Idaho Air Quality Monitoring Study

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Executive Summary

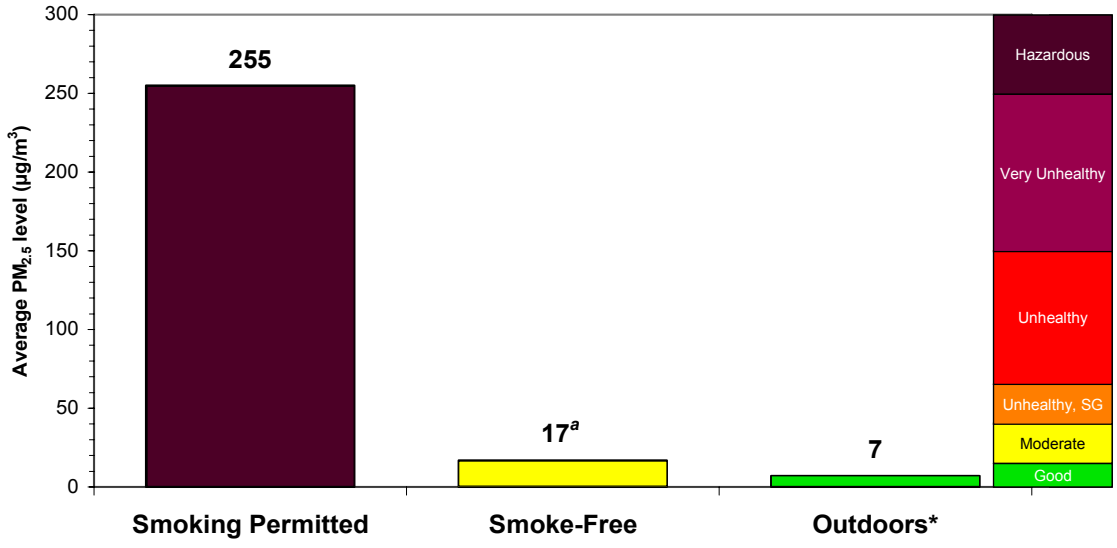
In May and June 2009, indoor air quality was assessed in 19 bars and restaurants in Idaho. Fourteen of these locations were bars where indoor smoking was permitted while the other 5 locations included 4 smoke-free restaurants (by law) and one smoke-free bar (voluntary).

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 level of fine particle air pollution was hazardous in Idaho bars permitting smoking ($PM_{2.5}$ = 255 µg/m^3). This level of air pollution is 15 times higher than smoke-free venues in Idaho, and 36 times higher than outdoor pollution levels in Boise.
- Employees in Idaho bars were exposed to levels of air pollution 4.2 times higher than safe annual levels established by the U.S. Environmental Protection Agency due to their occupational exposure to tobacco smoke pollution.
- The smoke-free air law in Idaho is effectively protecting the health of workers and patrons from the health effects of exposure to tobacco smoke pollution in the restaurants sampled while those in smoking-permitted bars are still exposed to hazardous levels of air contaminants.

Average Level of Indoor Air Pollution in Idaho Locations Sampled



[a] p<0.001 for comparison of smoke-free to smoking-permitted (Independent samples *t* test of log-transformed values)

* Used for comparison purposes. Based on the 2008 average $PM_{2.5}$ level from the 2 EPA monitoring sites in Ada County, Idaho (http://www.epa.gov/air/data/). The color-coded EPA Air Quality Index is also shown to demonstrate the magnituted of the measured particle concentrations.

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., 27 states, Washington D.C., and Puerto Rico have passed strong smoke-free air 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, North Carolina, Ohio, Oregon, Rhode Island, South Dakota,[1] Utah, Vermont, Washington, and Wisconsin.[2] Well over 50% of the U.S. population is now protected from secondhand smoke in all public places.[7] 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 determine the level of fine particle air pollution in Idaho venues permitting smoking and to compare this to smoke-free venues and outdoor air. Idaho's smoke-free air law went into effect on July 1, 2004 and prohibits smoking in public places, publicly-owned workplaces, bowling centers and restaurants, including those with attached bars. The state law exempts bars and small businesses with 5 or fewer employees.

