Canadian provinces and territories also have comprehensive smoke-free air laws in effect. Hundreds of cities and counties across the U.S. have also taken action, as have whole countries including Ireland, Scotland, Uruguay, Norway, New Zealand, Sweden, Italy, Spain and England.

Fort Wayne, Indiana is in Allen County and is the second largest city in Indiana. On June 1, 2007, Fort Wayne implemented one of the strictest smoke free air laws in the state. Fort Wayne's original smoke free air law implemented January 1, 1999, allowed smoking in bars and restaurants if they had separate smoking rooms and allowed smoking in freestanding bars. The new law overturned the original law and removed smoking rooms from the previous law, expanded the law to cover bars, expanded the law to cover bowing alleys, and expanded the law to cover membership clubs. Now all indoor city workplaces are 100% smoke free. Exceptions of the law include: private homes, up to 20 percent of rooms in hotels, some private nursing home rooms and all retail tobacco stores. Smoking is allowed eight feet from the patio doorway of exterior patios in an unenclosed area of restaurants, as long as the patio doorway is not a public entrance or exit for the restaurant. Smoking shall be not less than 20 feet from all other doorways or openings leading into the venue.

Hazardous levels of indoor air pollution caused by indoor smoking have been previously identified in Fort Wayne and Indianapolis hospitality venues in a 2005 report.[8] The goal of this current study was to evaluate the effect of the new June 1, 2007 ordinance on the level of indoor air pollution in Fort Wayne worksites that went smoke-free. It was

hypothesized that indoor air would be less polluted in venues after the implementation of the ordinance.

Methods

Overview

A total of 14 bars, restaurants, bowling alleys and pool halls were visited both before and after the June 1, 2007 implementation of the Fort Wayne ordinance prohibiting smoking in indoor public places. The pre-law visits were made in May 2007, while the post-law visits were made in June 2007. Post-law visits occurred on the same day of the week and at the same time of day as the pre-law visits. Some sites were individually-owned establishments and some were part of local or national chain entities.

Measurement Protocol

Researchers spent a minimum of 30 minutes in each venue. The number of people inside the venue and the number of burning cigarettes were recorded every 15 minutes during sampling. These observations were averaged over the time inside the venue to determine the average number of people on the premises and the average number of burning cigarettes. The IntelliMeasure Distance Estimator (Stanley Tools, New Briton, CT) was used to measure room dimensions and hence the volume of each of the venues. The active smoker density was calculated by dividing the average number of burning cigarettes by the volume of the room in meters.

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 where the particulate matter in the air scatters the light from a laser. This portable light-scattering aerosol monitor was fitted with a 2.5 μm impactor in order to measure the concentration of particulate matter with a mass-median aerodynamic diameter less than or equal to 2.5 μm, or $PM_{2.5}$. Tobacco smoke particles are almost exclusively less than 2.5 μm with a mass-median diameter of 0.2 μm.[9] The Sidepak was used with a calibration factor setting of 0.32, suitable for secondhand smoke. This calibration factor was determined in an experiment with the SidePak collocated with another light-scattering instrument that had been previously calibrated against standard pump-and-filter gravimetric methods and used in SHS exposure studies.[10] Klepeis et al. found a similar SHS calibration factor for the Sidepak when compared to a Piezobalance (Kanomax, Inc.) which provides direct measurements of RSP mass concentrations.[11] This calibration factor has also been confirmed by another researcher who compared Sidepak measurements of SHS to gravimetric measurements using a Personal Environmental Monitor (PEM for PM2.5, MSP Corporation, Shoreview, MN).[12] 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 outdoors and entryway air. The remaining data points were averaged to provide an average $PM_{2.5}$ concentration within the venue.

> ***$PM_{2.5}$ is the concentration of particulate matter in the air smaller than 2.5 microns in diameter. Particles of this size are released in significant amounts from burning cigarettes, are easily inhaled deep into the lungs, and are associated with pulmonary and cardiovascular disease and mortality.***

Roswell Park Cancer Institute staff trained the Indiana testers and analyzed the data.

Statistical Analyses

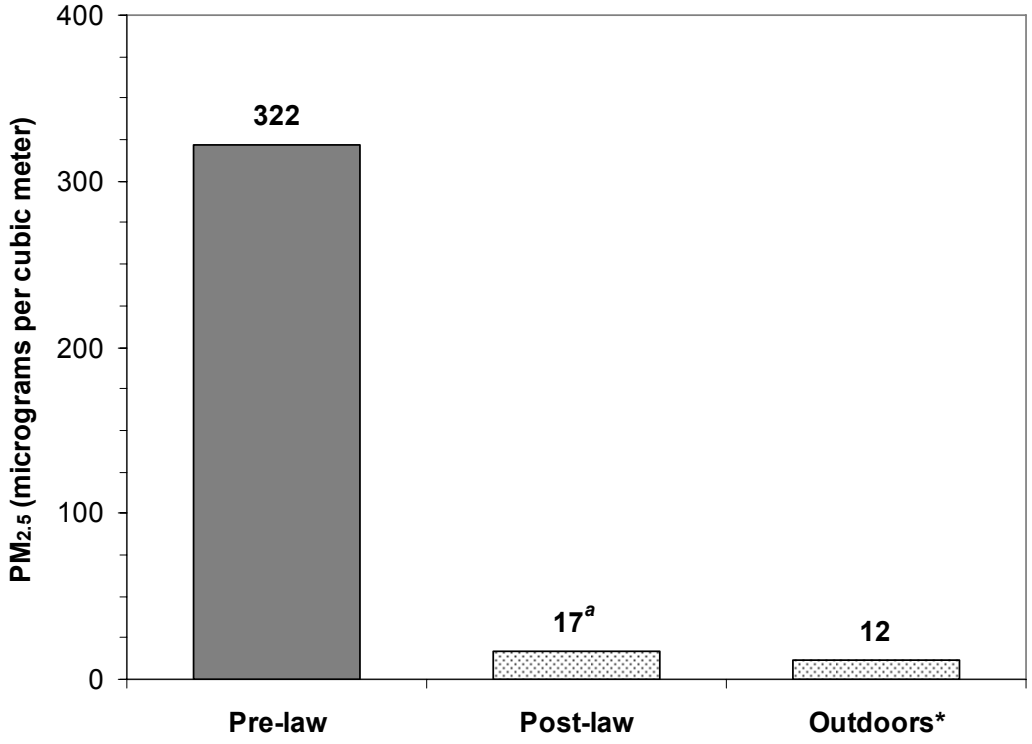
The primary goal was to assess the difference in the average level of $PM_{2.5}$ in worksites and public places after the implementation of a smoke-free air law. Since $PM_{2.5}$ levels are generally log-normally distributed, all statistical testing was performed using log-transformed $PM_{2.5}$ values. Pre- and post-law $PM_{2.5}$ values were compared using a paired samples t-test. Descriptive statistics including the venue volume, number of patrons, and average smoker density (i.e., number of burning cigarettes per 100 m^3) are reported for each venue and averaged for each time period as well.

