

Omaha, Nebraska Air Monitoring Study: Effect of the Omaha Smoke-Free Air Ordinance



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March 2009

Executive Summary

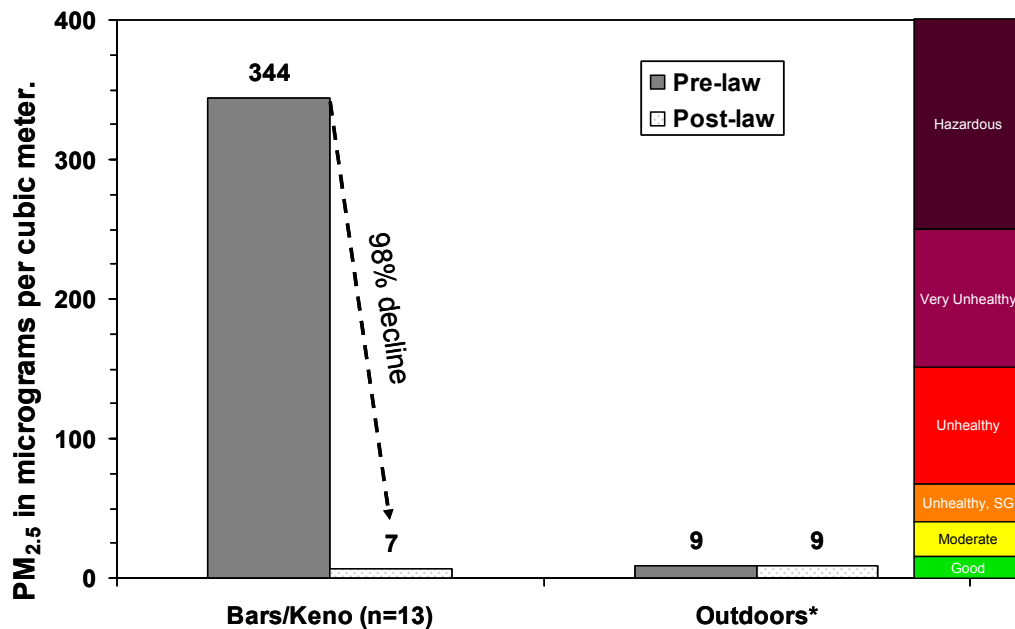
In December 2006, indoor air quality was assessed in 13 bars (n=8) and keno establishments (n=5) in Omaha, Nebraska. These same sites were re-visited in November 2008 after they were required to prohibit indoor smoking according to local law.

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:

- In 2006, levels of fine particle air pollution were hazardous in Omaha bars and keno establishments. (pre-law PM_{2.5} = 344 µg/m³)
- Employees in Omaha bars and keno establishments were exposed to levels of air pollution 5.7 times higher than safe annual levels established by the U.S. Environmental Protection Agency due to their occupational exposure to tobacco smoke pollution.
- In 2008, these levels dropped 98% to safe levels.
- The strong smokefree workplace ordinance in Omaha is effectively protecting the health of workers and patrons from the health effects of exposure to tobacco smoke pollution.

Figure 1. Average Level of Air Pollution in Omaha, Nebraska



*2006 (pre-law) and 2008 (post-law) respectively, average for Omaha, Nebraska. US EPA AirData report generated February 25, 2009 from <http://www.epa.gov/air/data/>
 Note: The color-coded US EPA Air Quality Index is shown to illustrate the magnitude of the measured particle concentrations. (SG=sensitive groups)

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., 24 states, Washington D.C., and Puerto Rico have enacted strong smoke-free laws that include restaurants and bars. The states are Arizona, California, Colorado, Connecticut, Delaware, Hawaii, Illinois, Iowa, Maine, Maryland, Massachusetts, Minnesota, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oregon, Rhode Island, Utah, Vermont, and Washington (the Nebraska law goes into effect in June 2009). Well over 50% of the U.S. population is now protected from secondhand smoke in all public places.[7] In 2008 Nebraska passed a strong smoke-free air law for workplaces and public places including all restaurants and bars, that will be implemented in June 2009. Strong comprehensive smoke-free laws are currently in place in Lincoln, Grand Island, Humboldt and Omaha, Nebraska. 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, England and France.

The goal of this study was to evaluate the effect of the Omaha smoke-free air ordinance on the level of fine particle indoor air pollution in standalone bars and keno establishments in Omaha, Nebraska. In June 2006, the Omaha City Council passed an ordinance, "Prohibition on Smoking in Workplaces and Public Gathering Places".¹ This ordinance prohibited smoking in indoor worksites and public places but exempted stand alone bars, horse racing tracks, tobacco retail shops and keno establishments until 2011. However, on May 30, 2008, the Nebraska Supreme Court ruled the temporary exemption for these places was unconstitutional. On June 17, 2008, in response to the Supreme Court ruling, the Douglas County District Court entered an order overturning the temporary exemptions in the Omaha ordinance. Therefore, as of June 17, 2008 stand alone bars and keno establishments in Omaha were required to be smokefree according to the Omaha City ordinance.

It is hypothesized that: 1) indoor particle air pollution levels will decline significantly in a cohort of bars and keno establishments that are sampled before and after the smoke-free

¹ Omaha City Council Ordinance No. 37412 adding Article VIII to Chapter 12 of the Omaha Municipal Code. (<http://www.ci.omaha.ne.us/Smoking%20Ban%20Ordinance.pdf> accessed Feb. 22, 2009)

air law; and, 2) the degree of indoor particle air pollution will be correlated with the amount of smoking.