It is hypothesized that: 1) indoor particle air pollution levels will be significantly lower in restaurants and bars that do not allow indoor smoking compared to bars where smoking is permitted; and, 2) across all venues sampled, the degree of indoor particle air pollution will be correlated with the amount of smoking.

[1] The South Dakota law was passed by state legislators but has not been implemented yet due to a voter petition whose validity is being determined. (http://www.aberdeennews.com/apps/pbcs.dll/article?AID=/20090703/NEWS10/907039989)

[2] The North Carolina and Wisconsin laws go into effect 1/2/2010 and 7/5/2010 respectively

Methods

Overview

In May and June 2009, indoor air quality was assessed in 19 bars and restaurants in Boise, Meridian, and Garden City, Idaho. Fourteen of these locations were bars that were not required to be smoke-free according to state law. The other 5 locations include 4 restaurants that are required to be smoke-free by law and one bar that was voluntarily smoke-free.

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 know 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 $PM_{2.5}$. 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.

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.

Teams of trained testers from 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 difference in the average levels of $PM_{2.5}$ between smoke-free and smoking-permitted establishments. Statistical significance is assessed using an independent 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 19 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 m^3 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 14 locations permitting indoor smoking was 255 $\mu g/m^3$, compared to 17 $\mu g/m^3$ in the smoke-free places (Figure 1). Statistical analysis of the log transformed $PM_{2.5}$ concentrations shows this was a significant 93% difference in fine particle indoor air pollution ($t(17)=6.09$, $p<0.001$).

Table 1. Fine Particle Air Pollution in Idaho Bars and Restaurants

Venue Number	Date Sampled	Size (m^3)	Average # people	Average # burning cigs	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
Smoking Observed†						
1	5/29/2009	447	24	5.2	1.16	50
2	5/29/2009	182	22	3.8	2.09	869
3	5/29/2009	86	16	0.8	0.88	58
4	6/2/2009	333	10	1.3	0.37	235
5	6/2/2009	571	13	3.0	0.53	263
6	6/5/2009	313	21	2.5	0.80	80
7	6/5/2009	284	18	3.6	1.27	112
8	6/5/2009	487	45	8.0	1.64	119
9	6/5/2009	.	26	8.0	.	647
10	6/5/2009	933	49	9.3	1.00	340
11	6/5/2009	275	86	8.0	2.91	311
12	6/12/2009	1819	19	4.7	0.26	154
13	6/12/2009	375	36	6.0	1.60	223
14	6/12/2009	487	40	8.0	1.64	109
Average		**507**	**30**	**5.2**	**1.24**	**255**
No Observed Smoking‡						
15	5/22/2009	326	16	0.0	0.00	7
16	5/22/2009	335	18	0.0	0.00	47
17	6/26/2009	535	22	0.0	0.00	16
18	6/26/2009	9888	25	0.0	0.00	10
19	6/26/2009	585	26	0.0	0.00	5
Average		**2334**	**21**	**0.0**	**0.00**	**17**

*Average number of burning cigarettes per 100 cubic meters.

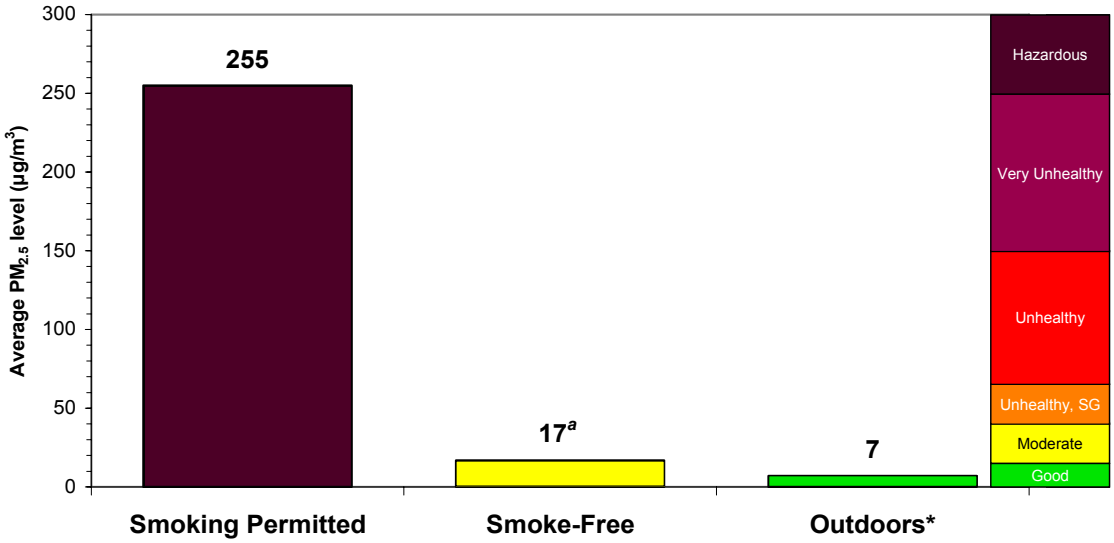
† These locations are all "bars" that permit smoking