Results

The average $PM_{2.5}$ level in the 14 locations that went smoke-free as a result of the Fort Wayne ordinance was 322 $\mu g/m^3$ before the law and 17 $\mu g/m^3$ after the law. This was a decrease of 94% in fine particle indoor air pollution (95% C.I. 86% to 97%). These aggregate results are shown in Figure 1. The average number of burning cigarettes decreased from 4.0 cigarettes to 0.0 and the average active smoker density decreased from 0.81 burning cigarettes per 100 m^3 to 0.00 in these locations.

There are 2 outdoor air monitoring sites in Fort Wayne that use the EPA's Federal Reference Method for measuring $PM_{2.5}$ in outdoor air. The average $PM_{2.5}$ level for 2006 from each of these sites was found at http://www.epa.gov/air/data/ and they were used to determine the average outdoor $PM_{2.5}$ level as a comparison for this study. This average outdoor $PM_{2.5}$ level is 11.9 $\mu g/m^3$ (shown in Figure 1).

Figure 1. Indoor Air Pollution Before and After Fort Wayne Smoke-free Air Ordinance



[a] p≤0.001 for comparison of pre-law and post-law values (Paired t-test of log-transformed values)

* Used for comparison purposes. Based on the 2006 average $PM_{2.5}$ level at Fort Wayne EPA monitoring sites. http://www.epa.gov/air/data/

Table 1 shows the results for each establishment visited.

Table 1. Fine Particle Air Pollution in Fort Wayne Hospitality Venues

		Pre-Law					Post-Law					
Venue Number	Size (m^3)	Date Sampled	Average # people	Average # burning cigs	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)	Date Sampled	Average # people	Average # burning cigs	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)	% reduction in $PM_{2.5}$
1	103	5/18/07	16	0.8	0.73	32	6/22/07	18	0.0	0.00	56	-75.0%
2	3779	5/18/07	26	0.3	0.01	8	6/22/07	27	0.0	0.00	4	50.0%
3	616	5/18/07	53	5.0	0.81	226	6/22/07	18	0.0	0.00	6	97.3%
4	489	5/18/07	69	3.7	0.75	245	6/22/07	45	0.0	0.00	17	93.1%
5	230	5/18/07	62	6.7	2.90	684	6/22/07	22	0.0	0.00	12	98.2%
6	822	5/18/07	76	10.3	1.26	645	6/22/07	74	0.0	0.00	11	98.3%
7	924	5/18/07	37	3.7	0.40	406	6/22/07	42	0.0	0.00	10	97.5%
8	280	5/19/07	29	0.8	0.27	37	6/23/07	34	0.0	0.00	8	78.4%
9	235	5/19/07	20	0.7	0.28	148	6/23/07	9	0.0	0.00	8	94.6%
10	541	5/19/07	78	7.7	1.42	777	6/23/07	35	0.0	0.00	11	98.6%
11	498	5/19/07	38	3.0	0.60	179	6/23/07	15	0.0	0.00	7	96.1%
12	1071	5/19/07	37	6.3	0.59	186	6/23/07	12	0.0	0.00	8	95.7%
13	503	5/19/07	92	6.7	1.33	572	6/23/07	82	0.0	0.00	22	96.2%
14	2550	5/19/07	9	0.7	0.03	357	6/23/07	23	0.0	0.00	57	84.0%
Average	903		46	4.0	0.81	322		32	0.0	0.00	17	94.7%

NOTES: * Average number of burning cigarettes per 100 cubic meters.

$PM_{2.5}$ concentrations decreased after the law in 13 of the 14 places visited. It is not clear why levels in venue number 1 were higher during post-law monitoring. The increased $PM_{2.5}$ levels could have been from cooking, or smoking that occurred before the testers entered.

The real-time plots showing the $PM_{2.5}$ level in each venue minute-by-minute during sampling are presented in the Appendix, Figures 2 through 7, starting on page 11. The real-time plots throughout sampling reveal the following results: 1) low background levels are observed outdoors; 2) much higher levels of fine particle air pollution are measured in venues before the law, when smoking was permitted; 3) peak exposure levels when smoking was permitted can far exceed the average recorded levels in a given venue; 4) indoor fine particle pollution levels are much lower following implementation of the smoke-free air law.

Figures 2 and 3 (pages 11 and 12) show the plots for the pre-law monitoring done on May 18 and 19 respectively. $PM_{2.5}$ levels are shown on the left-hand axis and the average smoking density in each venue visited is shown as a bar graph on the right-hand axis. Figures 4 and 5 (pages 13 and 14) show the plots in the same 14 locations but during the post-law monitoring performed on June 22 and 23. No smoking was observed in any of the locations during these post-law visits. Figures 6 and 7 (pages 15 and 16) show the pre- and post-law data together on the same graph for comparison purposes. Figure 6 shows the $PM_{2.5}$ levels both before and after the law in venues 1 through 7 and Figure 7 shows the levels both before and after the law in venues 8 through 14. The large reduction in indoor fine particle air pollution after the law is apparent in these two figures.