Methods

Overview

Between December 8 and December 15, 2006, indoor air quality was assessed in 13 bars (n=8) and keno (n=5) establishments in Omaha, Nebraska. All of these locations were allowed to have indoor smoking according to the Omaha Municipal Code at that time. A stand-alone bar is defined as a bar that has only limited food service. Keno establishments are those that are licensed by the city to operate keno and may either be stand-alone bars or have full food service. These same 13 locations were re-visited from November 13 and November 15, 2008 after the Municipal Code was amended and they were required to be smokefree.

Measurement Protocol

A minimum of 30 minutes was spent 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. Room dimensions were also determined using a combination of any or all of the following techniques; a sonic measuring device, counting of construction materials of a known size such as floor tiles, or estimation. Room volumes were calculated from these dimensions. 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 $\text{PM}_{2.5}$. Tobacco smoke particles are almost exclusively less than 2.5 μm with a mass-median diameter of 0.2 μm . [8] The Sidepak was used with a calibration factor setting of 0.32, suitable for secondhand smoke. [9, 10] 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

TSI SidePak AM510 Personal Aerosol Monitor



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.

Teams of testers from Tobacco Free Nebraska and the American Cancer Society did the sampling and researchers from Roswell Park Cancer Institute analyzed the data.

Statistical Analyses

The primary goal was to assess the change in the average levels of PM_{2.5} in bars and keno establishments after the smokefree air law went into effect. In addition to looking at the overall sample, venues were also stratified into 1) stand alone bars and 2) keno establishments. Statistical significance is assessed overall and among strata using a paired-samples *t* test on the log-transformed PM_{2.5} concentrations. PM_{2.5} concentrations were log-transformed to achieve normality and homogeneity of variances. The second hypothesis was tested by using all 26 sample visits and correlating the average smoker densities to the PM_{2.5} levels using the Spearman rank correlation coefficient (*r_s*). Descriptive statistics including the venue volume, number of patrons, and average smoker density (i.e., number of burning cigarettes) per 100 m³ are reported for each venue and averaged for all venues.

Results

A summary of each location visited is shown in Table 1. The average PM_{2.5} level in the 13 locations (bars and keno establishments) before the law was 344 µg/m³, compared to 7 µg/m³ after the law, when indoor smoking was prohibited (Figure 1). Statistical analysis of the log transformed PM_{2.5} concentrations shows this was a significant 98% reduction in fine particle indoor air pollution (*t*(12)=12.0, *p*<0.001).

Table 1. Average PM_{2.5} Level in Each Venue in Omaha, Nebraska: Pre-law and Post-law

Venue number	Venue Type	Volume (m ³)	Pre-Law				Post-Law			
			People (mean)	Cigarettes (mean)	Smoker Density*	Mean PM _{2.5} (µg/m ³)	People (mean)	Cigarettes (mean)	Smoker Density*	Mean PM _{2.5} (µg/m ³)
1	Stand-alone Bar	433	19	6.7	1.54	363	23	0.0	0.00	4
2	Keno	288	37	1.3	0.46	59	123	0.0	0.00	4
3	Stand-alone Bar	272	25	2.8	1.03	157	40	0.0	0.00	7
4	Keno	552	40	10.0	1.81	267	33	0.0	0.00	3
5	Stand-alone Bar	166	36	7.3	4.43	435	26	0.0	0.00	9
6	Stand-alone Bar	612	30	9.0	1.47	371	14	0.0	0.00	16
7	Stand-alone Bar	1,284	68	10.0	0.78	482	13	0.3	0.03	2
8	Stand-alone Bar	510	94	9.0	1.77	328	21	0.0	0.00	23
9	Keno	1,430	73	11.0	0.77	123	36	0.0	0.00	6
10	Keno	372	27	2.7	0.72	269	44	0.0	0.00	5
11	Stand-alone Bar	227	16	1.7	0.74	637	26	0.0	0.00	*47
12	Stand-alone Bar	247	35	7.5	3.04	921	16	0.0	0.00	3
13	Keno	765	13	1.0	0.13	57	35	0.0	0.00	5
Mean		550	39	6.2	1.44	344	35	0.0	0.00	7

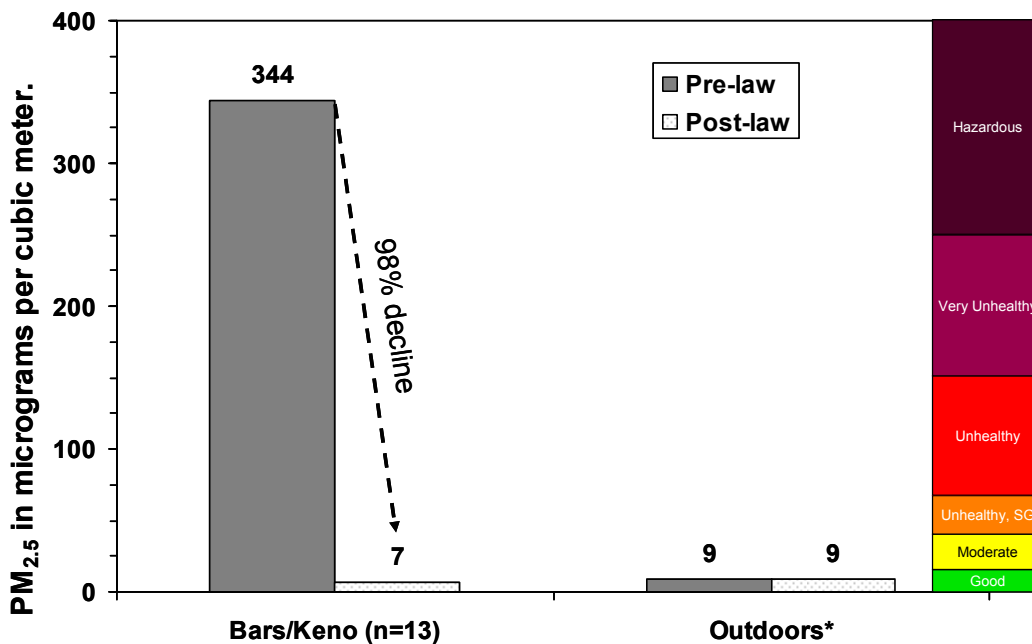
* Monitor was located near door to outdoor smoking area. Smoke drifting indoors was observed.

