Multi-City Air Monitoring Study, March-July 2004.

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Executive Summary

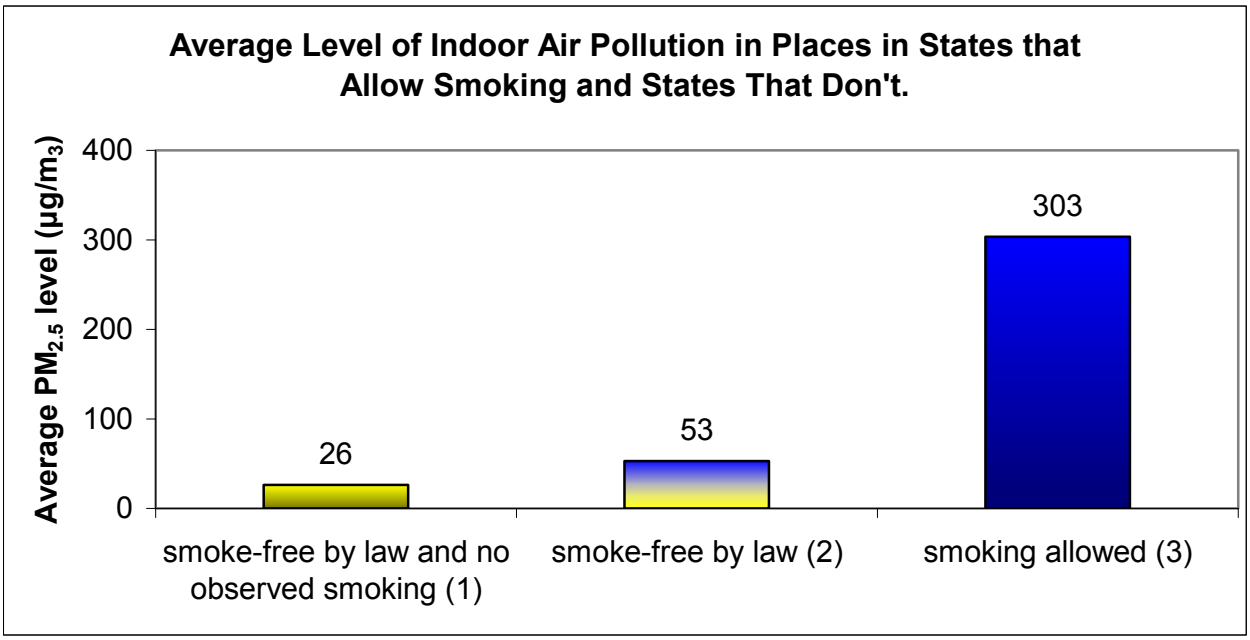
Indoor air quality was assessed in 61 bars and restaurants in eight cities in seven states between March 27 and July 9, 2004 using the TSI SidePak AM510 Personal Aerosol Monitor. Venues were sampled in Los Angeles, Buffalo, Baltimore, Washington DC, Philadelphia, Hoboken, New York City, and Galveston. A minimum of six venues were sampled in each city and were chosen from at least two popular entertainment districts to enhance the representativeness of selected venues. Twenty-three (23) venues sampled were required to be smoke-free by state or city law and 38 venues were not required to provide a smoke-free environment. The Personal Aerosol Monitor measures respirable suspended particles (RSP) or more specifically, $PM_{2.5}$. $PM_{2.5}$ 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 and are easily inhaled deep into the lungs. These particles are associated with respiratory and cardiovascular illness and death. In addition, these particles serve as an indicator of the amount of the over 250 chemicals in secondhand smoke that are known to be toxic or carcinogenic. Key findings of the study include:

- The level of $PM_{2.5}$ was 83% lower in the venues required by state or city law to be smoke-free compared to those venues where smoking was permitted without restrictions.
- In the venues required to be smoke-free by law and that were actually compliant with the law, the level of $PM_{2.5}$ was 91% lower compared to those venues where smoking was permitted without restrictions
- The US Environmental Protection Agency establishes an annual $PM_{2.5}$ standard level of 15 $\mu g/m^3$ (micrograms per cubic meter of air) in order to protect public health with an adequate margin of safety[1]. The average $PM_{2.5}$ level observed in venues in states where smoking was

permitted without restriction was 303 $\mu g/m^3$. For a full-time employee in such a venue, this EPA limit is exceeded by 4-fold just from occupational exposure.

- The three cities that require bars and restaurants to be smoke-free had the lowest indoor pollution levels: New York City (25 $\mu g/m^3$), Buffalo (27 $\mu g/m^3$) and Los Angeles (94 $\mu g/m^3$ or 26 $\mu g/m^3$ in venues compliant with the law)
- The highest levels of indoor air pollution were found in the five cities with no restrictions on indoor smoking: Washington, DC (392 $\mu g/m^3$), Galveston (343 $\mu g/m^3$), Baltimore (293 $\mu g/m^3$), Philadelphia (254 $\mu g/m^3$), and Hoboken (231 $\mu g/m^3$).
- Observed compliance was high – no smoking was observed in 87% of the venues that were required to be smoke-free by law.

Figure 1. RSP levels in all venues sampled between March 27 and July 9, 2004

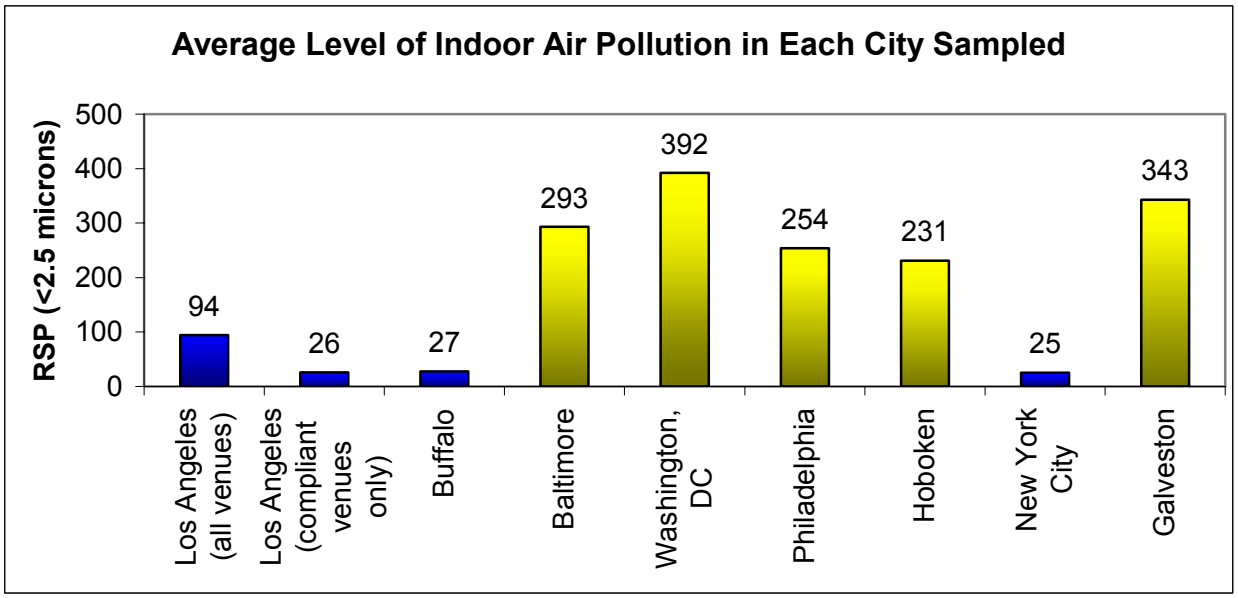


(1) These 20 venues were smoke-free by law and no smoking was observed during air monitoring; i.e. all venues that were compliant with the law

(2) These 23 venues were smoke-free by law but they include 3 venues where smoking was observed; i.e. 3 venues were non-compliant with the law

(3) These 38 venues were in states that allow smoking

Figure 2. RSP levels in bars/restaurants for each city sampled, March 27 to July 9, 2004.



NOTE: Yellow bars represent cities in states that allow smoking in bars and restaurants. Blue bars represent cities in states that prohibit smoking in bars and restaurants.
NOTE: All venues sampled in LA are smokefree by law. However, in 3 of the 9 sampled venues smoking was observed; that is 3 of the 9 venues were not compliant with the law

City	Number of Venues	Avg. size (m^3)	Avg. # people in venue	Avg. active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
Los Angeles (all venues)	9	331	37	0.3	94
Los Angeles (compliant venues only)	6	410	39	0.0	26
Buffalo	7	428	62	0.0	27
Baltimore	9	525	61	1.0	293
Washington, DC	7	214	73	1.9	392
Philadelphia	7	577	84	1.2	254
Hoboken	7	320	62	1.5	231
New York City	7	323	75	0.0	25
Galveston	8	668	43	0.8	343

NOTES:
* Average number of burning cigarettes per $100m^3$
The average PM2.5 level in all venues where smoking was not permitted was 53 (µg/m3).
The average PM2.5 level in all venues where smoking was permitted was 303 (µg/m3).

Introduction

Secondhand smoke (SHS) contains at least 250 chemicals that are known to be toxic or carcinogenic, and is itself a known human carcinogen[2], responsible for an estimated 3,000 lung cancer deaths annually in never smokers in the U.S. as well as over 35,000 deaths annually from coronary heart disease in never smokers and respiratory infections, asthma, Sudden Infant Death Syndrome, and other illnesses in children[3]. Even short-term exposures to SHS, such as those that might be experienced by a patron in a restaurant or bar that allows smoking, may increase the risk of experiencing an acute cardiovascular event[4]. 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[5,6]. Because policies requiring smoke-free environments are the most effective method for reducing SHS exposure in public places[7], Healthy People 2010 Objective 27-13 encourages all states and the District of Columbia to establish laws on smoke-free indoor air that prohibit smoking or limit it to separately ventilated areas in public places and worksites. Currently, 7 states (California, Delaware, New York, Maine, Connecticut, Massachusetts and Rhode Island) have passed comprehensive clean indoor air regulations that cover virtually all indoor worksites including bars and restaurants.

The EPA cited over 80 epidemiologic studies in creating a particulate air pollution standard in 1997[8]. 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 65 $\mu g/m^3$ 24-hour exposure[8]. $PM_{2.5}$ 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 and are easily inhaled deep into the lungs.

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. 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[9]. Repace studied 8 hospitality venues 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].

Other studies have directly assessed the role SHS exposure has on human health. One study found that respiratory health improved rapidly in a sample of bartenders after a state clean smoke-free workplace law was implemented in California[11], 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[12].