Discussion

The EPA cited over 80 epidemiologic studies in creating a particulate air pollution standard in 1997.[13] The EPA has recently updated this standard and, in order to protect the public health, the EPA has set limits of 15 $\mu g/m^3$ as the average annual level of $PM_{2.5}$ exposure and 35 $\mu g/m^3$ for 24-hour exposure.[13, 14] In order to compare the findings in this study with the annual EPA $PM_{2.5}$ exposure standard, it was assumed that a full-time employee in the locations sampled that allow smoking works 8 hours, 250 days a year, is exposed to 322 $\mu g/m^3$ (the average level in all sites before the ordinance) on the job, and is exposed only to background particle levels of 11.9 $\mu g/m^3$ during non-work times. For a full-time employee their average annual $PM_{2.5}$ exposure was 83 $\mu g/m^3$. The EPA average annual $PM_{2.5}$ limit is exceeded by 5.5 times due to their occupational exposure. After the smoke-free air law, these same workers are now exposed to an average particle concentration of 17 $\mu g/m^3$ and, for a full-time employee in these Fort Wayne venues, the average annual exposure is 13 $\mu g/m^3$, a safe level according to the EPA. Based on the latest scientific evidence, the EPA staff currently proposes even lower $PM_{2.5}$ standards to adequately protect the public health,[15] making the high $PM_{2.5}$ exposures of people in smoking environments even more alarming.

Previous studies have evaluated air quality by measuring the change in levels of respirable suspended particles (RSP) between smoke-free venues and those that permit smoking. In Indiana, an 89% decrease in $PM_{2.5}$ was documented in Bloomington locations that went smoke-free after that town implemented a smoke-free air ordinance.[8] A similar 85% reduction in $PM_{2.5}$ levels was seen in Indianapolis locations that went smoke-free, however levels were unchanged in the locations that were exempt from the Indianapolis ordinance.[16] Ott et al. did a study of a single tavern in California and showed an 82% average decrease in RSP levels after smoking was prohibited by a city ordinance.[17] Repace studied 8 hospitality venues, including one casino, in Delaware before and after a statewide prohibition of smoking in these types of venues and found that about 90% of the fine particle pollution could be attributed to tobacco smoke.[10] Similarly, in a study of 22 hospitality venues in Western New York, Travers et al. found a 90% reduction in RSP levels in bars and restaurants, an 84% reduction in large recreation venues such as bingo halls and bowling alleys, and a 58% reduction even in locations where only SHS from an adjacent room was observed at baseline.[18] A cross-sectional study of 53 hospitality venues in 7 major cities across the U.S. showed 82% less indoor air pollution in the locations subject to smoke-free air laws, even though compliance with the laws was less than 100%.[19]

Other studies have directly assessed the effects SHS exposure has on human health. One study found that respiratory health improved rapidly in a sample of bartenders after a state smoke-free workplace law was implemented in California[20], and another study reported a 40% reduction in acute myocardial infarctions in patients admitted to a regional hospital during the 6 months that a local smoke-free ordinance was in effect.[21] Smoke-free legislation in Scotland was associated with significant early improvements in symptoms, lung function, and systemic inflammation of all bar workers, while asthmatic bar workers also showed reduced airway inflammation and improved quality of life.[22]

Farrelly et al. also showed a significant decrease in both salivary cotinine concentrations and sensory symptoms in hospitality workers after New York State's smoke-free law prohibited smoking in their worksites.[23]

The effects of passive smoking on the cardiovascular system in terms of increased platelet aggregability, endothelial dysfunction, increased arterial stiffness, increased atherosclerosis, increased oxidative stress and decreased antioxidant defense, inflammation, decreased energy production in the heart muscle, and a decrease in the parasympathetic output to the heart, are often nearly as large (averaging 80% to 90%) as chronic active smoking. Even brief exposures to SHS, of minutes to hours, are associated with many of these cardiovascular effects. The effects of secondhand smoke are substantial and rapid, explaining the relatively large health risks associated with secondhand smoke exposure that have been reported in epidemiological studies.[24]

The hazardous health effects of exposure to second-hand smoke are now well-documented and established in various independent research studies and numerous international reports. The body of scientific evidence is overwhelming: there is no doubt within the international scientific community that second-hand smoke causes heart disease, lung cancer, nasal sinus cancer, sudden infant death syndrome (SIDS), asthma and middle ear infections in children and various other respiratory illnesses. There is also evidence suggesting second-hand smoke exposure is also causally associated with stroke, low birthweight, spontaneous abortion, negative effects on the development of cognition and behavior, exacerbation of cystic fibrosis, cervical cancer, and breast cancer in pre-menopausal women. The health effects of secondhand smoke exposure are detailed in recent reports by the California Environmental Protection Agency[25] and the U.S. Surgeon General[26].

Conclusions

This study documented the substantial improvement in indoor air quality that occurred after the implementation of Fort Wayne's smoke-free air ordinance. Fine particle air pollution dropped a dramatic 94% in places where smoking was occurring before the law.

Before implementation of the Fort Wayne ordinance, locations allowing indoor smoking were significantly more polluted than indoor smoke-free sites and than outdoor air in Fort Wayne, with levels of pollution in excess of EPA standards. As a result of the Fort Wayne ordinance, air quality is dramatically improved for workers and patrons of these hospitality venues. This reduction in exposure to toxic secondhand smoke will result in improved quality of life and health outcomes for Fort Wayne workers and residents.

Acknowledgments

Support for this study was provided by Indiana Tobacco Prevention and Cessation and the Flight Attendant Medical Research Institute.

Appendix

U.S. Environmental Protection Agency Air Quality Index		
Air Quality Index Levels of Health Concern	**$PM_{2.5}$ ($\mu g/m^3$)**	**Meaning**
Good	**≤15**	**Air quality is considered satisfactory, and air pollution poses little or no risk.**
Moderate	**16-40**	**Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.**
Unhealthy for Sensitive Groups	**41-65**	**Members of sensitive groups may experience health effects. The general public is not likely to be affected.**
Unhealthy	**66-150**	**Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.**
Very Unhealthy	**151-250**	**Health alert: everyone may experience more serious health effects.**
Hazardous	**≥251**	**Health warnings of emergency conditions. The entire population is more likely to be affected.**

Real-time plots of $PM_{2.5}$ levels in this study start on the following page.