The average smoker density before the law was 1.44 burning cigarettes per 100 m³ and dropped to 0.00 burning cigarettes per 100 m³ after the law (note that there was one observed cigarette during post-law sampling but the ASD rounds to 0.00). Observed compliance with the smokefree air ordinance was 92% (12 of 13 venues) as one burning cigarette was observed in venue #7 after the law. Looking at all 26 sample visits combined (13 pre-law and 13 post-law) PM_{2.5} level was significantly correlated with the active smoker density ($r_s=0.83$, $p<0.001$), indicating that the amount of indoor smoking is the primary driver of the indoor particle pollution levels.

Venue #11 had the highest level of PM_{2.5} during the post-law sampling (47 µg/m³). Observational notes from this visit indicate that the air monitor was located near an open door to the outdoor smoking area and smoke was observed drifting indoors.

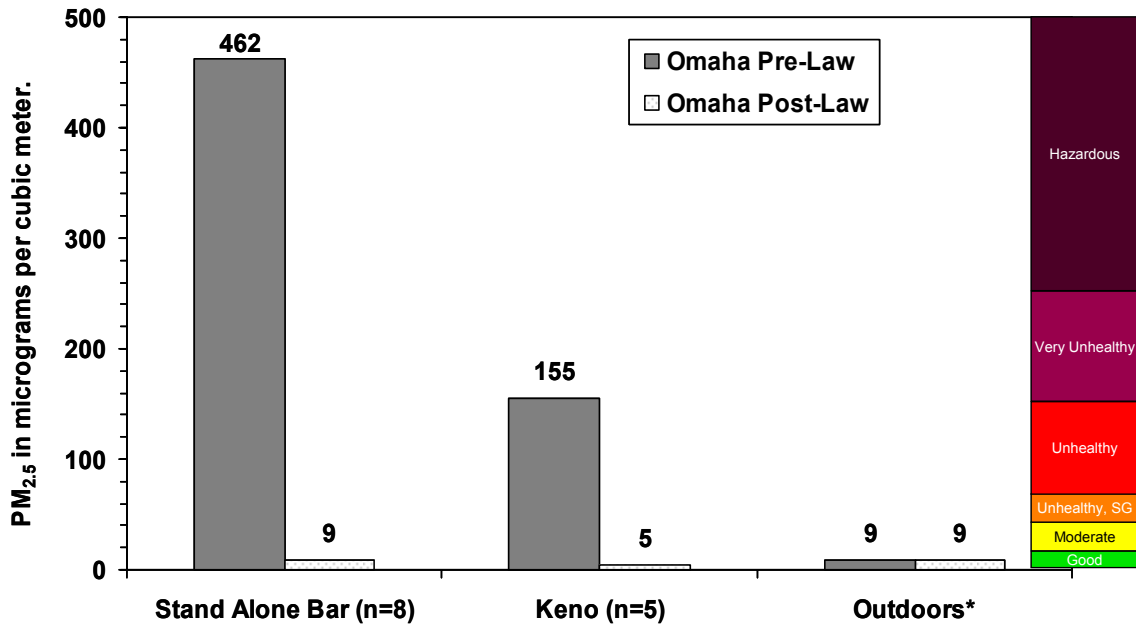
The locations visited were also stratified by type of location with the strata being bars and keno establishments. As seen in Figure 2, the average pre-law indoor PM_{2.5} concentration in bars was significantly higher (462 µg/m³) than the average concentration keno establishments (155 µg/m³). The higher PM_{2.5} concentration in bars is consistent with the higher smoker density in bars compared to keno establishments (1.85 versus 0.78 burning cigs per 100 m³). After the law, both bars and keno establishments had low PM_{2.5} levels similar to outdoor air in Omaha.

Figure 1. Average Level of Air Pollution in Omaha, Nebraska



*2006 (pre-law) and 2008 (post-law) respectively, average for Omaha, Nebraska. US EPA AirData report generated February 25, 2009 from <http://www.epa.gov/air/data/>
 Note: The color-coded US EPA Air Quality Index is shown to illustrate the magnitude of the measured particle concentrations. (SG=sensitive groups)

Figure 2. Average Level of Indoor Air Pollution in Omaha, Nebraska Establishments by Type of Venue



*2006 (pre-law) and 2008 (post-law) respectively, average for Omaha, Nebraska. US EPA AirData report generated February 25, 2009 from <http://www.epa.gov/air/data/>
 Note: The color-coded US EPA Air Quality Index is shown to illustrate the magnitude of the measured particle concentrations. (SG=sensitive groups)

The real-time plots showing the level of indoor air pollution in each venue sampled are presented in Figures 3 through 8. Figures 3-5 show the results of the pre-law sampling and Figures 6-8 show the same venues sampled post-law. Note that the scale on the y-axis is twice as large for pre-law (Figures 3-5) compared to post-law (Figures 6-8). The real-time PM_{2.5} plots throughout the duration of sampling reveal the following results: 1) low background levels are observed outdoors; 2) much higher levels of indoor air pollution are observed before the law when indoor smoking was permitted; and 3) peak exposure levels in some venues when smoking was permitted reached levels far in excess of the average recorded level.