The purpose of this study was to examine indoor air quality in a large sample of hospitality venues from multiple states to assess the relationship among indoor air pollution levels, the presence of smoke-free regulations, and the presence of on-premise smoking. We also assessed the consistency of these relationships across a wide geographic region. We hypothesize that indoor air quality will be greater in those venues where smoking is prohibited by law and where no smoking is occurring than in those places where smoking is unregulated. We also hypothesize that the improvement in indoor air quality will be consistent across study locations.

Methods

Overview

Between March 27 and July 9, 2004, indoor air quality was assessed in 61 bars and restaurants in eight cities located in seven states. Descriptive information about each venue is presented in Table 1.

Three cities are in states that require virtually all bars and restaurants to be smoke-free (Los Angeles, CA; Buffalo, NY; and New York City, NY). California has required bars and restaurants to be smoke-free since January 1998, and similar smoke-free regulations took effect in New York City in March 2003 and in New York State in July 2003.

Five cities are in states where smoking is generally unregulated in bars and restaurants (Baltimore, MD; Washington, DC; Hoboken, NJ; Philadelphia, PA; and Galveston, TX).

Procedure for Selection of Cities and Venues to be Sampled

The eight cities were selected to represent highly populated areas that either have or have not implemented comprehensive smoke-free regulations. Within each city, efforts were made to visit a minimum of 3 bars and 3 restaurants in each city, and at least two popular entertainment districts were visited in each city. With the help of local contacts, a list of candidate venues believed to be representative of hospitality venues in each entertainment district was created. This list served as the basis for selecting venues for air sampling. Additional locations, which were in close proximity to other locations sampled, were selected throughout the course of the evening in some cities. Most sampling was performed on Thursday, Friday, and Saturday evenings (84% of venues) and the other 16% of venues were sampled on Wednesday, Sunday, or a Monday. All sampling occurred

between 6PM and 3AM. Table 1 presents some general descriptive information on the size and occupancy of each venue.

Table 1.

Venue Number	City	Smoke-free By Law?*	Was Smoking Observed?	Date Sampled	Active smoker density**	Average PM2.5 level (µg/m3)
1	Los Angeles	Yes	No	March 27, 2004	0.0	23
2	Los Angeles	Yes	No	March 27, 2004	0.0	19
3	Los Angeles	Yes	No	March 28, 2004	0.0	15
4	Los Angeles	Yes	No	March 28, 2004	0.0	26
5	Los Angeles	Yes	Yes	March 28, 2004	0.4	128
6	Los Angeles	Yes	Yes	March 28, 2004	2.5	496
7	Los Angeles	Yes	Yes	March 28, 2004	0.2	70
8	Los Angeles	Yes	No	March 29, 2004	0.0	4
9	Los Angeles	Yes	No	March 29, 2004	0.0	66
10	Buffalo	Yes	No	April 3, 2004	0.0	26
11	Buffalo	Yes	No	April 3, 2004	0.0	11
12	Buffalo	Yes	No	April 3, 2004	0.0	6
13	Buffalo	Yes	No	April 3, 2004	0.0	12
14	Buffalo	Yes	No	April 3, 2004	0.0	18
15	Buffalo	Yes	No	April 3, 2004	0.0	116
16	Buffalo	Yes	No	April 3, 2004	0.0	3
17	Baltimore	No	Yes	April 7, 2004	0.2	70
18	Baltimore	No	Yes	April 7, 2004	0.7	496
19	Baltimore	No	Yes	April 7, 2004	2.8	636
20	Baltimore	No	Yes	April 8, 2004	0.1	67
21	Baltimore	No	Yes	April 8, 2004	0.2	89
22	Baltimore	No	Yes	April 8, 2004	0.3	87
23	Baltimore	No	Yes	April 8, 2004	2.1	424
24	Baltimore	No	Yes	April 8, 2004	1.4	526
25	Baltimore	No	Yes	April 8, 2004	1.0	244
26	Washinton, DC	No	Yes	April 9, 2004	1.0	220
27	Washinton, DC	No	No	April 9, 2004	0.0	76
28	Washinton, DC	No	Yes	April 9, 2004	1.6	207
29	Washinton, DC	No	Yes	April 9, 2004	2.5	285
30	Washinton, DC	No	Yes	April 9, 2004	3.9	607
31	Washinton, DC	No	Yes	April 9, 2004	2.2	1,119
32	Washinton, DC	No	Yes	April 9, 2004	1.9	229
33	Philadelphia	No	Yes	April 10, 2004	0.9	96
34	Philadelphia	No	Yes	April 10, 2004	0.6	83
35	Philadelphia	No	Yes	April 10, 2004	0.6	119
36	Philadelphia	No	Yes	April 10, 2004	2.0	391
37	Philadelphia	No	Yes	April 10, 2004	0.5	162
38	Philadelphia	No	Yes	April 10, 2004	2.1	436
39	Philadelphia	No	Yes	April 10, 2004	1.3	490
40	Hoboken	No	Yes	April 16, 2004	1.7	219
41	Hoboken	No	No	April 16, 2004	0.0	50
42	Hoboken	No	Yes	April 16, 2004	1.5	353
43	Hoboken	No	Yes	April 16, 2004	2.0	197
44	Hoboken	No	Yes	April 16, 2004	1.8	221
45	Hoboken	No	Yes	April 16, 2004	0.8	251
46	Hoboken	No	Yes	April 16, 2004	2.5	329
47	New York City	Yes	No	April 17, 2004	0.0	20
48	New York City	Yes	No	April 17, 2004	0.0	28
49	New York City	Yes	No	April 17, 2004	0.0	20
50	New York City	Yes	No	April 17, 2004	0.0	22
51	New York City	Yes	No	April 17, 2004	0.0	38
52	New York City	Yes	No	April 17, 2004	0.0	31
53	New York City	Yes	No	April 17, 2004	0.0	18
54	Galveston	No	Yes	July 8, 2004	0.1	90
55	Galveston	No	Yes	July 9, 2004	0.4	171
56	Galveston	No	Yes	July 9, 2004	1.6	207
57	Galveston	No	Yes	July 9, 2004	1.7	518
58	Galveston	No	Yes	July 9, 2004	1.0	982
59	Galveston	No	Yes	July 9, 2004	1.5	614
60	Galveston	No	Yes	July 9, 2004	0.2	100
61	Galveston	No	Yes	July 9, 2004	0.1	62

NOTES:

* Used to compare indoor air pollution levels between places that are required to be smoke-free and places that are not.

** Average number of burning cigarettes per $100m^3$

Measurement Protocol

The average time spent in each venue was 45 minutes (range, 20 minutes to 139 minutes). 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 Zircon DM S50 Sonic Measure (Zircon Corporation, Campbell, CA) 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 RSP in the air (see Figure 1). The SidePak uses a built-in sampling pump to draw air through the device where the particulate matter in the air scatter the light from a laser to assess the real-time concentration of particles larger than 2.5μm in milligrams per cubic meter. The SidePak was calibrated against a laser photometer, 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.

Figure 3. TSI SidePak AM510 Personal Aerosol Monitor

Secondhand smoke is not the only source of indoor particulate matter, but $PM_{2.5}$ monitoring is highly sensitive to it. While ambient particle concentrations and cooking are additional sources of

indoor particle levels, smoking is by far the largest contributor to indoor air pollution. Furthermore, there is a direct link between levels of RSP and polycyclic aromatic hydrocarbons (PAH), known carcinogens in cigarette smoke, with RSP levels being approximately 3 orders of magnitude greater than PAH's[10].

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. The monitor was generally located in a central location on a table or bar and not on the floor so the air being sampled was within the occupants' normal breathing zone. 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.

Definition of 'Smoke-free' Venue

'Smoke-free' venues are defined as those 23 venues that are required to be smoke-free by law, which include all of the venues in New York State and California. In three instances, smoking was observed in a venue that was required to be smoke-free. Treating these venues as 'smoke-free' provides a conservative test of the difference in indoor air quality across different hospitality venue regulations. In two instances, no smoking was observed in a venue where smoking was permitted by law, although smoking was occurring in other adjacent or downstairs locations within the same facility. Similarly, these venues were counted as 'smoking' in accordance with the prevailing statewide smoking regulations in bars and restaurants, which provides a conservative, but more realistic, test of the differences in indoor air pollution levels in places that are required to be smoke-free and places that are not.

Statistical Analyses

The primary goal was to assess the difference in the average levels of RSP in places that were smoke-free and places that were not, which is assessed with Mann Whitney U-test. Within each city, the mean RSP are reported across all of the venues sampled and these are compared with the mean levels of all venues in the entire sample were 'smoke-free' and those that were not. In addition, descriptive statistics including the venue volume, number of patrons, and average smoker density (i.e., number of burning cigarettes) per 100 m^3 is also reported for each venue and averaged for all venues.

Results

Across all 61 bars and restaurants sampled in this study, 23 were required to be smoke-free by state or city law and the average RSP level in these venues was 53 $\mu g/m^3$. Thirty-eight venues were sampled that were not required to be smoke-free, and the average RSP level in these venues was 303 $\mu g/m^3$ (Figure 1). The level of indoor air pollution was 83% lower in the venues that were required to be smoke-free compared to those where smoking was permitted. Additional details about each venue sampled are included in Table 1. The average volume of venues sampled was 430 m^3 and was comparable between places where smoking was prohibited and where it was not (386 m^3 vs. 442 m^3, respectively); however, the average smoker density was much greater in venues where smoking was not restricted by state law (0.1 burning cigarettes per 100 m^3 vs. 1.3 burning cigarettes per 100 m^3).

The average RSP level in the 22 venues where no smoking was observed during sampling was 29 $\mu g/m^3$ compared to 310 $\mu g/m^3$ in the 39 venues where smoking was observed (91% reduction). (NOTE: 3 bars were smoking in violation, but 2 bars were smoke-free even though state law permitted smoking – this explains the n=22 and n=39, which at first seem at odds with the previously reported data in Figure 1.)

Averaged across each city, the lowest levels of indoor air pollution were found in New York City (25 $\mu g/m^3$) and the highest levels were found in Washington, DC (392 $\mu g/m^3$, which includes one smoke-free venue in the calculation). The five cities without state smoking restrictions had the five highest average levels of RSP, and the three cities in states with smoke-free regulations had the lowest levels (Figure 2).