Figure 2.

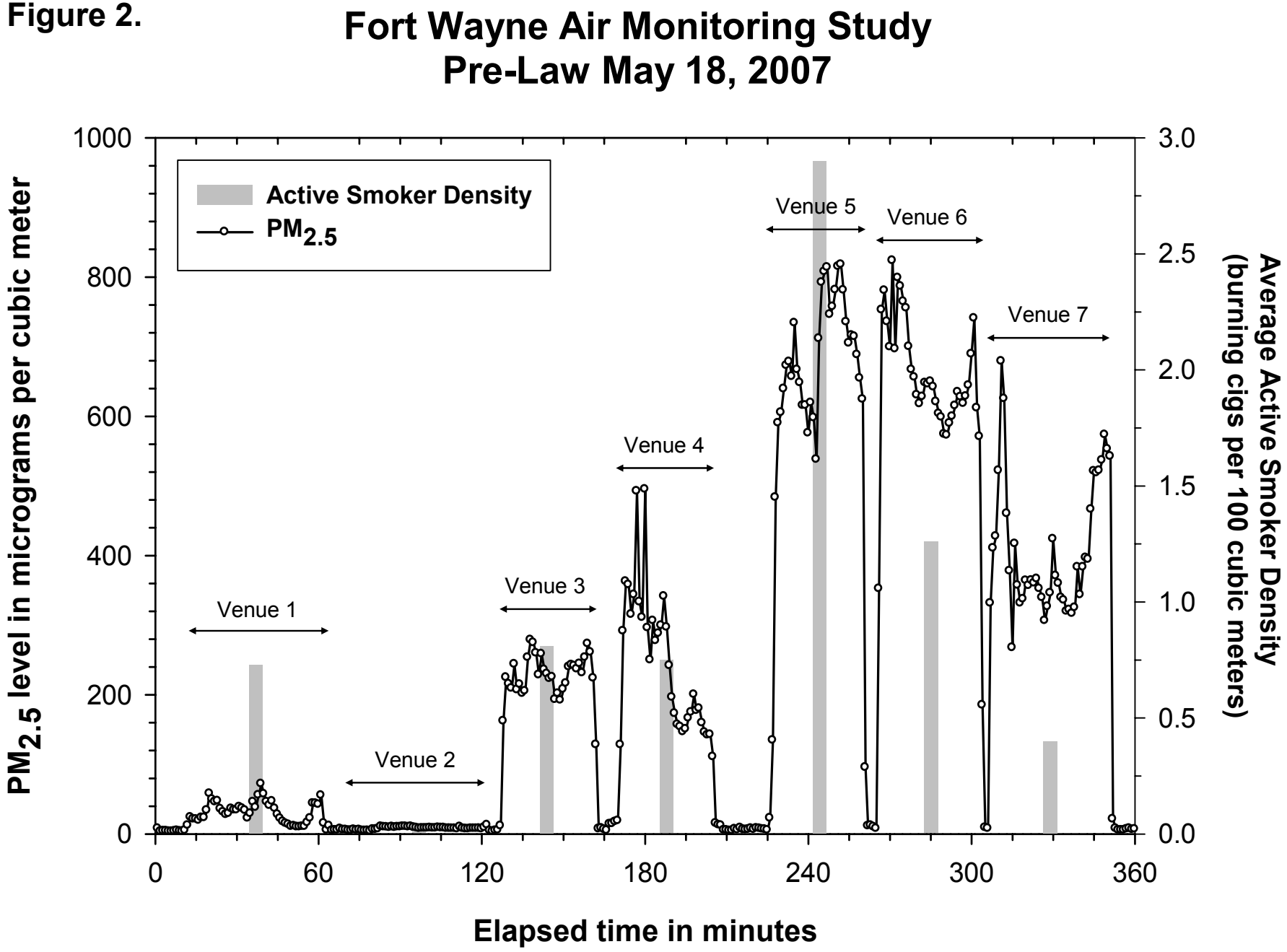

Fort Wayne Air Monitoring Study
Pre-Law May 18, 2007
Active Smoker Density
PM2.5
Venue 1
Venue 2
Venue 3
Venue 4
Venue 5
Venue 6
Venue 7
PM2.5 level in micrograms per cubic meter
Average Active Smoker Density (burning cigs per 100 cubic meters)
Elapsed time in minutes
0
200
400
600
800
1000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
60
120
180
240
300
360

Figure 3.