‡ These locations are all "restaurants" that are smoke-free by law, except #15 which is a "bar" that is voluntarily smoke-free

The average smoker density (ASD) in the 14 smoking-permitted bars was 1.24 burning cigarettes per 100 m^3. In contrast, the 5 smoke-free venues had an ASD of 0.00, as no burning cigarettes were observed in these venues. Looking at all 19 sample visits, $PM_{2.5}$ level was significantly correlated with the active smoker density (r_s=0.68, p<0.001), indicating that the amount of indoor smoking is the primary driver of the indoor particle pollution levels.

Figure 1.

Average Level of Indoor Air Pollution in Idaho Locations Sampled



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The real-time plots showing the level of indoor air pollution in each venue sampled are presented in Figures 2 through 4. The real-time $PM_{2.5}$ plots throughout the duration of sampling reveal the following results: 1) low background levels are observed outdoors; 2) high levels of indoor air pollution are observed in the venues where smoking was permitted; and 3) peak exposure levels in some venues where 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 $\mu g/m^3$ as the average annual level of $PM_{2.5}$ exposure and 35 $\mu g/m^3$ for 24-hour exposure.[11] 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 255 $\mu g/m^3$ (the average level in all sites before the law) on the job, and is exposed only to background particle levels of 7 $\mu g/m^3$ during non-work times. For a full-time employee their average annual $PM_{2.5}$ exposure is 64 $\mu g/m^3$. The EPA average annual $PM_{2.5}$ limit is exceeded by over 4 times due to their occupational exposure. In contrast, workers in the smoke-free locations are exposed to an average particle concentration of 17 $\mu g/m^3$ and, for a full-time employee in these Idaho venues, the average annual exposure is 9 $\mu g/m^3$, 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,[12] 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 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.[13] 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.[14] 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.[15] 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%.[16]

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[17]. 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.[18] 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.[19] 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.[20]

The effects of passive smoking on the cardiovascular system in terms of increased platelet aggregation, 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.[21]

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[22] and the U.S. Surgeon General[23].

Conclusions

This study demonstrates that employees and patrons in Idaho bars allowing indoor smoking are exposed to harmful levels of indoor air pollution resulting from indoor smoking. A comprehensive smoke-free air policy that prohibits indoor smoking in all indoor places is the only proven means to eliminate this exposure to toxic tobacco smoke pollution. This type of policy will result in improved quality of life and health outcomes for Idaho workers and residents.

Acknowledgments

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Special thanks go to volunteers from the American Cancer Society Cancer Action Network who collected the data for this study.

Support for Roswell Park Cancer Institute researchers was provided by the Campaign for Tobacco Free Kids and the Flight Attendant Medical Research Institute.