Details on the level of indoor air pollution in each city sampled are presented in Figures 4-10. Results from the real-time $PM_{2.5}$ plots throughout the duration of sampling for each city reveal the following three general trends: 1) much higher levels of indoor air pollution are observed in venues where smoking is permitted; 2) low levels are observed indoors before and after sampling as well as outdoors when the research teams was in transit between venues; and 3) peak exposure levels in some venues can reach levels far in excess of the average recorded level.

Los Angeles, California – March 27-29, 2004 (Figure 4)

Nine venues were sampled in Los Angeles, California between March 27, 2004 and March 29, 2004. Since January 1, 1998, all bars and restaurants are required by state law to be smoke-free. Of the nine venues sampled, smoking was observed in three venues and no smoking was observed in six venues. The average room volume was 331 m^3, and the average smoker density was 1.0 burning cigarettes per 100 m^3 in the 3 venues where smoking was observed and 0.0 in the other 6 venues. Average $PM_{2.5}$ level was 94 $\mu g/m^3$ for all nine venues, but was 10-fold higher in the three venues where smoking was observed (average 231 $\mu g/m^3$) compared to the average in the six smoke-free venues (average 26 $\mu g/m^3$).

Buffalo, New York – April 3, 2004 (Figure 5)

Seven venues were sampled in Buffalo, New York on April 3, 2004. Since July 24, 2003, all bars and restaurants are required by state law to be smoke-free, and no smoking was observed in any of the seven venues sampled. The average room volume was 428 m^3, and the average smoker density was zero. Average $PM_{2.5}$ level was 27 $\mu g/m^3$ for all 7 venues.

Baltimore, Maryland – April 7-8, 2004 (Figure 6)

Nine venues were sampled in Baltimore, Maryland on April 7, 2004 (one venue was sampled twice). Maryland law permits smoking in bars and restaurants, and smoking was observed in all venues visited. The average room volume was 525 m^3, and the average smoker density was 1.0 burning cigarettes per 100m^3. Average $PM_{2.5}$ level was 293 $\mu g/m^3$ for all 9 venues.

Washington, DC – April 9, 2004 (Figure 7)

Seven venues were sampled in Washington, DC on April 8, 2004. District of Columbia law permits smoking in bars and restaurants. Smoking was observed in six of the seven venues with the other being smoke-free at the time of sampling. The average room volume was 214 m^3, and the average smoker density was 2.2 in the 6 venues where smoking was observed. Average $PM_{2.5}$ level was 392 $\mu g/m^3$ for all seven venues, which includes the rating for the smoke-free facility.

Philadelphia, Pennsylvania – April 10, 2004 (Figure 8)

Seven venues were sampled in Philadelphia, Pennsylvania on April 10, 2004. Pennsylvania law permits smoking in bars and restaurants, and smoking was observed in all 7 venues. The average room volume was 577 m^3, and the average smoker density was 1.2 burning cigarettes per 100 m^3. Average $PM_{2.5}$ level was 254 $\mu g/m^3$ for all seven venues.

Hoboken, New Jersey – April 16, 2004 (Figure 9)

Seven venues were sampled in Hoboken, New Jersey on April 16, 2004. New Jersey law permits smoking in bars and restaurants, and smoking was observed in 6 of the 7 venues sampled with the other being smoke-free. The average room volume was 320 m^3, and the average smoker density was 1.7 burning cigarettes per 100 m^3 in the 6 venues where smoking was observed. Average $PM_{2.5}$ level was 231 $\mu g/m^3$ for all seven venues, which includes the smoke-free venue.

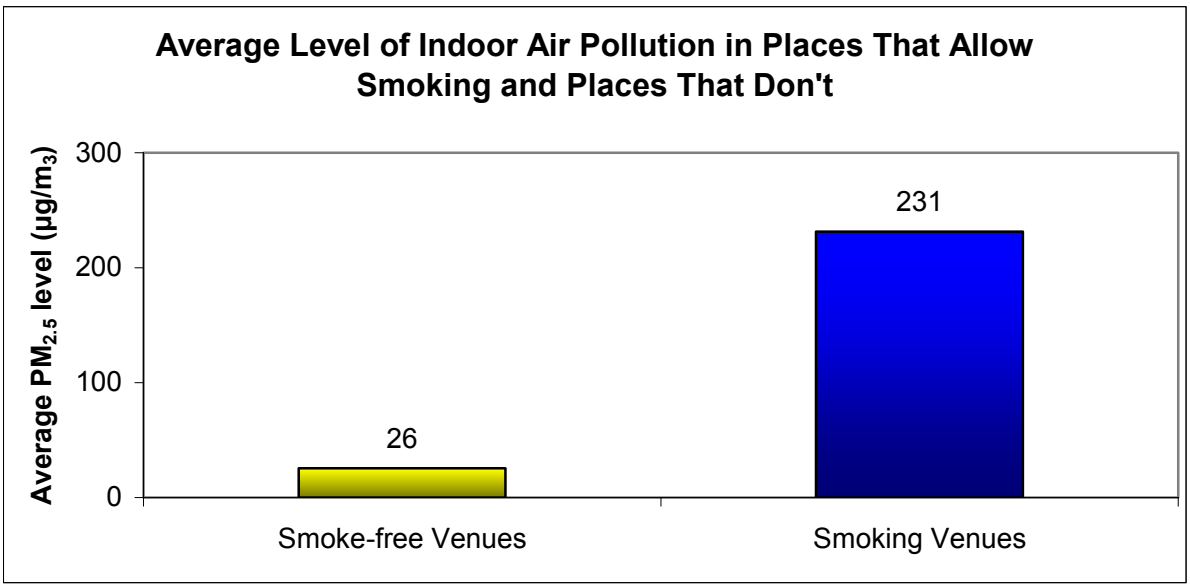
New York City, New York – April 17, 2004 (Figure 10)

Seven venues were sampled in New York City, New York on April 17, 2004. Since March 30, 2003, all bars and restaurants are required by city law to be smoke-free, and no smoking was observed in any of the seven venues sampled. The average room volume was 323 m^3, and the average smoker density was zero. Average $PM_{2.5}$ level was 25 $\mu g/m^3$ for all seven venues.

Galveston, Texas – July 8-9, 2004 (Figure 11)

Eight venues were sampled in Galveston, Texas on Thursday July 8th and Friday July 9th. Texas law permits smoking in bars and restaurants and smoking was observed in all eight venues. The average room volume was 668 m^3, and the average smoker density was 0.8 burning cigarettes per 100 m^3. Average $PM_{2.5}$ level was 343 $\mu g/m^3$ for all eight venues.

Figure 4. RSP levels in bars and restaurants sampled in Los Angeles, CA on March 27-29, 20(



Venue Number	Size (m^3)	# people in venue	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
Bars/Restaurants Where Smoking Was Occuring During Sampling				
5	151	29	0.4	128
6	224	48	2.5	496
7	146	20	0.2	70
Average	174	32	1.0	231
Smoke-free Bars/Restaurants				
1	175	15	0.0	23
2	389	45	0.0	19
3	714	45	0.0	15
4	366	50	0.0	26
8	547	39	0.0	4
9	267	40	0.0	66
Average	410	39	0.0	26

NOTES:

* Average number of burning cigarettes per $100m^3$

The average PM2.5 level in all venues where smoking was not permitted was 53 (µg/m3).

The average PM2.5 level in all venues where smoking was permitted was 303 (µg/m3).

Multi-City Air Monitoring Study: Los Angeles, CA March 27th – 29th, 2004

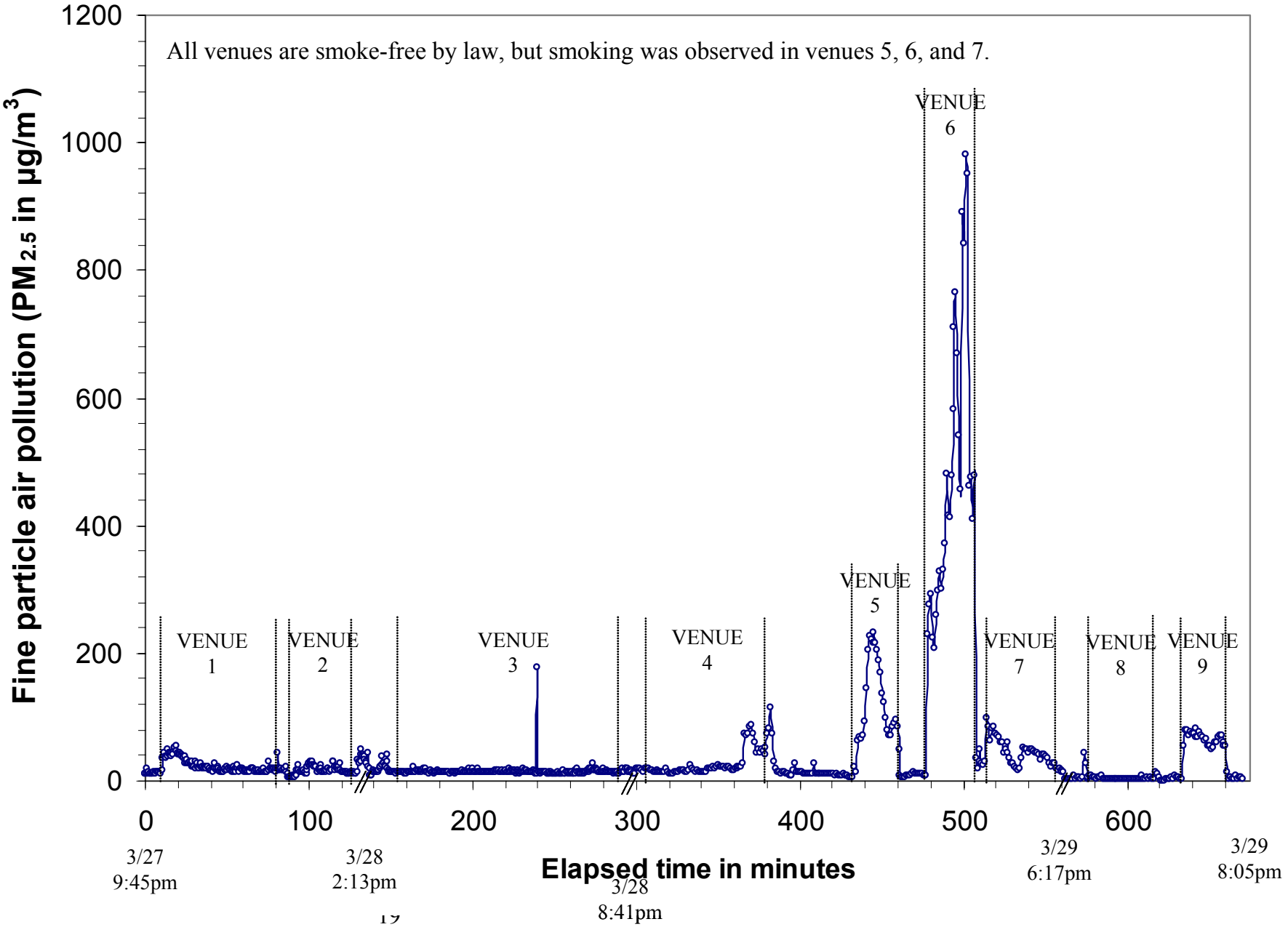
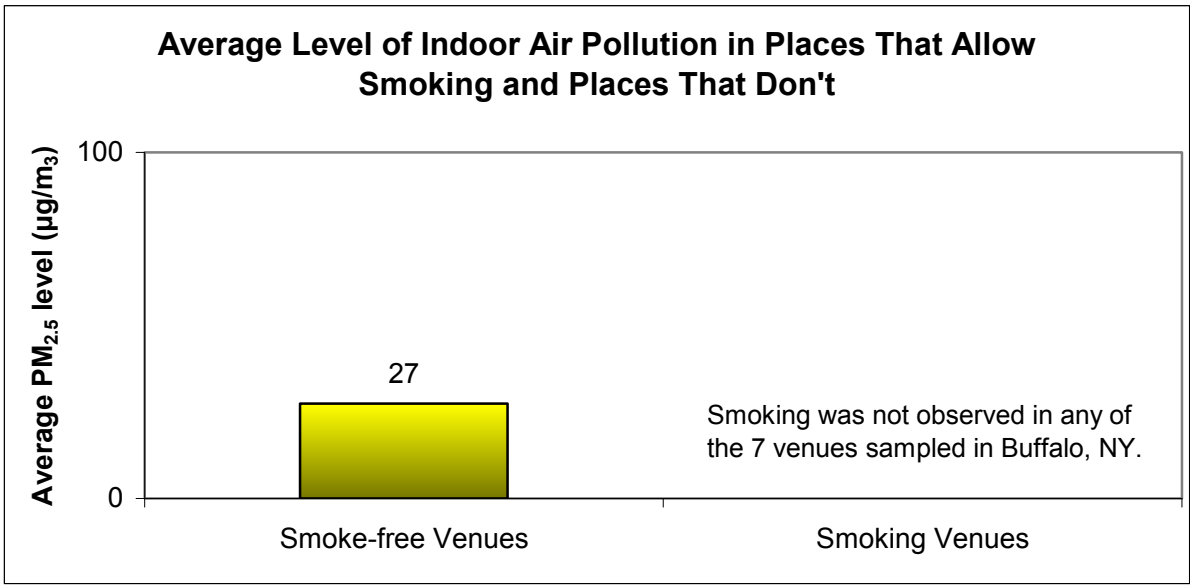