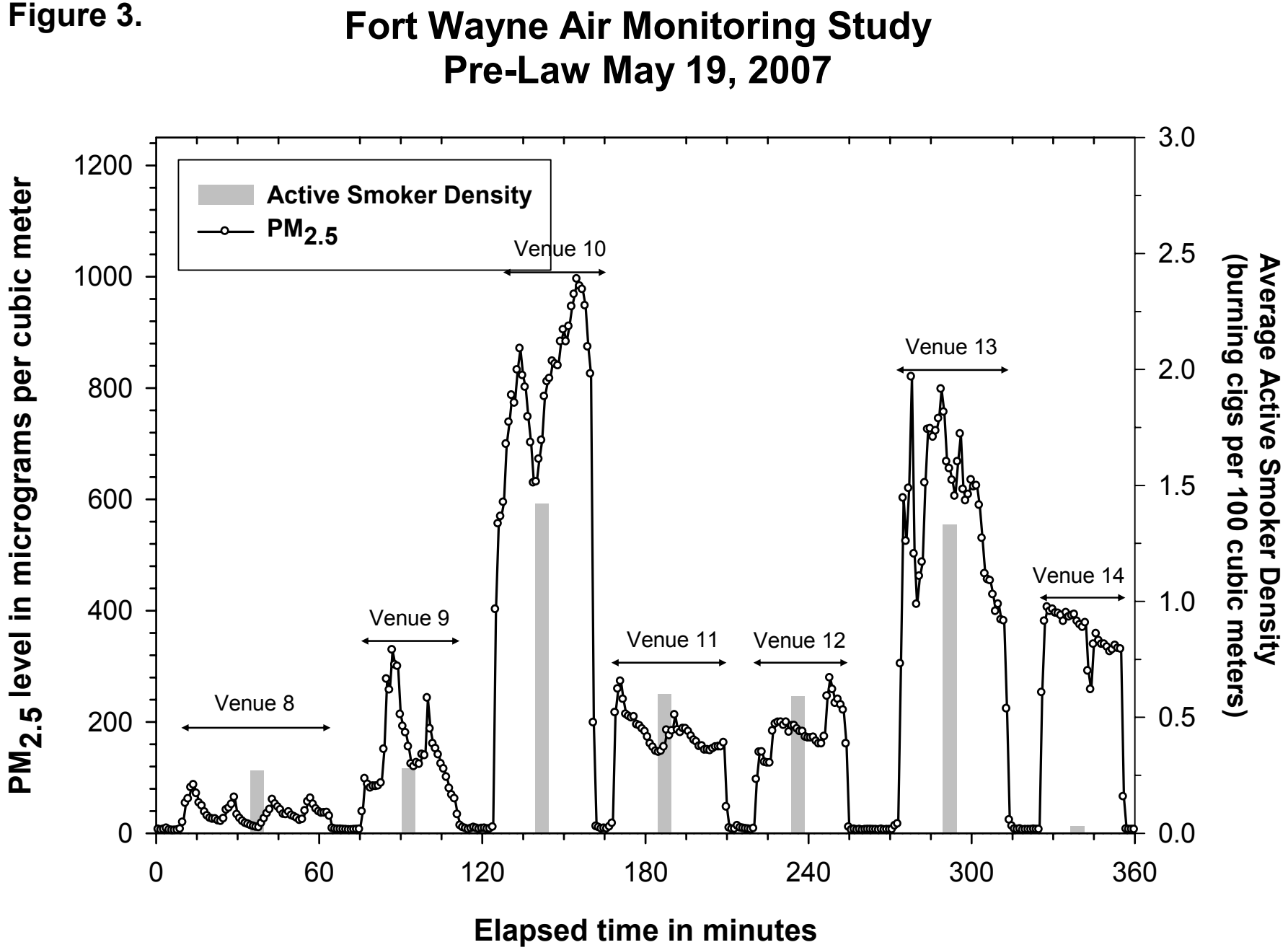

Fort Wayne Air Monitoring Study
Pre-Law May 19, 2007
Active Smoker Density
PM2.5
Venue 8
Venue 9
Venue 10
Venue 11
Venue 12
Venue 13
Venue 14
PM2.5 level in micrograms per cubic meter
Average Active Smoker Density (burning cigs per 100 cubic meters)
Elapsed time in minutes
0
200
400
600
800
1000
1200
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
60
120
180
240
300
360

Figure 4.

