HUNTSVILLE, ALABAMA

INDOOR AIR QUALITY MONITORING STUDY

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Executive Summary

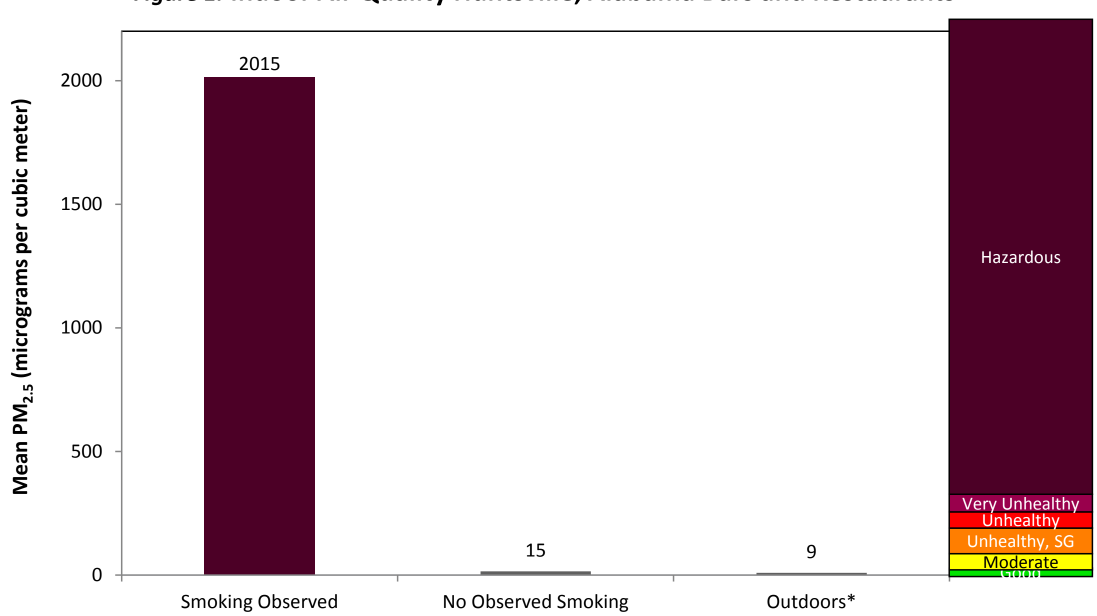
In February, 2015 indoor air quality was assessed in 16 restaurants and bars in Huntsville, Alabama. Currently Alabama law does not preempt the passage of local smokefree laws, and several communities within the state are taking advantage of their local control by enacting strong 100% smokefree air laws. However, Huntsville still permits smoking in public venues including restaurants and bars. Among the 16 locations monitored, there were 8 with observed smoking and 8 with no observed smoking.

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 the 8 locations with observed smoking, there were, on average, 18.8 cigarettes burning during the visits. This translates to an average of 1.98 burning cigarettes per 100 cubic meters of air in these places.
- In the 8 locations with observed indoor smoking the level of fine particle air pollution was hazardous ($PM_{2.5}$ = 2015 μg/m^3). This level of particle air pollution is 224 times higher than outdoor air in Huntsville, Alabama and 134 times higher than locations with no observed smoking.
- Employees working full time in the locations with indoor smoking are exposed to levels of air pollution 39 times higher than safe annual levels established by the U.S. Environmental Protection Agency due to their occupational exposure to tobacco smoke pollution.

Figure 1. **Indoor Air Quality Huntsville, Alabama Bars and Restaurants**



*Used for comparison purposes. Based on the 2014 average $PM_{2.5}$ level from the EPA monitoring sites in Huntsville, Alabama (http://www.epa.gov/airdata/ad_rep_mon.html). The color-coded EPA Air Quality Index is also shown to demonstrate the magnitude of the measured particle levels (*Weighted 2014 annual mean not final until May 1, 2015*)

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] Exposure to second hand smoke causes nearly 42,000 deaths annually among adults in the United States including more than 7,300 lung cancer deaths and nearly 34,000 premature deaths from heart disease each year among U.S. nonsmokers.[2] Secondhand smoke is also responsible for respiratory infections, asthma, Sudden Infant Death Syndrome, and other illnesses in children.[2] Reports have stated that even brief secondhand smoke exposure can damage cells in ways that set cancer process in motion.[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 establishing smoke-free environments is the most effective method for reducing SHS exposure in public places,[5] Healthy People 2020 Objective TU-13 encourages all States, Territories, Tribes and the District of Columbia to establish laws on smoke-free indoor air that prohibit smoking in public places and worksites.[6]