Figure 5. RSP levels in bars and restaurants sampled in Buffalo, NY on April 3, 2004.



Venue Number	Size (m^3)	# people in venue	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
Bars/Restaurants Where Smoking Was Occuring During Sampling				
All 7 Buffalo, NY venues sampled were smoke-free				
Smoke-free Bars/Restaurants				
10	713	121	0	26
11	663	110	0	11
12	349	19	0	6
13	333	13	0	12
14	393	25	0	18
15	319	89	0	116
16	223	57	0	3
Average	428	62	0	27

NOTES:

* Average number of burning cigarettes per $100m^3$

The average PM2.5 level in all venues where smoking was not permitted was 53 (µg/m3).

The average PM2.5 level in all venues where smoking was permitted was 303 (µg/m3).

Multi-City Air Monitoring Study: Buffalo, NY April 3rd, 2004

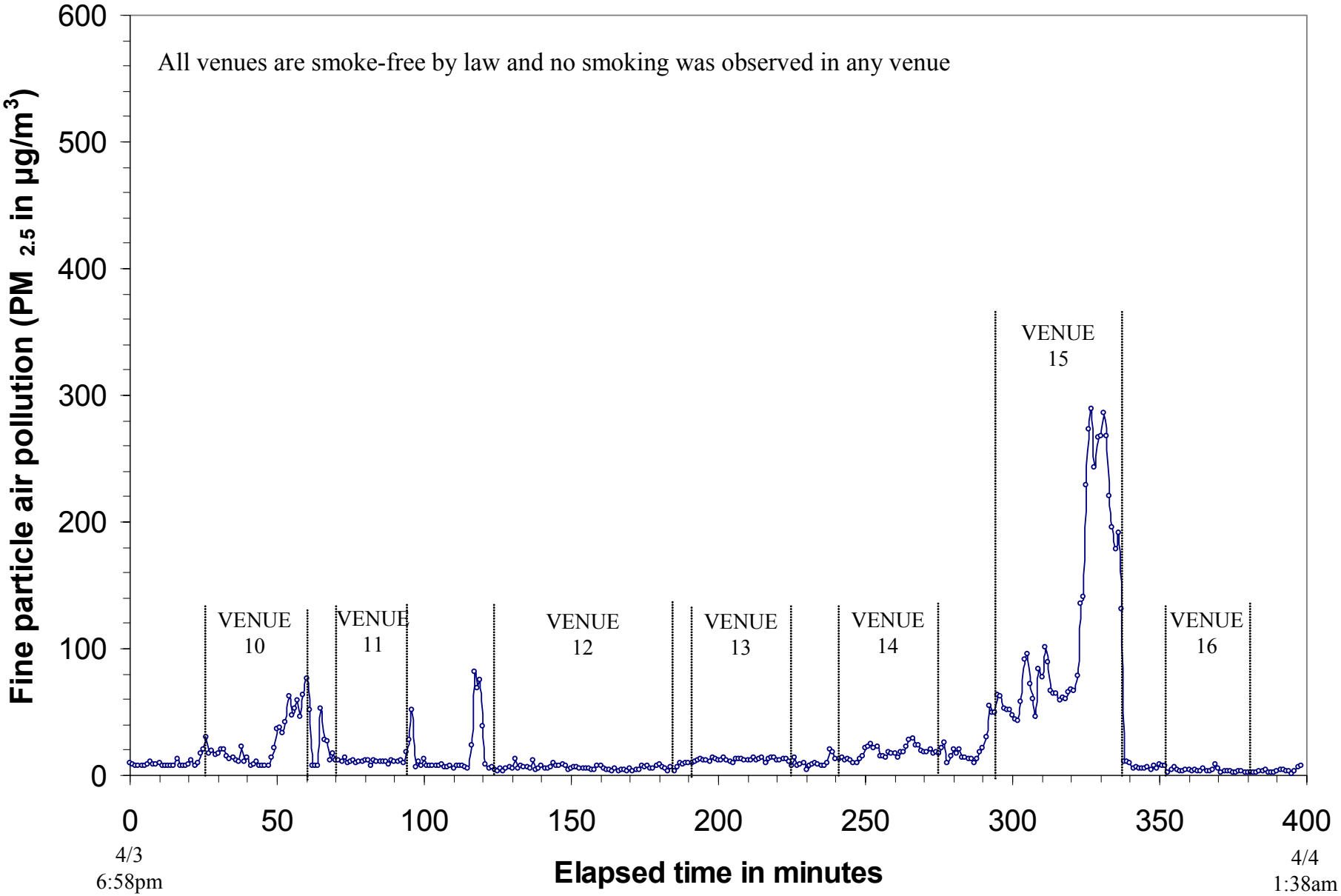
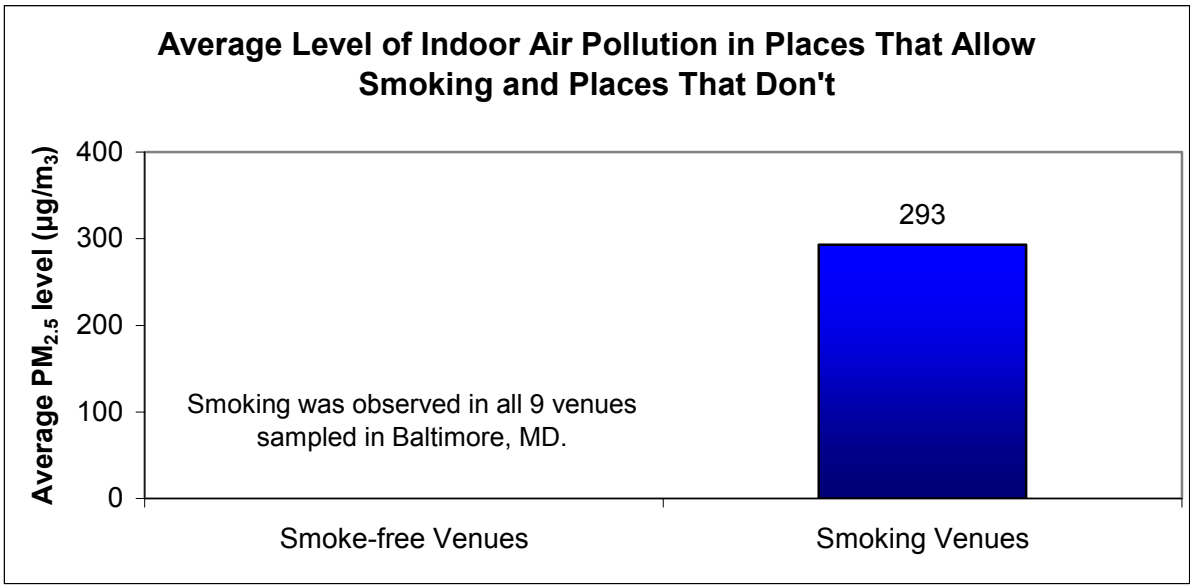


Figure 6. RSP levels in bars and restaurants sampled in Balitmore, MD on April 7 and 8, 2004.



Venue Number	Size (m^3)	# people in venue	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
Bars/Restaurants Where Smoking Was Occuring During Sampling				
17	1005	91	0.2	70
18	270	44	0.7	496
19	240	71	2.8	636
20	1005	86	0.1	67
21	605	36	0.2	89
22	413	54	0.3	87
23	235	48	2.1	424
24	581	87	1.4	526
25	371	37	1.0	244
Average	525	61	1.0	293

NOTES:

* Average number of burning cigarettes per $100m^3$

The average PM2.5 level in all venues where smoking was not permitted was 53 (µg/m3).