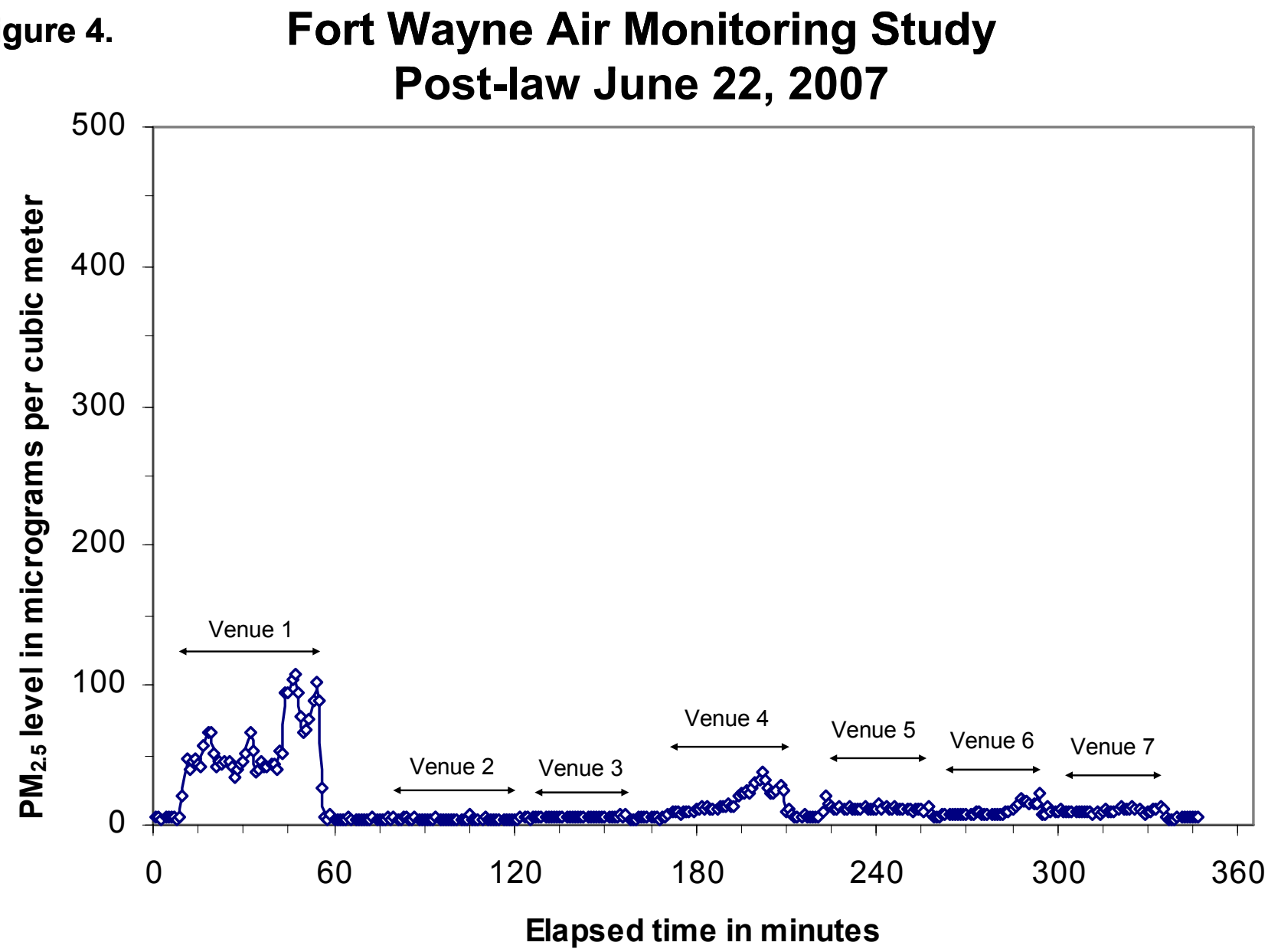

Fort Wayne Air Monitoring Study
Post-law June 22, 2007
PM2.5 level in micrograms per cubic meter
500
400
300
200
100
0
0
60
120
180
240
300
360
Elapsed time in minutes
Venue 1
Venue 2
Venue 3
Venue 4
Venue 5
Venue 6
Venue 7

Figure 5.

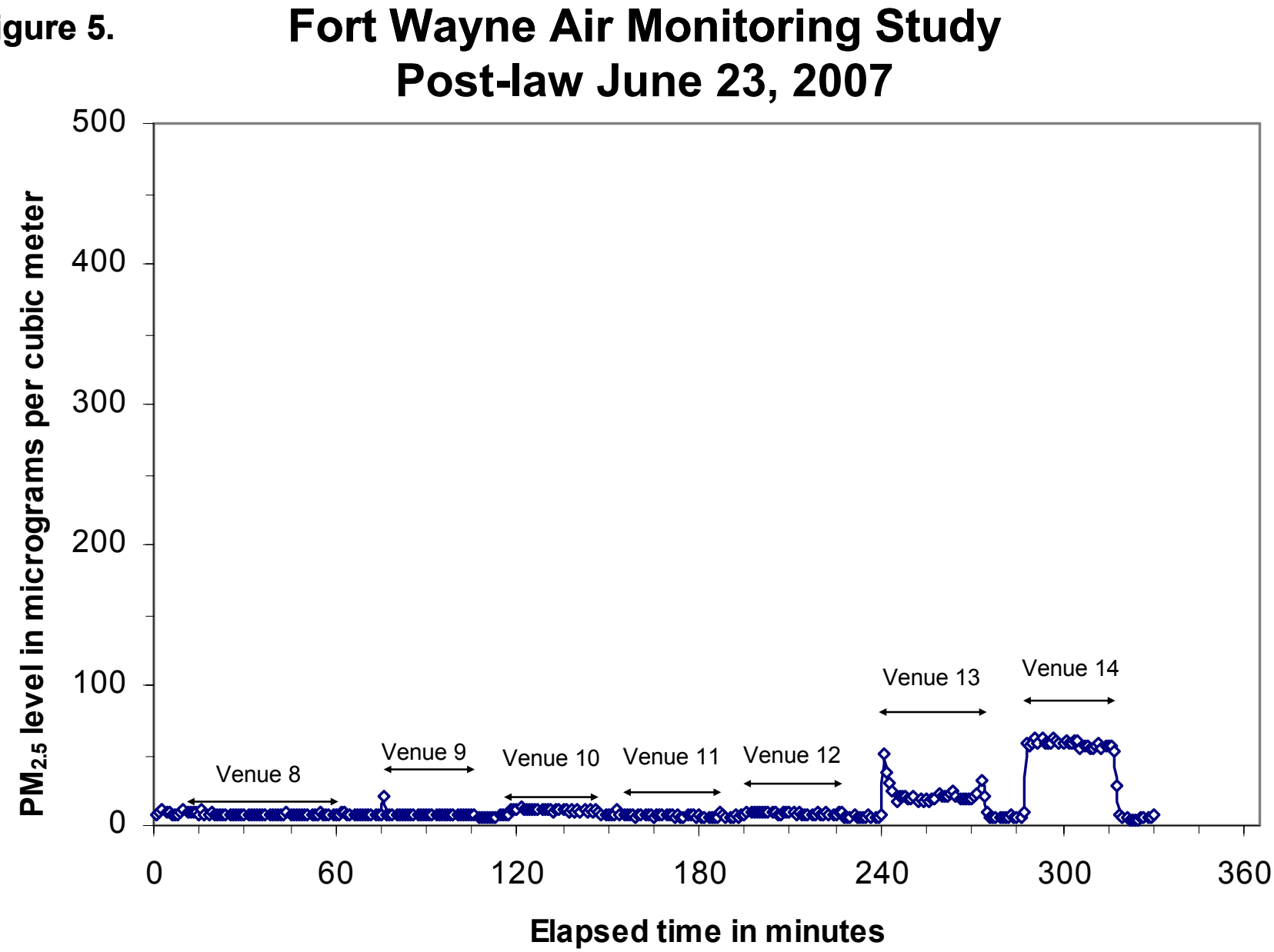

Fort Wayne Air Monitoring Study
Post-law June 23, 2007
PM2.5 level in micrograms per cubic meter
500
400
300
200
100
0
0
60
120
180
240
300
360
Elapsed time in minutes
Venue 8
Venue 9
Venue 10
Venue 11
Venue 12
Venue 13
Venue 14

Figure 6.