Currently in the United States, 24 states, Washington D.C, Puerto Rico and U.S. Virgin Islands have passed strong smoke-free air laws that include workplaces, restaurants and bars. About 50% of the U.S. population is now protected from secondhand smoke in all public places.[7] Eleven Canadian provinces and territories also have comprehensive smoke-free air laws in effect. Thousands 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.[9,10]

The goal of this study was to determine the level of fine particle air pollution in Huntsville, Alabama venues where smoking was observed and compare this to locations where there was no observed smoking. At the time of this study there was no local smoke-free air law in Huntsville, Alabama.

It is hypothesized that: 1) indoor particle air pollution levels will be significantly lower in locations where there was no observed smoking compared to locations where smoking was observed; and, 2) across all venues sampled, the degree of indoor particle air pollution will be correlated with the amount of smoking.

METHODS

In general, a good marker of SHS exposure should be easily and accurately measured at an affordable cost, providing a valid assessment of SHS exposure as a whole. However, SHS is a dynamic and complex mixture of thousands of compounds in vapor and particulate phases and it is not possible to directly measure SHS in its entirety. The two most commonly used and preferred methods of measuring SHS exposure are nicotine and fine particle ($PM_{2.5}$) sampling.[8] These methods are correlated with each other and with other SHS constituents. Nicotine sampling has the advantage of being specific to tobacco smoke, meaning there are no other competing sources of nicotine in the air. Active $PM_{2.5}$ sampling is not specific to tobacco smoke but was chosen for this study due to several advantages of this type of sampling: 1) data can be collected quickly, discreetly, and cost-effectively with a portable battery operated machine; 2) measurements are taken continuously and stored in memory so the changes in particle levels, including peak levels, can be readily observed; 3) the machine is highly sensitive to tobacco smoke, being able to instantly detect particle levels as low as 1 microgram per cubic meter; 4) $PM_{2.5}$ has known direct health effects in terms of morbidity and mortality and there are existing health standards for $PM_{2.5}$ in outdoor air (e.g. US EPA and WHO) that can be used to communicate the relative harm of $PM_{2.5}$ levels in places with smoking.

$PM_{2.5}$ 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 death.

In February 2015, indoor air quality was assessed in 16 restaurants and bars in Huntsville, Alabama. Among the locations sampled, there were 8 with observed smoking and 8 with no observed smoking.

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.

TSI SIDEPAK AM510 PERSONAL AEROSOL MONITOR

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.[10, 11] 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 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.

Statistical Analyses

To evaluate the first hypothesis, statistical significance is assessed using the Mann-Whitney test on the $PM_{2.5}$ concentrations in the locations with no observed smoking versus observed smoking locations. The second hypothesis is tested by using all 16 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 $100m^3$ are reported for each venue and averaged for all venues.

RESULTS

A summary of each location visited and tested is shown in Table 1. The average $PM_{2.5}$ level in the 8 locations with observed smoking was 2,015 μg/m^3 (Figure 1). The $PM_{2.5}$ concentrations in places with observed smoking were significantly higher than locations with no observed smoking where the mean $PM_{2.5}$ concentration was 15 μg/m^3 (U=0.00, p<0.001, r=.869).

In the 8 locations with observed smoking the average number of burning cigarettes was 18.8 which corresponds to an average smoker density (ASD) of 1.98 burning cigarettes per 100 m^3. Looking at all 16 sample visits, $PM_{2.5}$ levels are positively associated with the active smoker density indicating that the amount of indoor smoking is likely the primary driver of the indoor particle pollution levels. This association was statistically significant (r_s=0.802, p<0.001).