The average PM2.5 level in all venues where smoking was permitted was 303 (µg/m3).

Multi-City Air Monitoring Study: Baltimore, MD April 7th – 8th, 2004

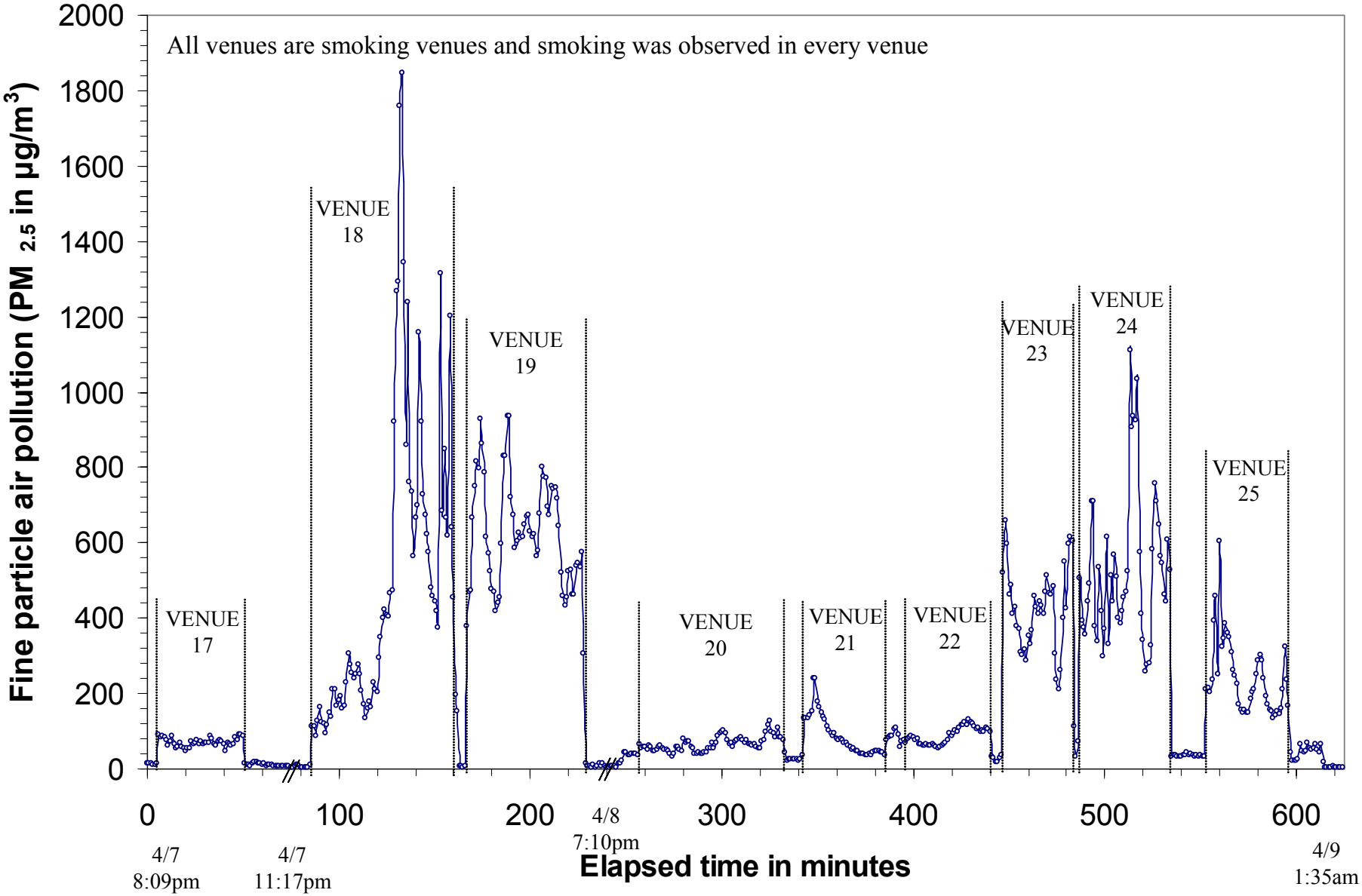
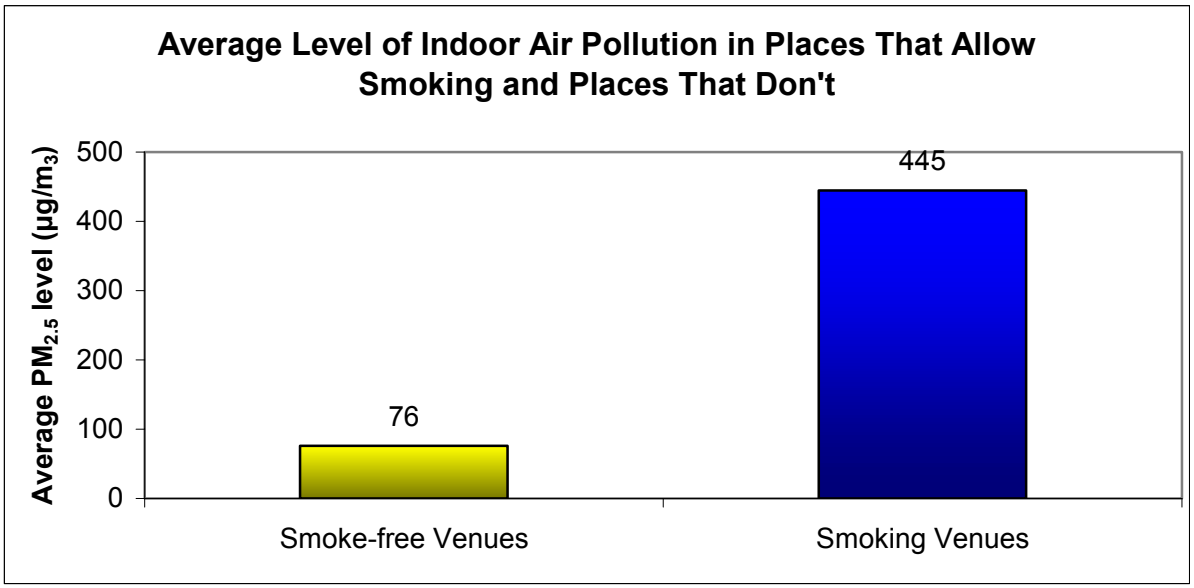


Figure 7. RSP levels in bars and restaurants sampled in Washington, DC on April 9, 2004.



Venue Number	Size (m^3)	# people in venue	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
Bars/Restaurants Where Smoking Was Occuring During Sampling				
26	199	85	1.0	220
28	193	46	1.6	207
29	185	81	2.5	285
30	162	79	3.9	607
31	124	42	2.2	1119
32	483	155	1.9	229
Average	224	81	2.2	445
Smoke-free Bars/Restaurants				
27	152	20	0.0	76
Average	152	20	0.0	76

NOTES:

* Average number of burning cigarettes per $100m^3$

The average PM2.5 level in all venues where smoking was not permitted was 53 (µg/m3).

The average PM2.5 level in all venues where smoking was permitted was 303 (µg/m3).

Multi-City Air Monitoring Study: Washington, DC April 9th, 2004

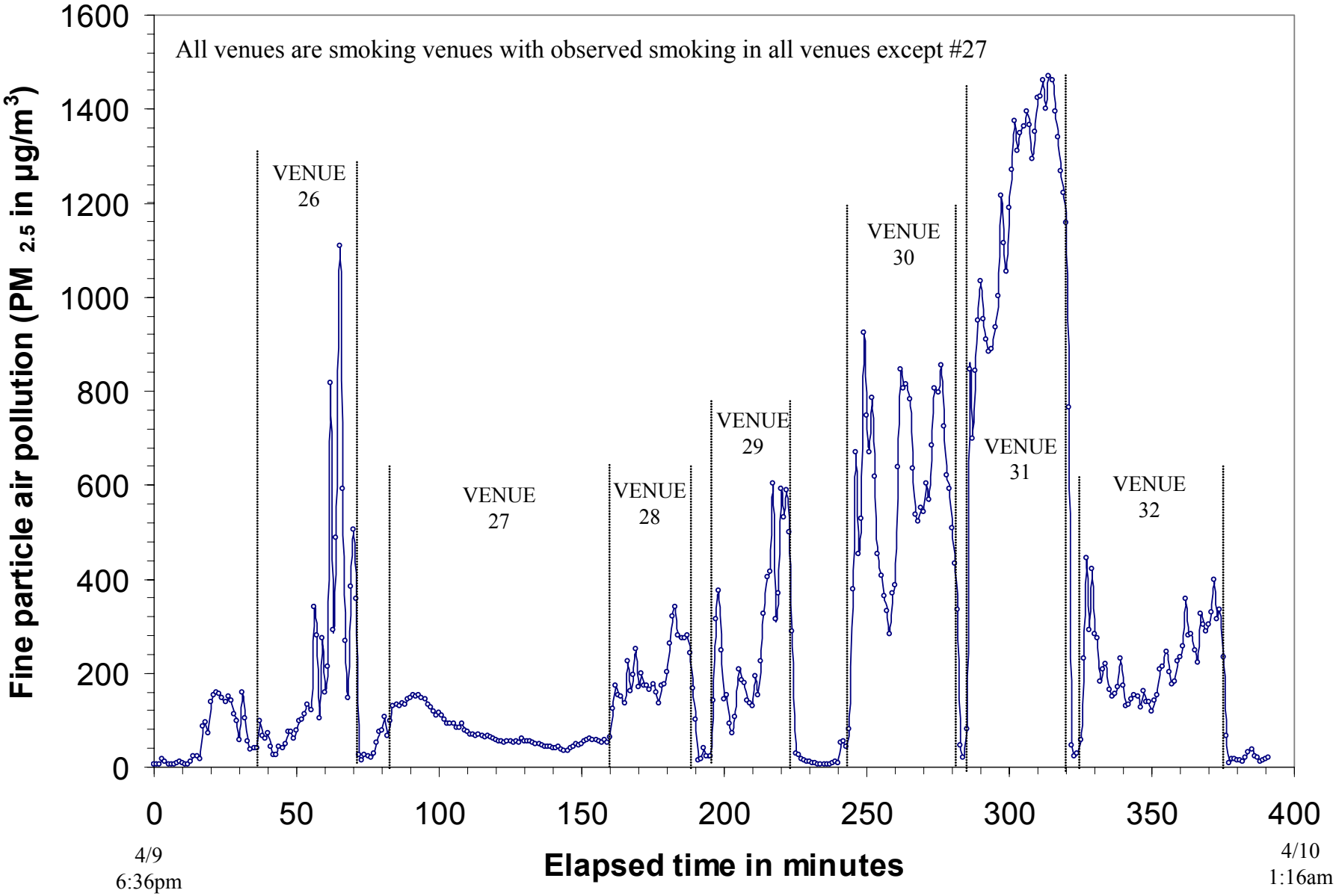
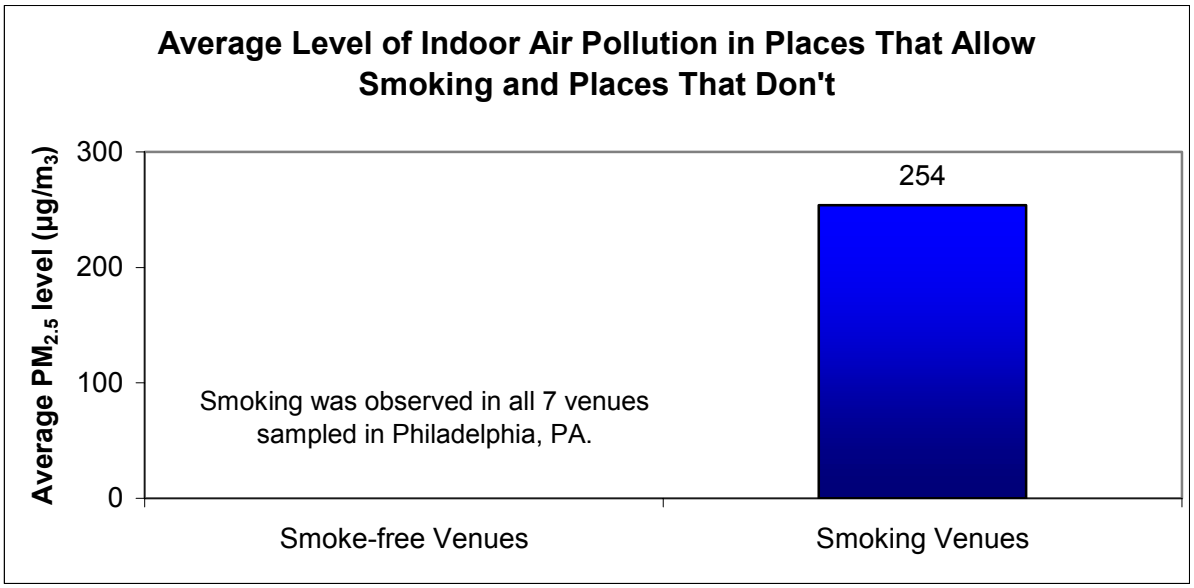