Discussion

The EPA cited over 80 epidemiologic studies in creating a particulate air pollution standard in 1997.[11] The EPA has recently updated this standard and, in order to protect the public health, the EPA has set limits of $15 \mu\text{g}/\text{m}^3$ as the average annual level of $\text{PM}_{2.5}$ exposure and $35 \mu\text{g}/\text{m}^3$ for 24-hour exposure.[11, 12] In order to compare the findings in this study with the annual EPA $\text{PM}_{2.5}$ 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 $344 \mu\text{g}/\text{m}^3$ (the average level in all sites before the law) on the job, and is exposed only to background particle levels of $9 \mu\text{g}/\text{m}^3$ during non-work times. For a full-time employee their average annual $\text{PM}_{2.5}$ exposure is $85 \mu\text{g}/\text{m}^3$. The EPA average annual $\text{PM}_{2.5}$ limit is exceeded by 5.7 times due to their occupational exposure. After the smokefree air law, workers are exposed to an average particle concentration of $7 \mu\text{g}/\text{m}^3$ and, for a full-time employee in these Omaha venues, the average annual exposure is $9 \mu\text{g}/\text{m}^3$, a safe level according to the EPA. Based on the latest scientific evidence, the EPA staff currently proposes even lower $\text{PM}_{2.5}$ standards to adequately protect the public health,[13] making the high $\text{PM}_{2.5}$ 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 smokefree venues and those that permit smoking. 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.[14] 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.[15] 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.[16] 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 smokefree air laws, even though compliance with the laws was less than 100%.[17]

Other studies have directly assessed the effects SHS exposure has on human health. Rapid improvements in the respiratory health of bartenders were seen after a state smokefree workplace law was implemented in California[18]. Smokefree 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.[19] Farrelly et al. also showed a significant decrease in both salivary cotinine concentrations and sensory symptoms in hospitality workers after New York State's smokefree law prohibited smoking in their worksites.[20] A meta-analysis of the 8 published studies looking at the effects of smokefree air policies on heart attack admissions yielded an estimate of an immediate 19% reduction in heart attack admissions associated with these laws.[21]

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.[22]

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. The health effects of secondhand smoke exposure are detailed in recent reports by the California Environmental Protection Agency[23] and the U.S. Surgeon General[24].

Conclusions

This study demonstrates that employees and patrons in Omaha bars and keno establishments were exposed to harmful levels of indoor air pollution resulting from indoor smoking, but now benefit from safe air quality as a result of the smokefree air ordinance. This will result in improved quality of life and health outcomes for Omaha workers and residents.

Acknowledgments

This study was funded by the Nebraska Department of Health and Human Services.

Special thanks go to staff and volunteers from Tobacco Free Nebraska and the American Cancer Society who collected the data for this study.

Support for Roswell Park Cancer Institute researchers was also provided by the Flight Attendant Medical Research Institute.

Roswell Park Cancer Institute (RPCI) is America's first cancer center founded in 1898 by Dr. Roswell Park. RPCI is the only upstate New York facility to hold the National Cancer Center designation of "comprehensive cancer center" and to serve as a member of the prestigious National Comprehensive Cancer Network.

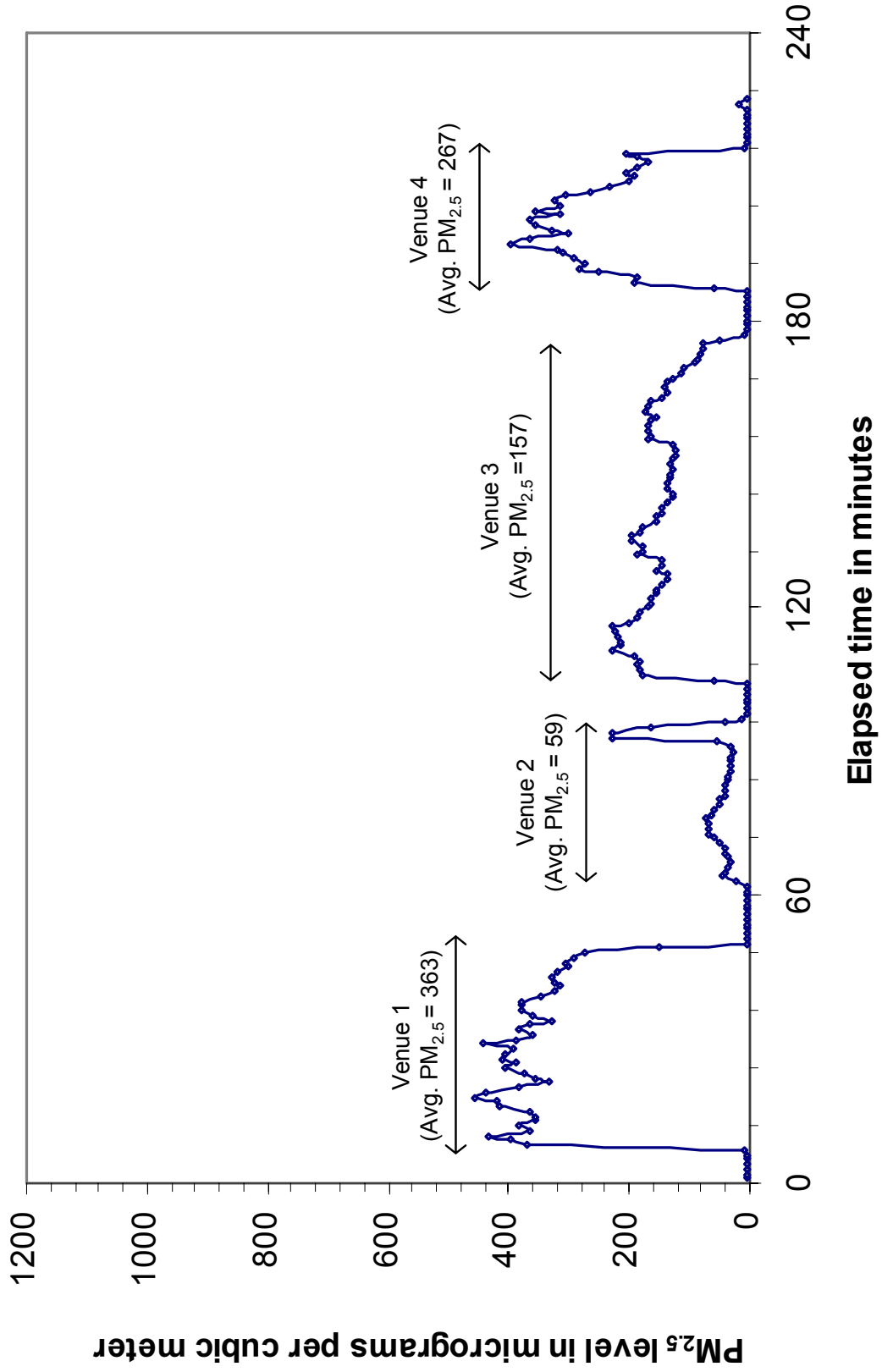
Over its long history, Roswell Park Cancer Institute has made fundamental contributions to reducing the cancer burden and has successfully maintained an exemplary leadership role in setting the national standards for cancer care, research and education.