Fort Wayne Air Monitoring Study
Pre-Post, May-June 2007

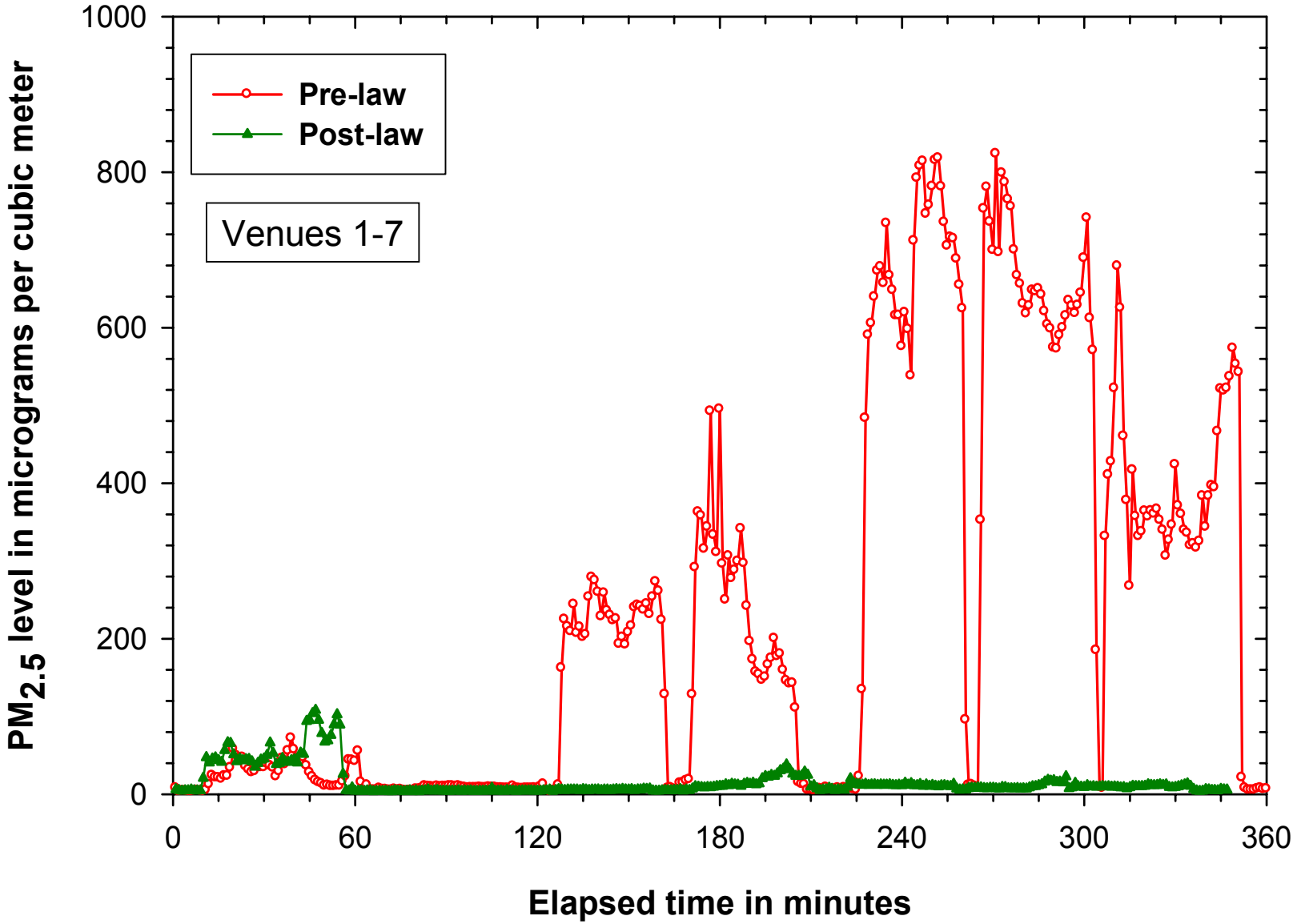
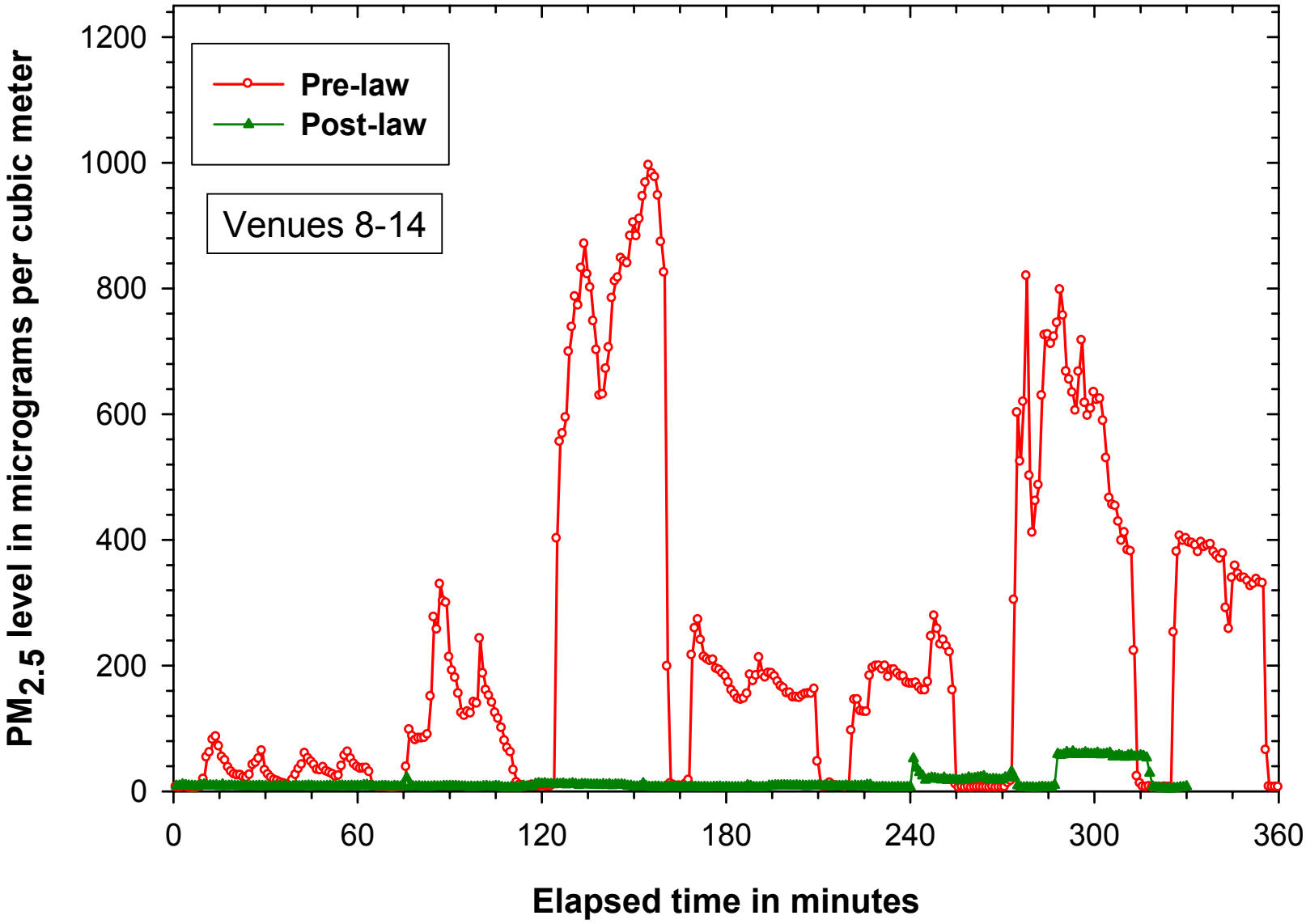