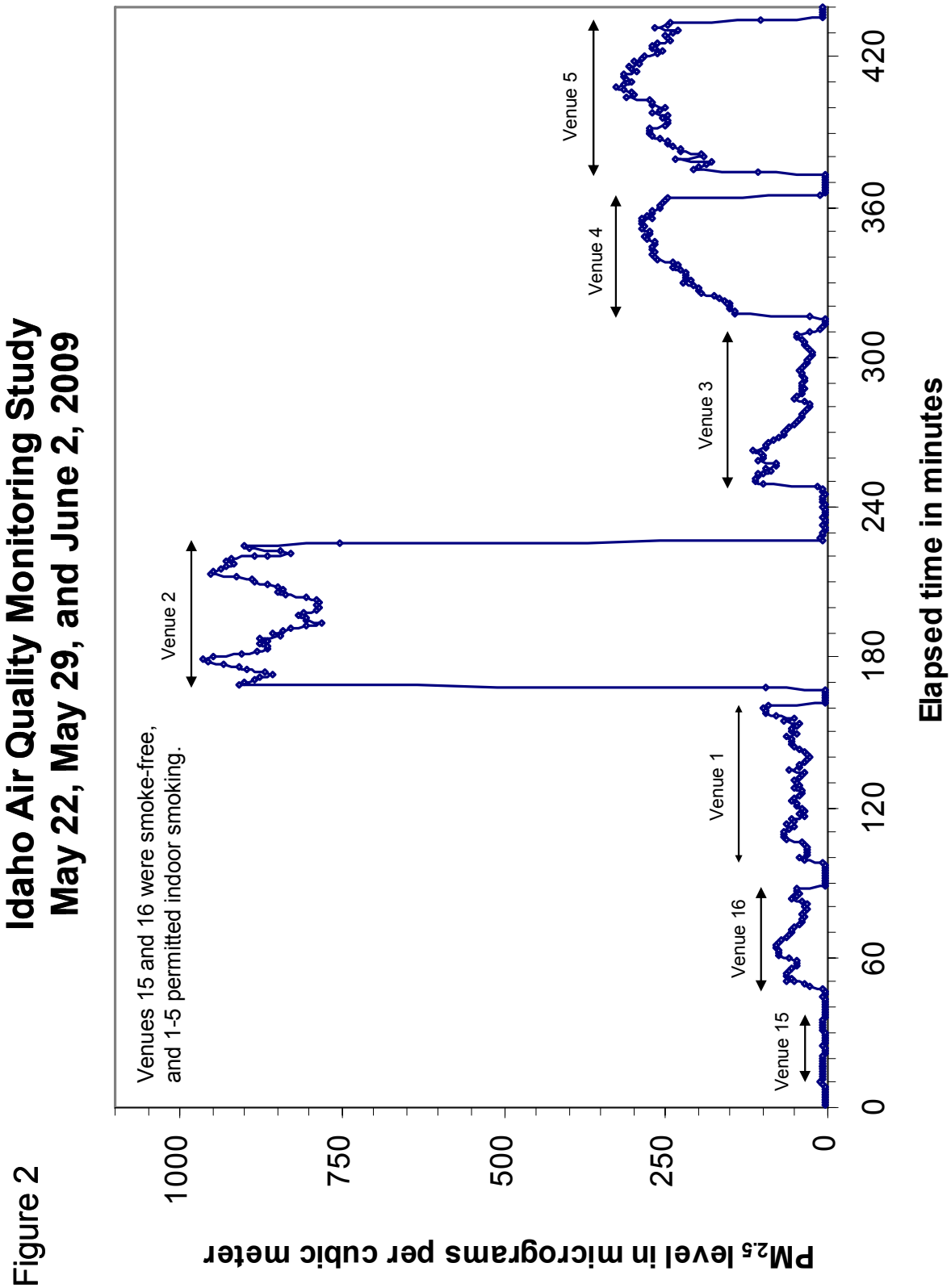
Roswell Park Cancer Institute (RPCI) is America's first cancer center founded in 1898 by Dr. Roswell Park. RPCI is the only upstate New York facility to hold the National Cancer Center designation of "comprehensive cancer center" and to serve as a member of the prestigious National Comprehensive Cancer 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 2


Idaho Air Quality Monitoring Study
May 22, May 29, and June 2, 2009
Venues 15 and 16 were smoke-free, and 1-5 permitted indoor smoking.
Venue 15
Venue 16
Venue 1
Venue 2
Venue 3
Venue 4
Venue 5
PM2.5 level in micrograms per cubic meter
0
250
500
750
1000
0
60
120
180
240
300
360
420
Elapsed time in minutes