The campus spans 25 acres in downtown Buffalo and consists of 15 buildings with about one million square feet of space. A new hospital building, completed in 1998, houses a comprehensive diagnostic and treatment center. In addition, the Institute built a new medical research complex and renovated existing education and research space to support its future growth and expansion.

For more information about Roswell Park and cancer in general, please contact the Cancer Call Center at 1-877-ASK-RPCI (1-877-275-7724).



Figure 3
Nebraska Air Monitoring Study – Omaha Pre-Law: December, 2006



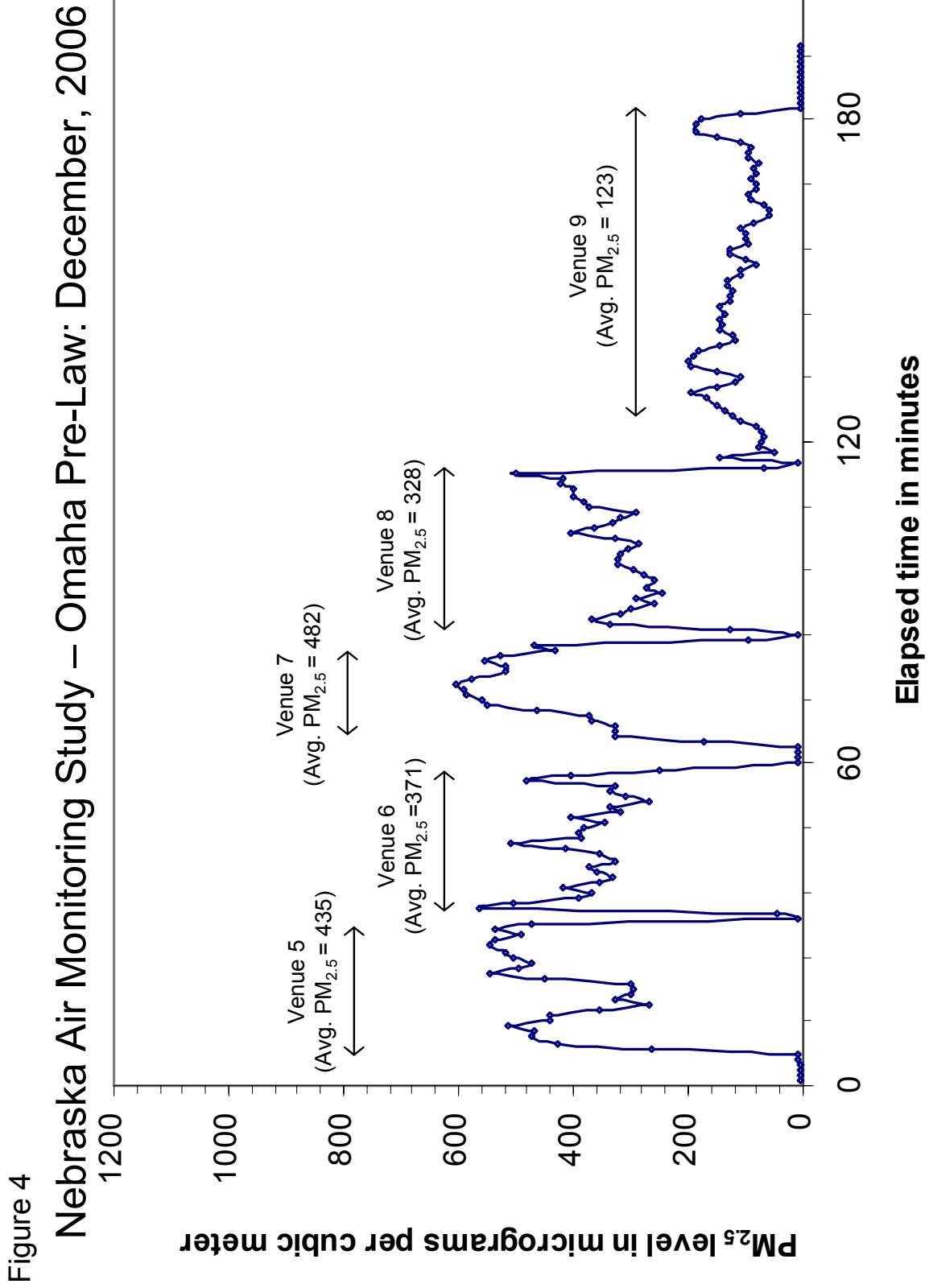
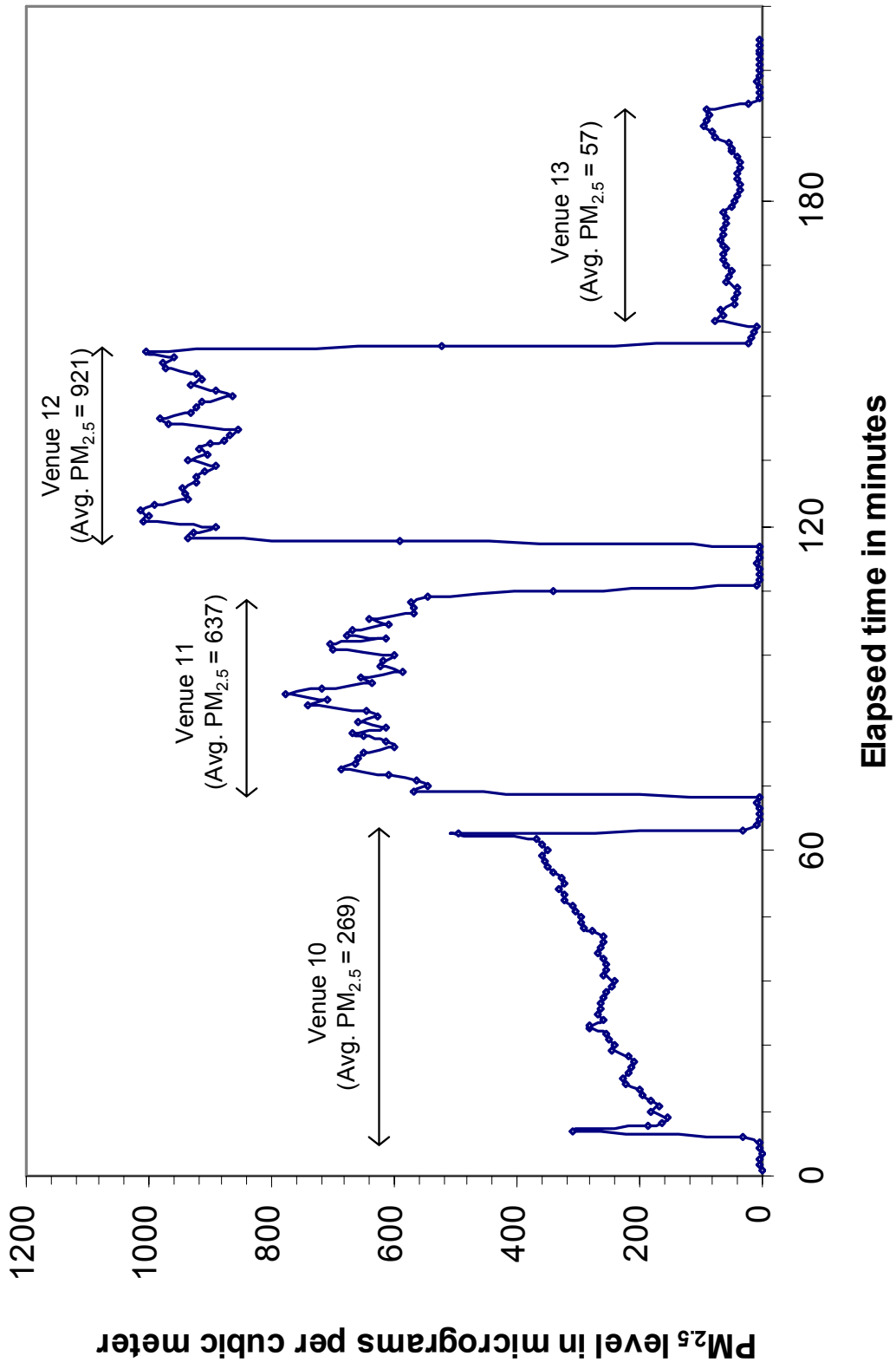