Figure 8. RSP levels in bars and restaurants sampled in Philadelphia, PA on April 10, 2004.



Venue Number	Size (m^3)	# people in venue	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
Bars/Restaurants Where Smoking Was Occuring During Sampling				
33	191	37	0.9	96
34	212	68	0.6	83
35	960	121	0.6	119
36	272	35	2.0	391
37	336	21	0.5	162
38	186	44	2.1	436
39	1884	260	1.3	490
Average	577	84	1.2	254

NOTES:

* Average number of burning cigarettes per $100m^3$

The average PM2.5 level in all venues where smoking was not permitted was 53 (µg/m3).

The average PM2.5 level in all venues where smoking was permitted was 303 (µg/m3).

Multi-City Air Monitoring Study: Philadelphia, PA April 10th, 2004

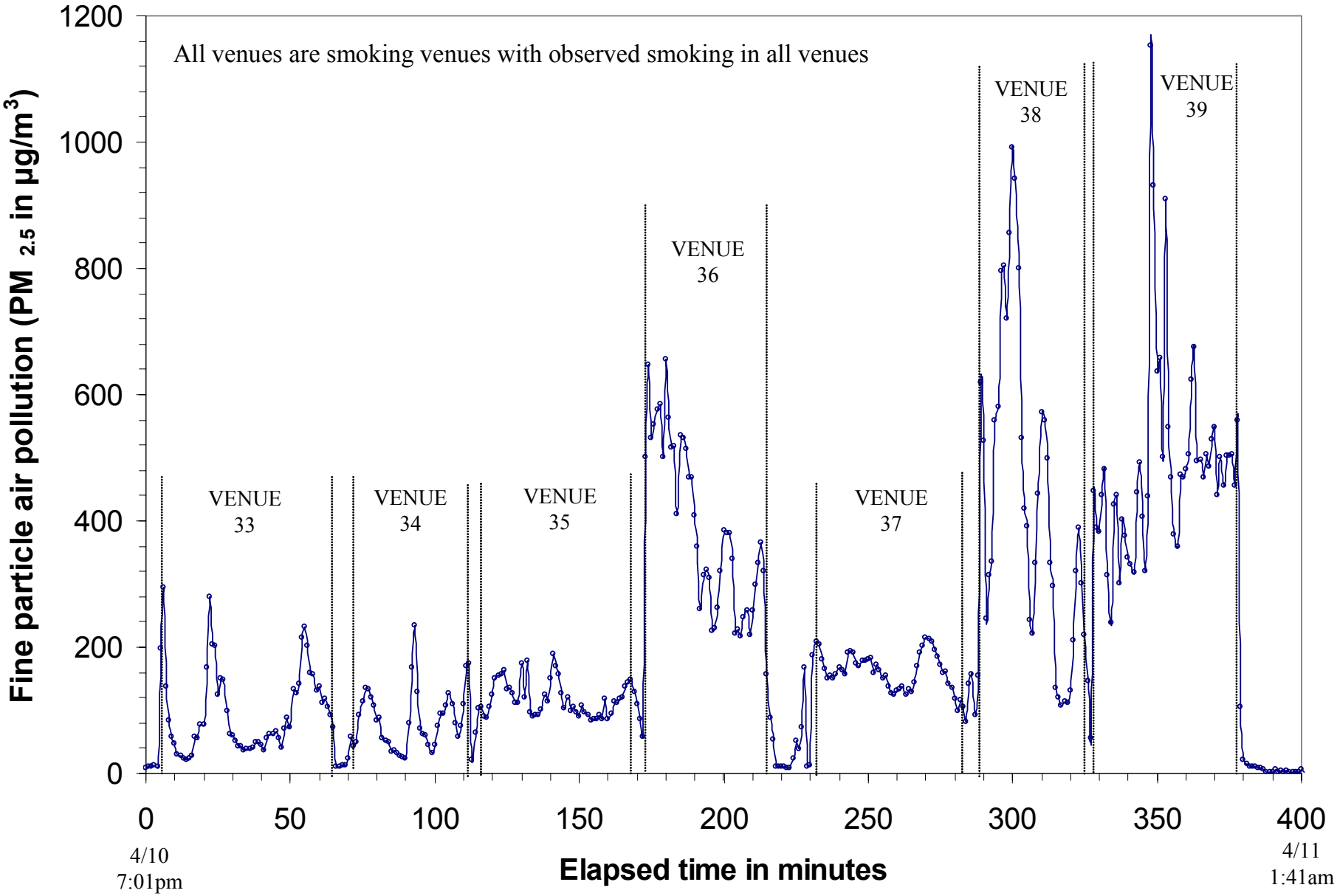
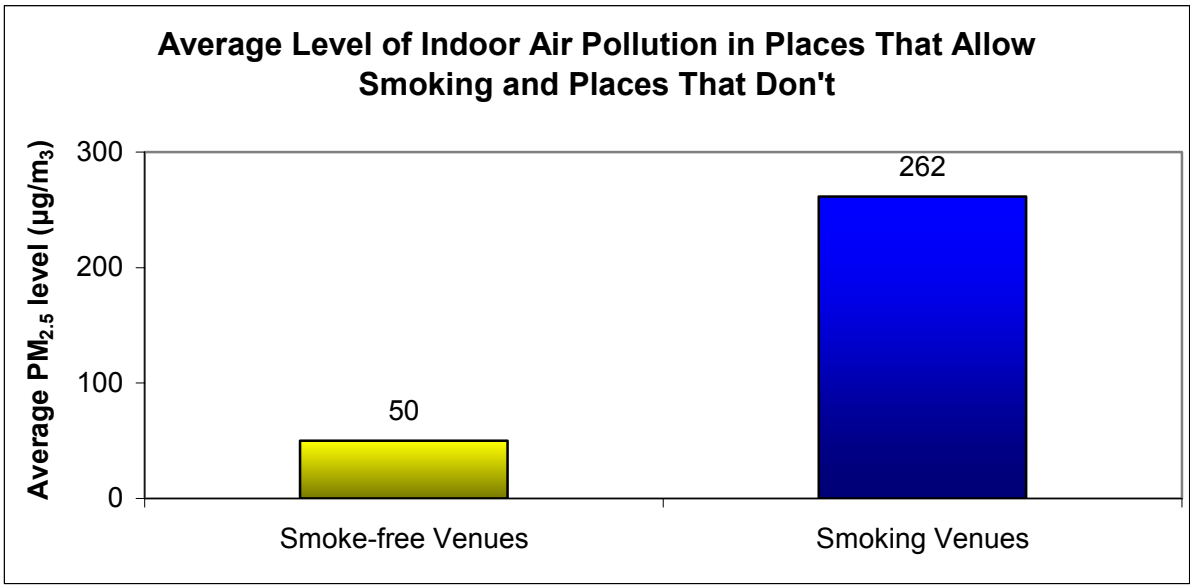


Figure 9. RSP levels in bars and restaurants sampled in Hoboken, NJ on April 16, 2004.



Venue Number	Size (m^3)	# people in venue	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
Bars/Restaurants Where Smoking Was Occuring During Sampling				
40	353	54	1.7	219
42	609	153	1.5	353
43	223	32	2.0	197
44	142	40	1.8	221
45	297	50	0.8	251
46	278	57	2.5	329
Average	317	64	1.7	262
Smoke-free Bars/Restaurants				
41	336	50	0.0	50
Average	336	50	0.0	50

NOTES:

* Average number of burning cigarettes per $100m^3$

The average PM2.5 level in all venues where smoking was not permitted was 53 (µg/m3).

The average PM2.5 level in all venues where smoking was permitted was 303 (µg/m3).