Figure 7.

Fort Wayne Air Monitoring Study
Pre-Post, May-June 2007



References

1. National Toxicology Program, *9th Report on Carcinogens 2000*. 2000, U.S. Department of Health and Human Services, National Institute of Environmental Health Sciences: Research Triangle Park, NC.
2. CDC, *Annual smoking-attributable mortality, years of potential life lost, and economic costs - United States, 1995-1999.* MMWR, 2002. **51**(14): p. 300-320.
3. U.S. Department of Health and Human Services, *Second national report on human exposure to environmental chemicals*. 2003, US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Environmental Health: Atlanta, GA.
4. U.S. Department of Health and Human Services, *Reducing tobacco use: a report of the Surgeon General*. 2000, US Government Printing Office: Washington, DC.
5. Hopkins, D.P., et al., *Reviews of evidence regarding interventions to reduce tobacco use and exposure to environmental tobacco smoke.* Am J Prev Med, 2001. **20**(2 Suppl): p. 16-66.
6. U.S. Department of Health and Human Services, *Healthy People 2010: Objectives for Improving Health (Volume 2)*. 2000, U.S. Government Printing Office: Washington, DC.
7. American Nonsmokers' Rights Foundation. *Summary of 100% Smokefree State Laws and Population Protected by 100% U.S. Smokefree Laws*. 2007 7/3/2007 [cited 2006 7/9/2007]; Available from: http://www.no-smoke.org/pdf/SummaryUSPopList.pdf.
8. Travers, M.J. and A. Hyland, *Indiana Air Monitoring Study, December 2004 – January 2005*. 2005, Roswell Park Cancer Institute: Buffalo.
9. Klepeis, N.E., et al., *Determining Size-Specific Emission Factors for Environmental Tobacco Smoke Particles.* Aerosol Science and Technology, 2003. **37**: p. 780-790.
10. Repace, J., *Respirable particles and carcinogens in the air of Delaware hospitality venues before and after a smoking ban.* J Occup Environ Med, 2004. **46**(9): p. 887-905.
11. Klepeis, N.E., W.R. Ott, and P. Switzer, *Real-Time Measurement of Outdoor Tobacco Smoke Particles.* Journal of the Air & Waste Management Association, 2007. **57**: p. 522-534.
12. Lee, K., *Comparison of TSI Sidepak Aerosol Monitor to gravimetric analyses of secondhand smoke particles.*, M.J. Travers, Editor. 2006.
13. U.S. Environmental Protection Agency, *National ambient air quality standards for particulate matter; final rule.* Federal Register, 1997. **62**(138): p. 38651-38701.
14. U.S. Environmental Protection Agency. *National Ambient Air Quality Standards for Particulate Matter. Final Rule.* 2006 September 21, 2006. [cited; Available from: http://www.epa.gov/oar/particlepollution/pdfs/20060921_preamble.pdf.
15. U.S. Environmental Protection Agency. *Draft Staff Paper for Particulate Matter Fact Sheet*. 2005 [cited 2006 October 4]; Available from: http://www.epa.gov/airlinks/pdfs/pmstaff2_fact.pdf.
16. Travers, M.J. and A. Hyland, *Indianapolis Air Monitoring Study 2006*. 2006, Roswell Park Cancer Institute: Buffalo.
17. Ott, W., P. Switzer, and J. Robinson, *Particle concentrations inside a tavern before and after prohibition of smoking: evaluating the performance of an indoor air quality model.* J Air Waste Manag Assoc, 1996. **46**: p. 1120-1134.
18. Travers, M.J., et al., *Indoor Air Quality in Hospitality Venues Before and After the Implementation of a Clean Indoor Air Law-Western New York, 2003.* Morbidity and Mortality Weekly Report (MMWR), 2004. **53**(44): p. 1038-1041.
19. Travers, M.J., A. Hyland, and J.L. Repace, *7-City Air Monitoring Study (7-CAMS), March-April 2004*. 2004, Roswell Park Cancer Institute: Buffalo.
20. Eisner, M.D., A.K. Smith, and P.D. Blanc, *Bartenders' respiratory health after establishment of smoke-free bars and taverns.* JAMA, 1998. **280**(22): p. 1909-14.
21. Sargent, R.P., R.M. Shepard, and S.A. Glantz, *Reduced incidence of admissions for myocardial infarction associated with public smoking ban: before and after study.* BMJ, 2004. **328**(7446): p. 977-80.
22. Menzies, D., 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**(14): p. 1742-8.

23. Farrelly, M.C., et al., *Changes in hospitality workers' exposure to secondhand smoke following the implementation of New York's smoke-free law.* Tob Control, 2005. **14**(4): p. 236-41.
24. Barnoya, J. and S.A. Glantz, *Cardiovascular effects of secondhand smoke: nearly as large as smoking.* Circulation, 2005. **111**(20): p. 2684-98.
25. California Environmental Protection Agency, *Proposed Identification of Environmental Tobacco Smoke as a Toxic Air Contaminant*. 2005, California Environmental Protection Agency, Air Resources Board, Office of Environmental Health Hazard Assessment.
26. U.S. Department of Health and Human Services, *The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General*. 2006, 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: Atlanta, GA.