Figure 5
Nebraska Air Monitoring Study – Omaha Pre-Law: December, 2006



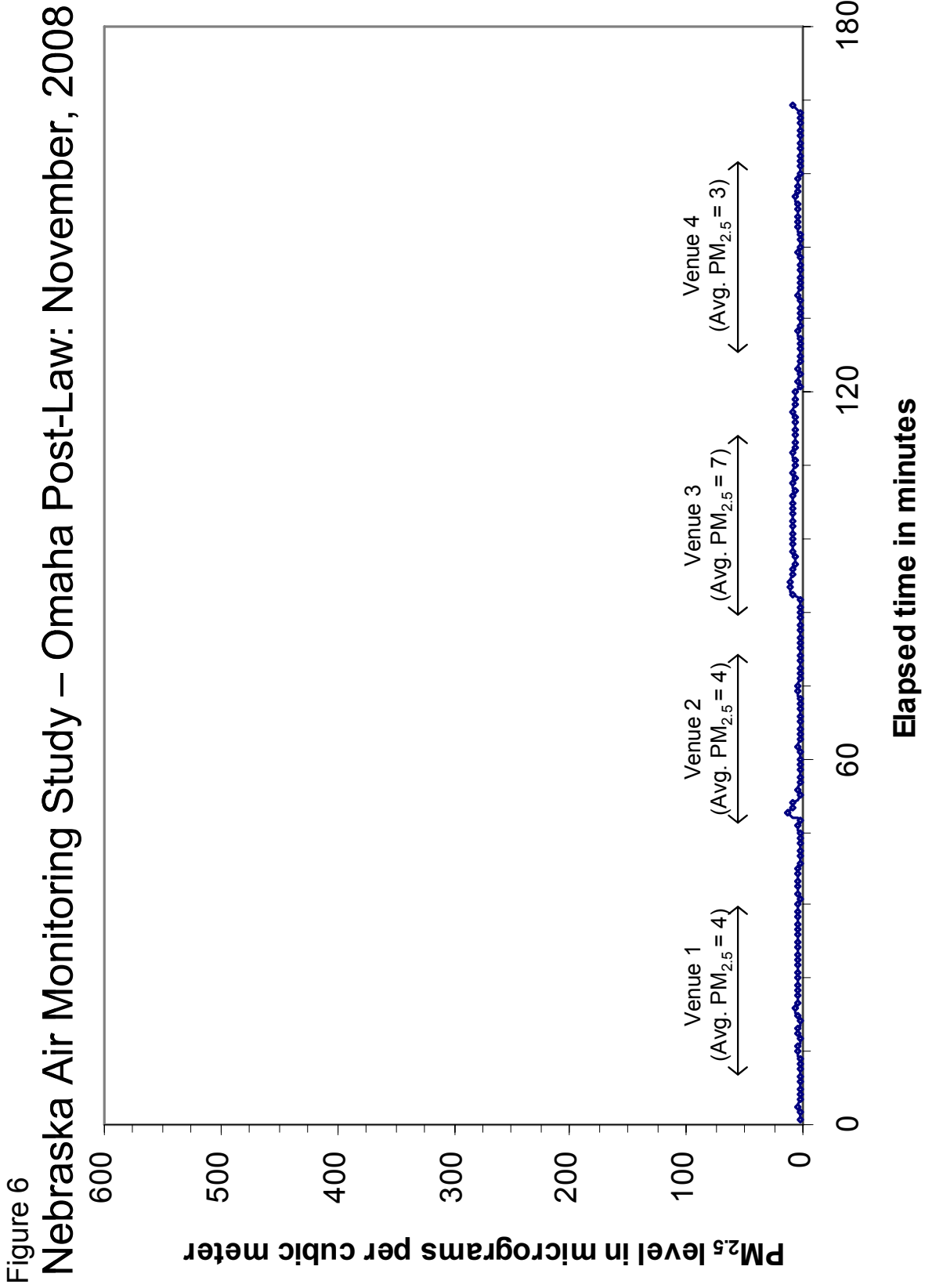
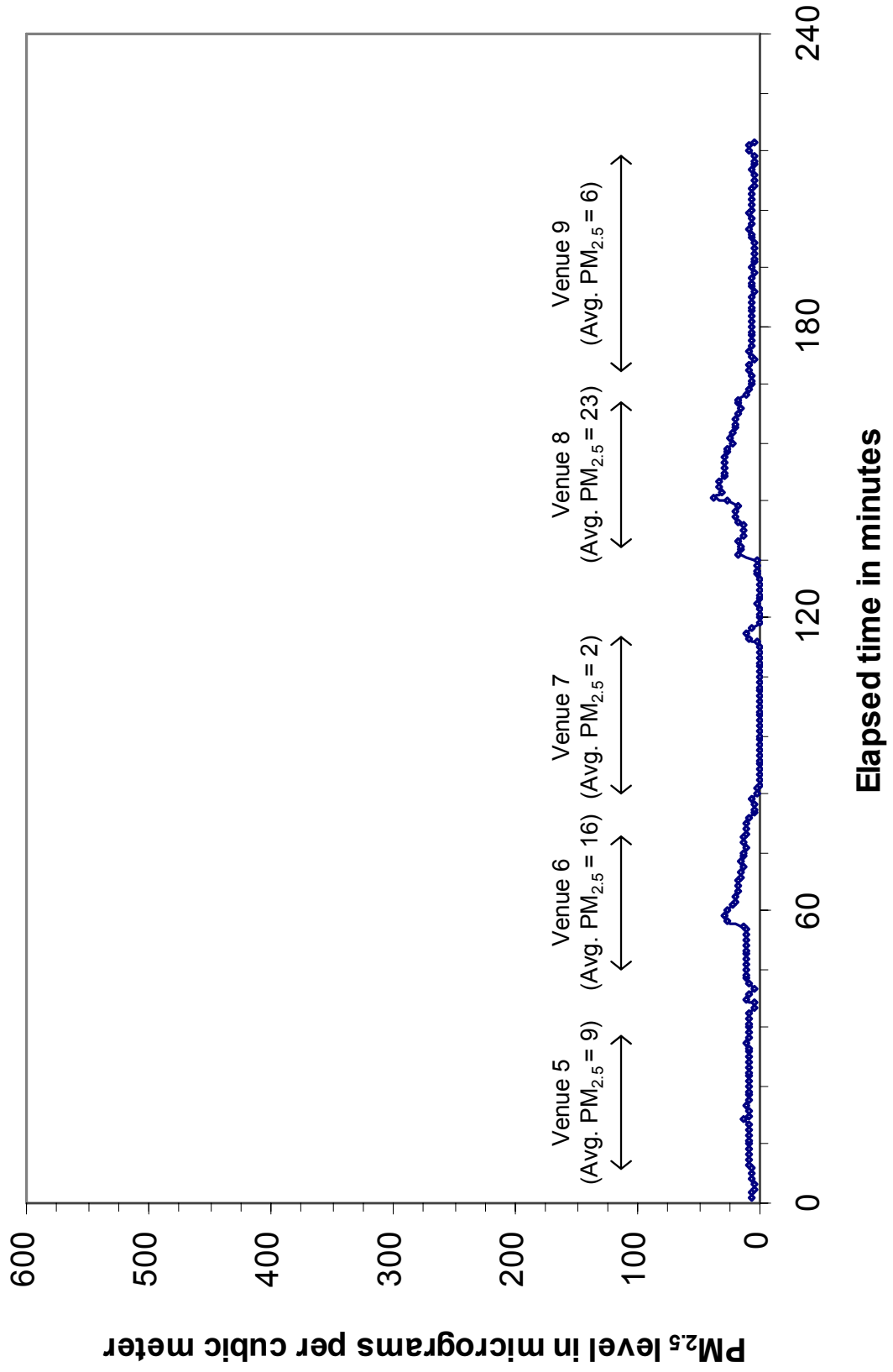