Multi-City Air Monitoring Study: Hoboken, NJ April 16th, 2004

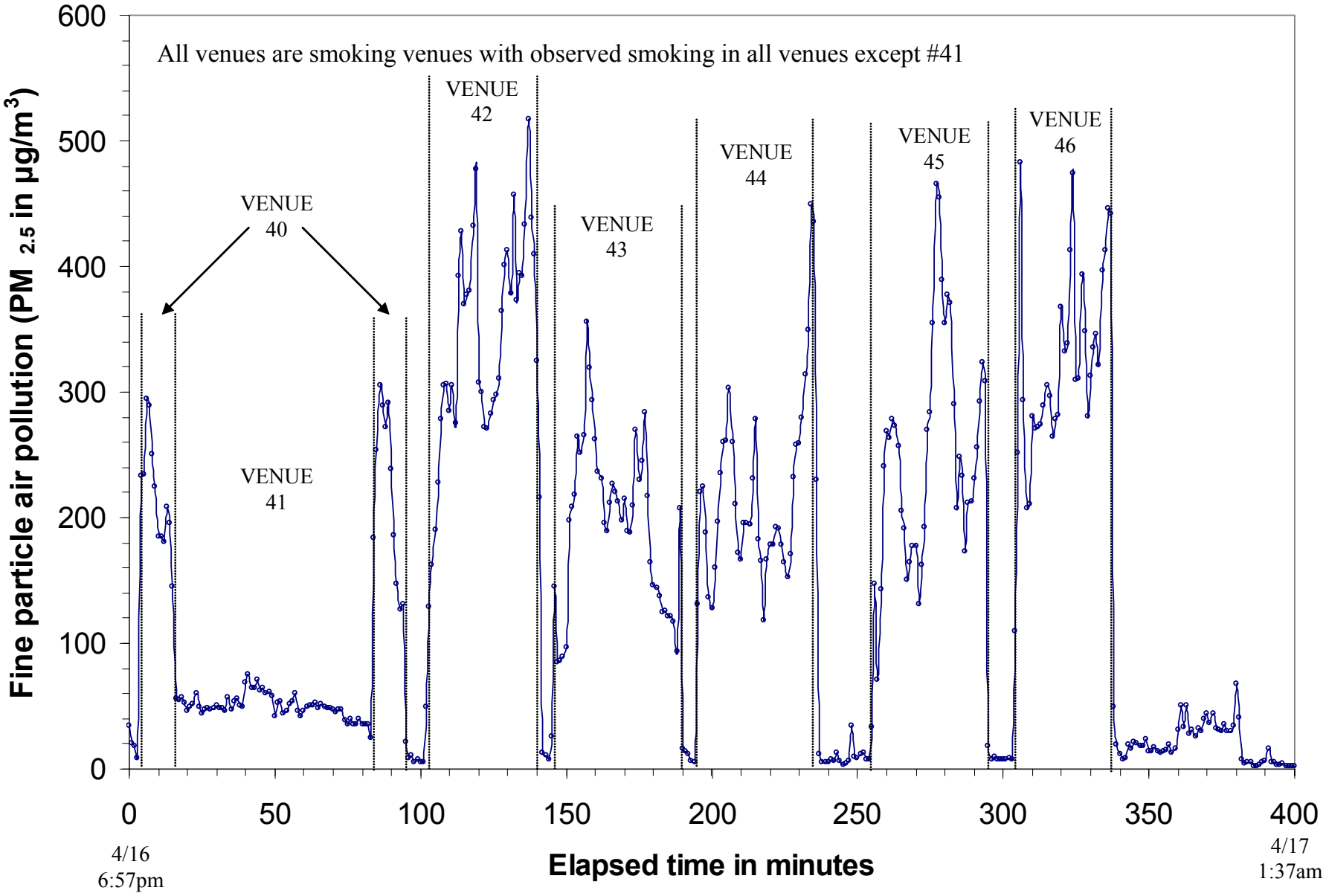
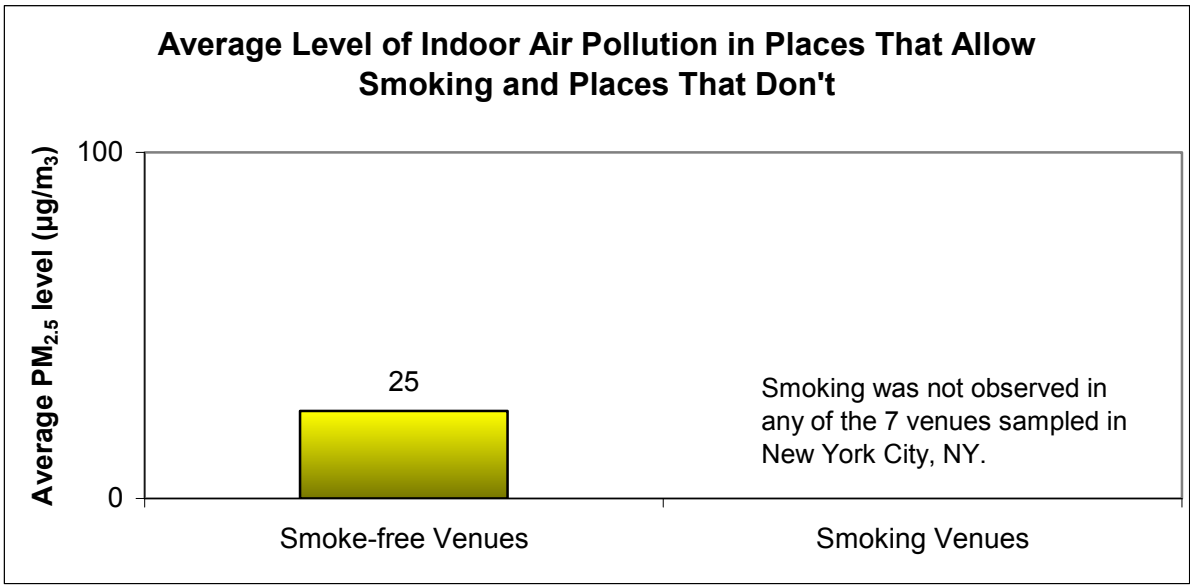


Figure 10. RSP levels in bars and restaurants sampled in New York City, NY on April 17, 2004.



Venue Number	Size (m^3)	# people in venue	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
Bars/Restaurants Where Smoking Was Occuring During Sampling				
All 7 New York City, NY venues sampled were smoke-free				
Smoke-free Bars/Restaurants				
47	186	35	0.0	20
48	194	51	0.0	28
49	883	162	0.0	20
50	326	98	0.0	22
51	218	40	0.0	38
52	118	60	0.0	31
53	338	79	0.0	18
Average	323	75	0.0	25

NOTES:

* Average number of burning cigarettes per $100m^3$

The average PM2.5 level in all venues where smoking was not permitted was 53 (µg/m3).

The average PM2.5 level in all venues where smoking was permitted was 303 (µg/m3).

Multi-City Air Monitoring Study: New York City, NY April 17th, 2004

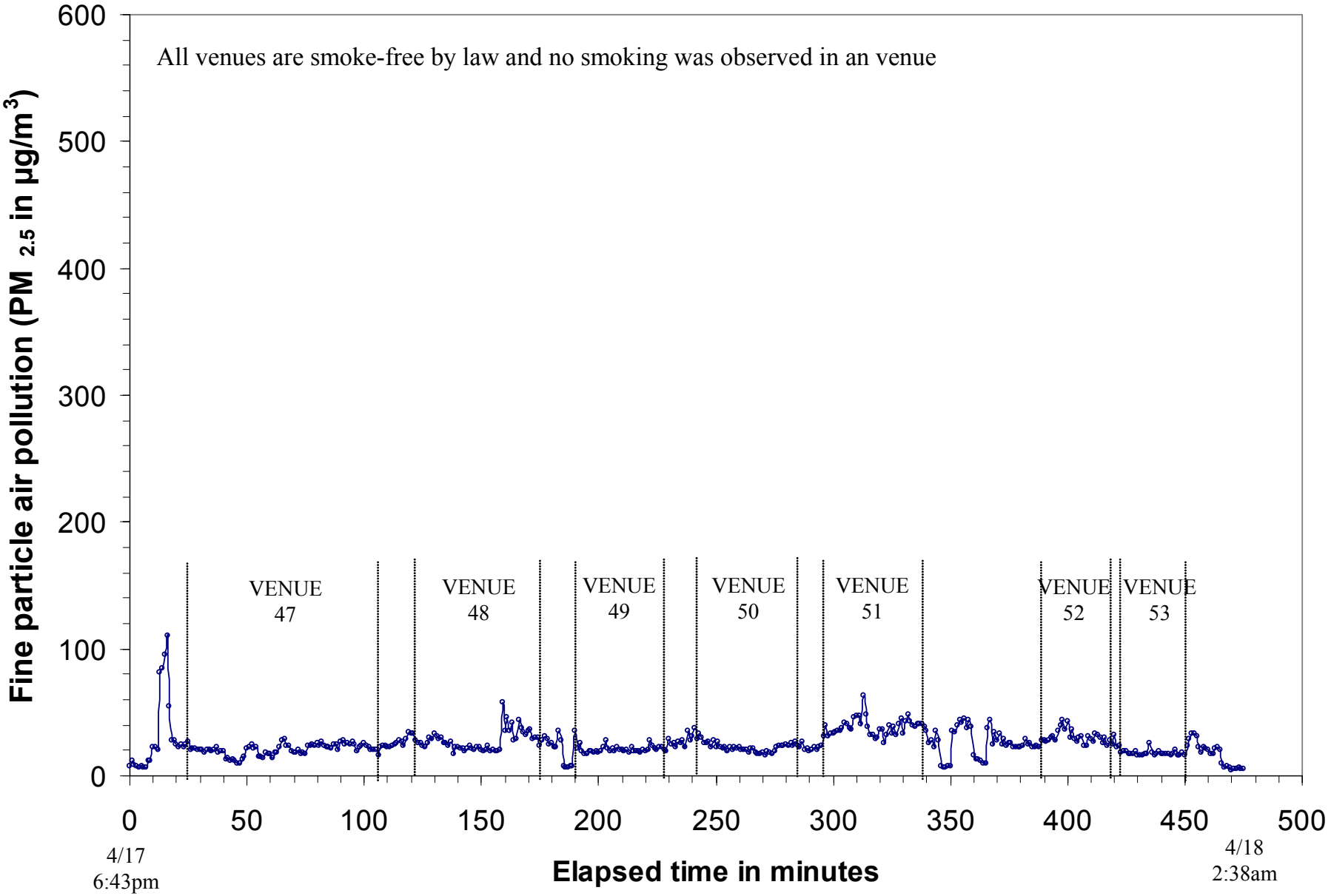
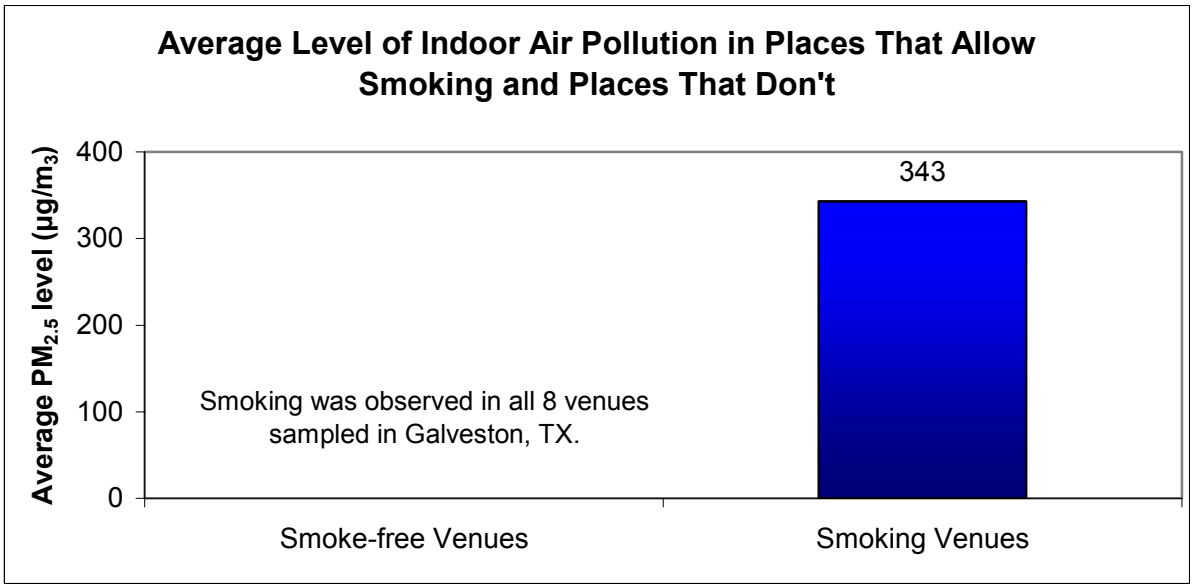