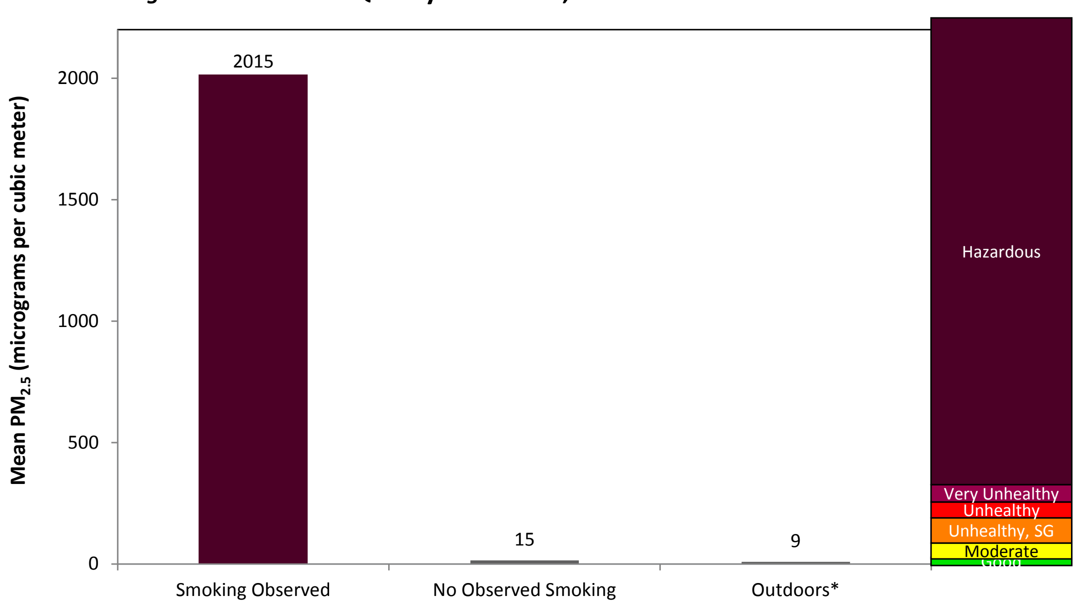
The real-time plots showing the level of indoor air pollution in each venue sampled are presented in Figures 2-4, starting on page 12. The real-time $PM_{2.5}$ plots reveal the following results: 1) low background levels are observed outdoors; 2) extremely high levels of indoor air pollution are observed in the venues where smoking was observed; and 3) peak exposure levels in some venues where smoking was observed reached levels far in excess of the average recorded level.

***Table 1.* Fine Particle Air Pollution in Huntsville, Alabama Bars and Restaurants**

Venue Number	Size (m^3)	Average # people	Average # burning cigs	Active smoker density*	Mean $PM_{2.5}$ level ($\mu g/m^3$)
No Observed Smoking					
1	6796	81	0.0	0.00	4
2	850	19	0.0	0.00	61
3	5097	66	0.0	0.00	5
4	1133	24	0.0	0.00	8
5	408	18	0.0	0.00	28
6	816	24	0.0	0.00	2
7	1593	53	0.0	0.00	5
8	1593	45	0.0	0.00	4
Average (n=8)	**2286**	**41**	**0.0**	**0.00**	**15**
Smoking Observed					
9	1133	49	16.0	1.41	4705
10	531	54	19.0	3.48	4344
11	3625	29	15.0	0.41	4564
12	850	35	16.0	1.91	1052
13	1133	22	8.0	0.68	305
14	6371	95	28.0	0.43	458
15	382	38	24.0	6.15	420
16	1699	42	24.0	1.40	274
Average (n=8)	**1966**	**46**	**18.8**	**1.98**	**2015**

*Average number of burning cigarettes per 100 cubic meters.

***Figure 1.* Indoor Air Quality Huntsville, Alabama Bars and Restaurants**



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DISCUSSION

The mean $PM_{2.5}$ levels (2,015 μg/m^3) documented here in Huntsville, AL locations with smoking are the highest we have seen in over two hundred communities we have examined across the United States. These are extreme exposures to particulate air pollution and the only comparable occupational exposure we can find in the United States to this level of particulate pollution is for wildland firefighters during frontline firefighting.[12] In fact, 3 locations sampled had $PM_{2.5}$ levels during part of the sampling that exceeded the maximum level measurable by the air quality monitor used in this study (TSI Sidepak AM510 Personal Aerosol Monitor). As such, the mean levels in these locations are actually underestimates of the true tobacco smoke related particulate concentrations.

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 12 μg/m^3 as the average annual level of $PM_{2.5}$ exposure and 35 μg/m^3 for 24-hour exposure.[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 2015 μg/m^3 (the average level in the sites with observed smoking) on the job, and is exposed only to background particle levels of 9 μg/m^3 during non-work times. For a full-time employee their average annual $PM_{2.5}$ exposure is 467 μg/m^3. The EPA average annual $PM_{2.5}$ limit is exceeded by 39 times due to their occupational exposure to tobacco smoke.