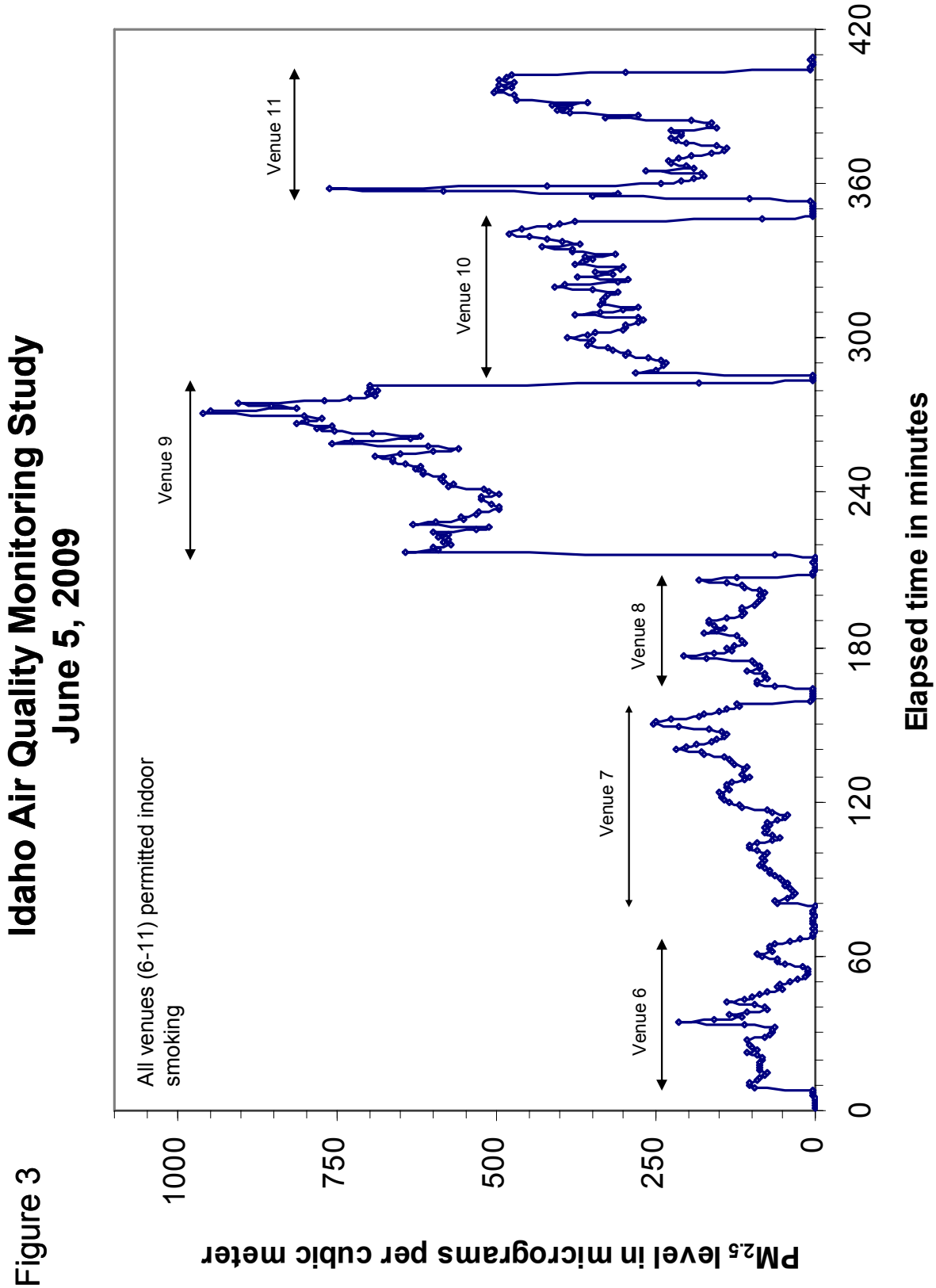
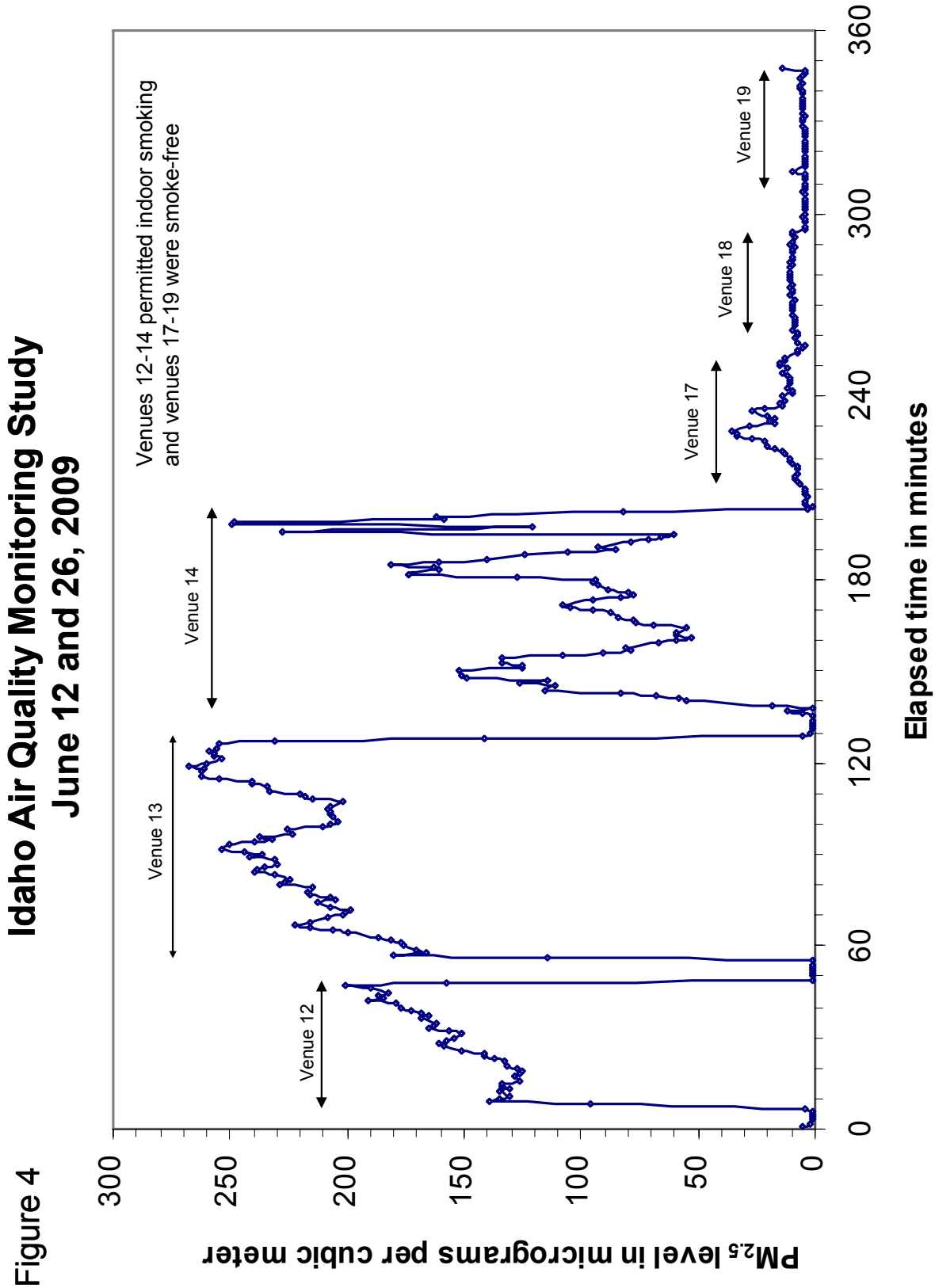

Idaho Air Quality Monitoring Study
June 5, 2009
All venues (6-11) permitted indoor smoking
Venue 6
Venue 7
Venue 8
Venue 9
Venue 10
Venue 11
PM2.5 level in micrograms per cubic meter
0
250
500
750
1000
0
60
120
180
240
300
360
420
Elapsed time in minutes

Figure 3

Figure 4


Idaho Air Quality Monitoring Study
June 12 and 26, 2009
Venues 12-14 permitted indoor smoking and venues 17-19 were smoke-free
Venue 12
Venue 13
Venue 14
Venue 17
Venue 18
Venue 19
PM2.5 level in micrograms per cubic meter
0
50
100
150
200
250
300
Elapsed time in minutes
0
60
120
180
240
300
360

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