Figure 11. RSP levels in bars and restaurants sampled in Galveston, TX on July 8 and 9, 2004.



Venue Number	Size (m^3)	# people in venue	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
Bars/Restaurants Where Smoking Was Occuring During Sampling				
54	1443	16	0.1	90
55	516	60	0.4	171
56	230	30	1.6	207
57	342	42	1.7	518
58	814	51	1.0	982
59	587	95	1.5	614
60	273	5	0.2	100
61	1139	48	0.1	62
Average	668	43	0.8	343

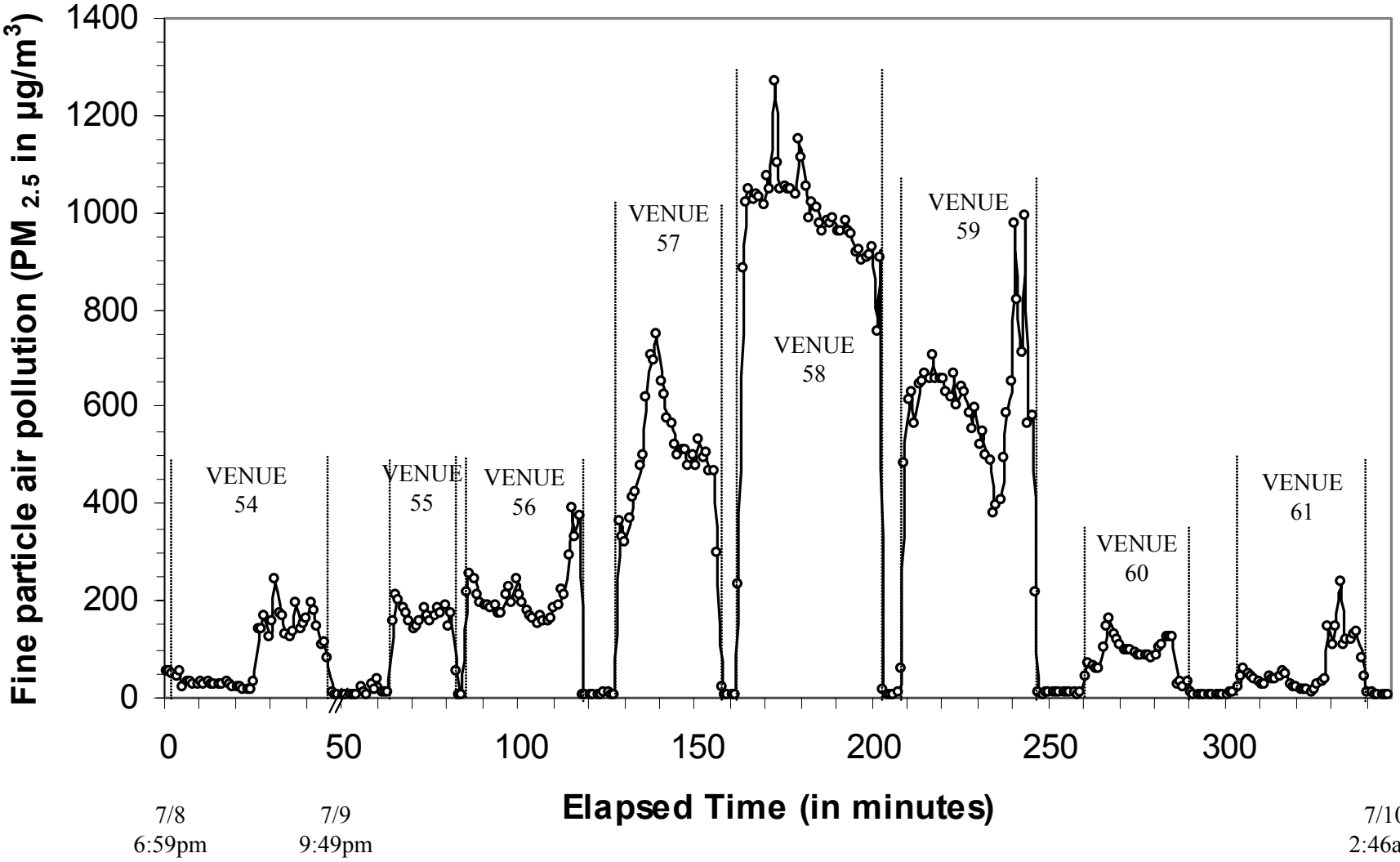
NOTES:

* Average number of burning cigarettes per $100m^3$

The average PM2.5 level in all venues where smoking was not permitted was 53 (µg/m3).

The average PM2.5 level in all venues where smoking was permitted was 303 (µg/m3).

Multi-City Air Monitoring Study: Galveston, TX July 8th-9th, 2004



Discussion

This study demonstrates that statewide laws to eliminate smoking in enclosed workplaces and public places dramatically reduces the levels of $PM_{2.5}$ in a wide range of hospitality venues. On average, $PM_{2.5}$ levels were 83% lower in venues in states that require bars and restaurants to provide a completely smoke-free indoor area compared to venues where no such regulations were present. This estimate represents the level of indoor air pollution reductions observed in a real-life setting because it includes data categorized according to the statewide law regulating smoking in bars and restaurants. During the observational period, smoking was observed in three venues that were required to be smoke-free and no smoking was observed in two venues that were not required to provide a smoke-free environment. When the analysis is restricted to those venues where smoking actually was and was not observed on site, the level of indoor air pollution was 91% lower in venues where no smoking was observed compared to venues where smoking was present.

The findings of this study are consistent with those of similar previous studies. For example, one study found a similar 90% decline in RSP levels in 8 hospitality venues in Delaware after smoking was prohibited there by a state law[10].

This study adds to the evidence that smoke-free policies provide employees and patrons protection from the health effects associated with secondhand smoke exposure. Several previous studies have assessed this more directly. For example, one study found that respiratory health improved rapidly in a sample of bartenders after a state clean smoke-free workplace law was implemented in California[11], and another study reported a 40% reduction in acute myocardial infarctions admitted to a regional hospital during the 6 months that a local smoke-free ordinance was in effect[12]. While this study does not assess health effects, it does provide a strong measure of secondhand smoke

exposure reduction likely to be experienced by hospitality workers when their worksites become smoke-free.

The EPA has set limits of 15 $\mu g/m^3$ as the average annual level of $PM_{2.5}$ exposure and 65 $\mu g/m^3$ 24-hour exposure in order to protect the public health[8]. The average $PM_{2.5}$ level observed in venues in states where smoking was permitted without restriction was 303 $\mu g/m^3$. For a full-time employee in such a venue, the average daily limit is exceeded by at least 4-fold (assuming zero exposure to $PM_{2.5}$ off the job and a 40 hour work week) and the 24-hour exposure limit is exceeded on a daily basis, on average, when the employee is on the job.

This study is subject to at least two limitations. First, venues sampled are not a true random sample of venues in each city. However, these venues were selected solely on the basis of sampling a wide range of venues in terms of size, location, and type of venue. Furthermore, venues were selected in at least two popular entertainment districts in each city to further enhance the sample representation. The finding that levels of $PM_{2.5}$ were consistently lower in locations that were required to be smoke-free by law compared to venues without such regulations across several cities and a variety of types of hospitality venues provides evidence that these results may be generalizable to other venues, cities, states, and nations. Secondly, secondhand smoke is not the only source of indoor particulate matter. While $PM_{2.5}$ monitoring is not specific for secondhand smoke, it is highly sensitive to it, as evidenced by the sharp spikes in $PM_{2.5}$ levels upon entering venues where smoking is permitted. Ambient particle concentrations and cooking are additional sources of indoor particle levels; however, smoking is by far the largest contributor to indoor air pollution. Because there is a normal background level of $PM_{2.5}$, then the reduction in this measure will be less than 100% even if all secondhand smoke is completely removed from the venue.

In summary, this is the largest study of this type covering 61 venues in eight cities. Results indicate that the level of indoor air pollution was more than 80% reduced in venues in states that require bars and restaurants to provide a smoke-free environment compared to those venues in states without such restrictions. Policies that remove secondhand smoke are an effective strategy to reduce workers exposure to this toxin, which may translate into improved health outcomes for these employees.

Acknowledgement

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