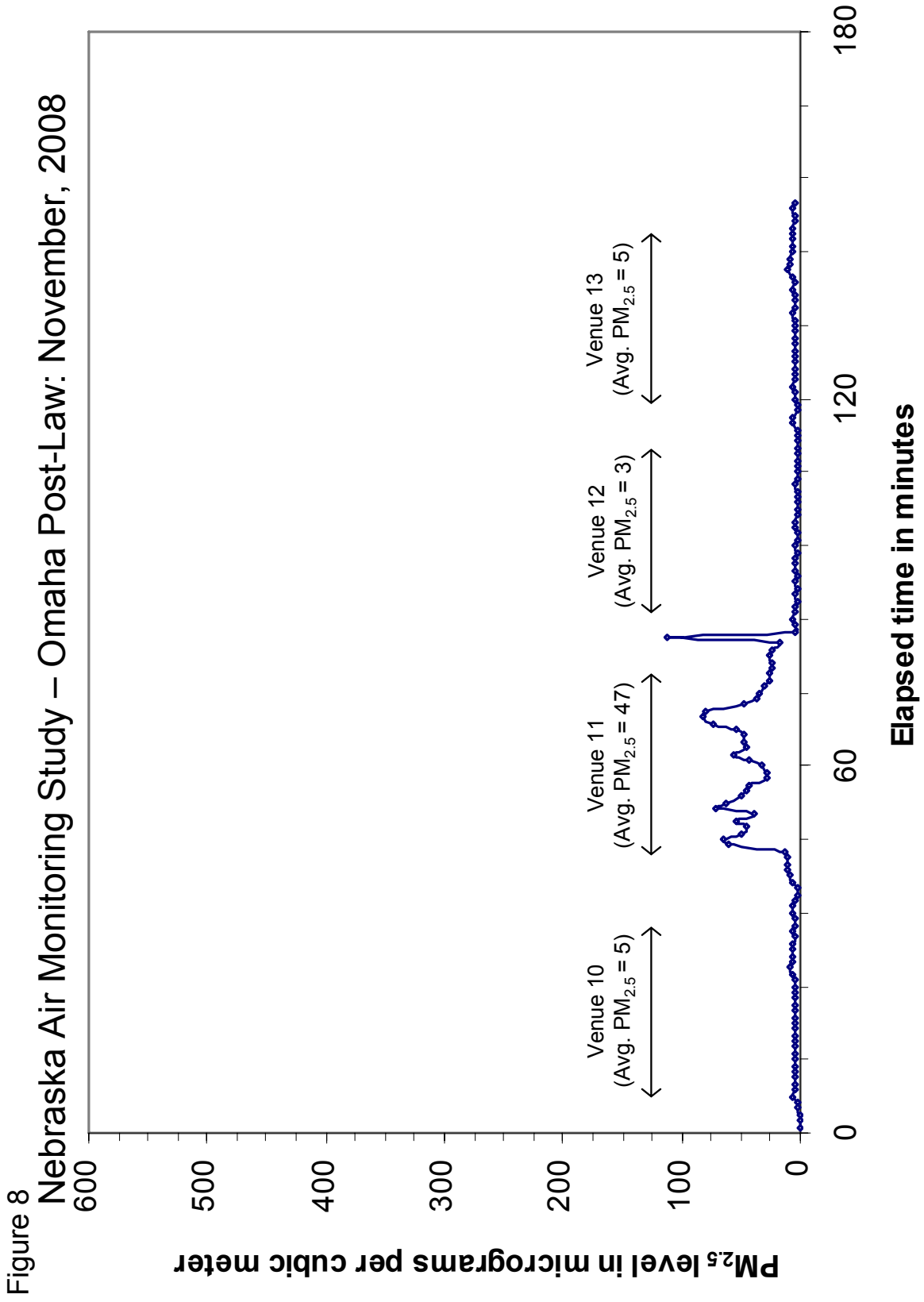


Figure 7
Nebraska Air Monitoring Study – Omaha Post-Law: November, 2008





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