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.[15] 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.[16] 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.[17] 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%.[18]

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[19]. 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.[20] 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.[21] 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.[22]

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.[23]

The hazardous health effects of exposure to secondhand 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 secondhand 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 secondhand 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[24] and the U.S. Surgeon General[25].

Conclusions

This study demonstrates that employees and patrons in Huntsville bars and restaurants with observed indoor smoking are exposed to extreme and hazardous levels of air pollution resulting from indoor smoking. A comprehensive smoke-free air policy that prohibits smoking in all indoor public 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 Huntsville workers and residents.

ACKNOWLEDGMENTS

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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).

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Huntsville, Alabama Air Quality Monitoring Study
February, 2015

Figure 2

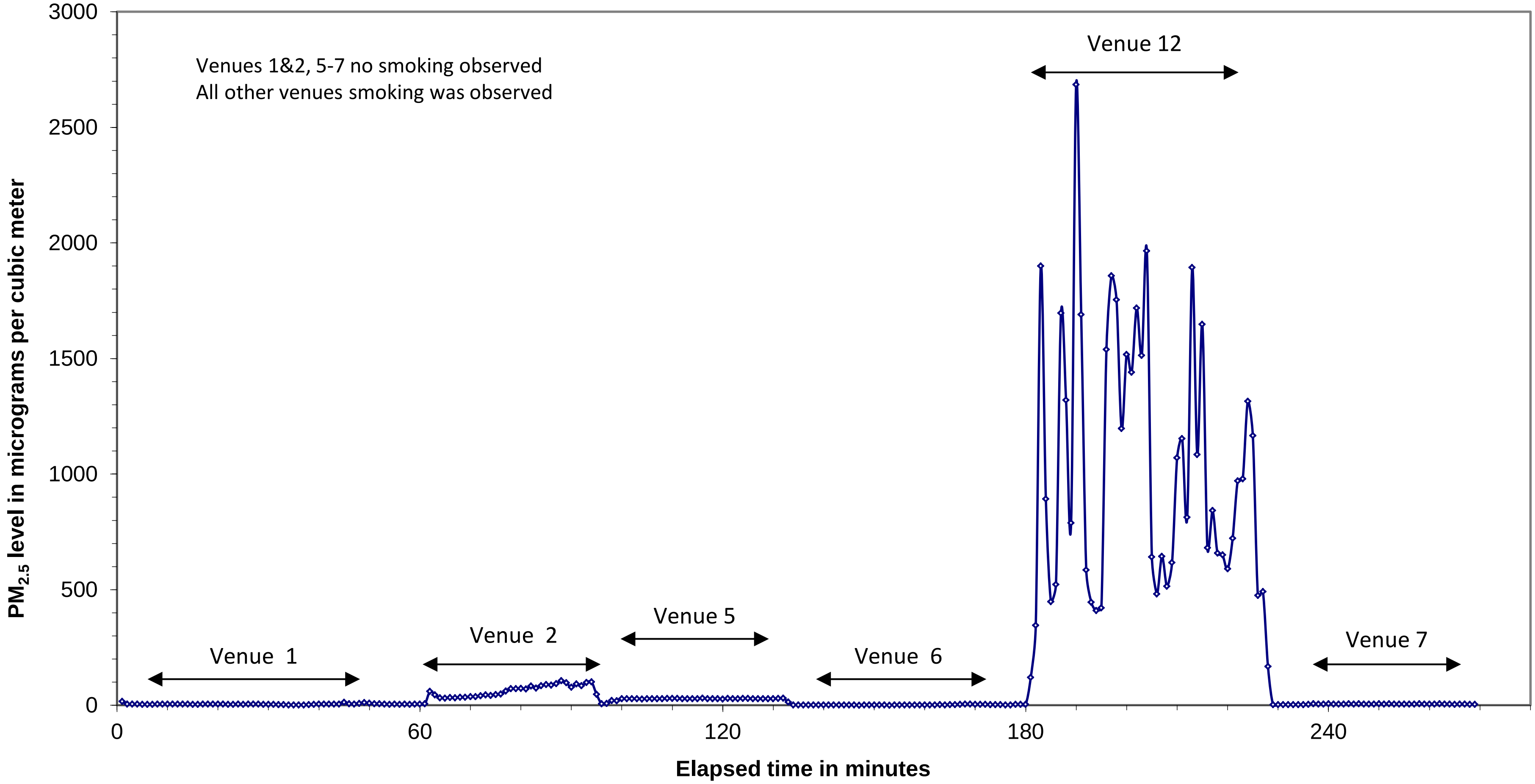

Figure 3

Huntsville, Alabama Air Quality Monitoring Study
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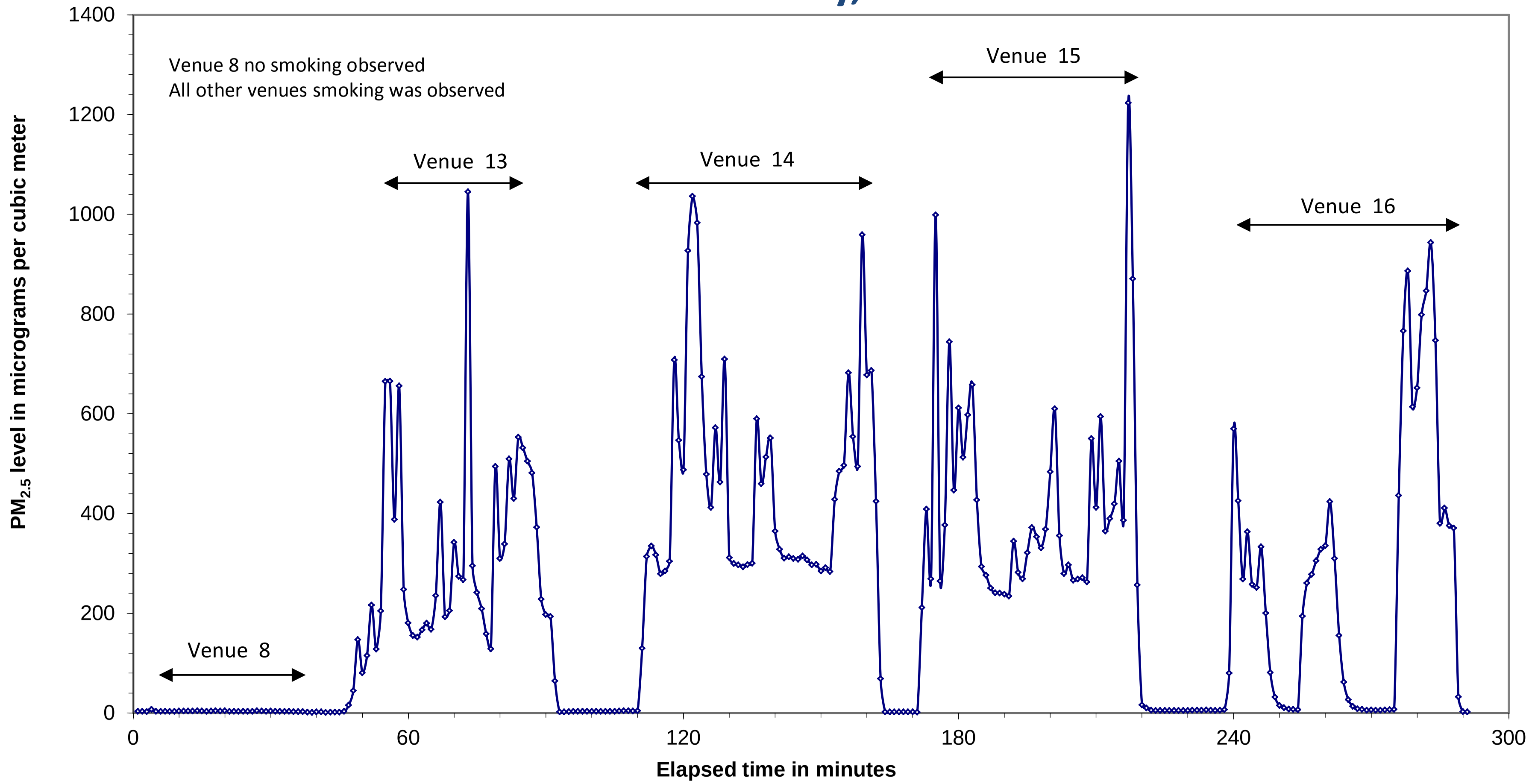

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Figure 4