SELMA, ALABAMA

INDOOR AIR QUALITY MONITORING STUDY

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EXECUTIVE SUMMARY

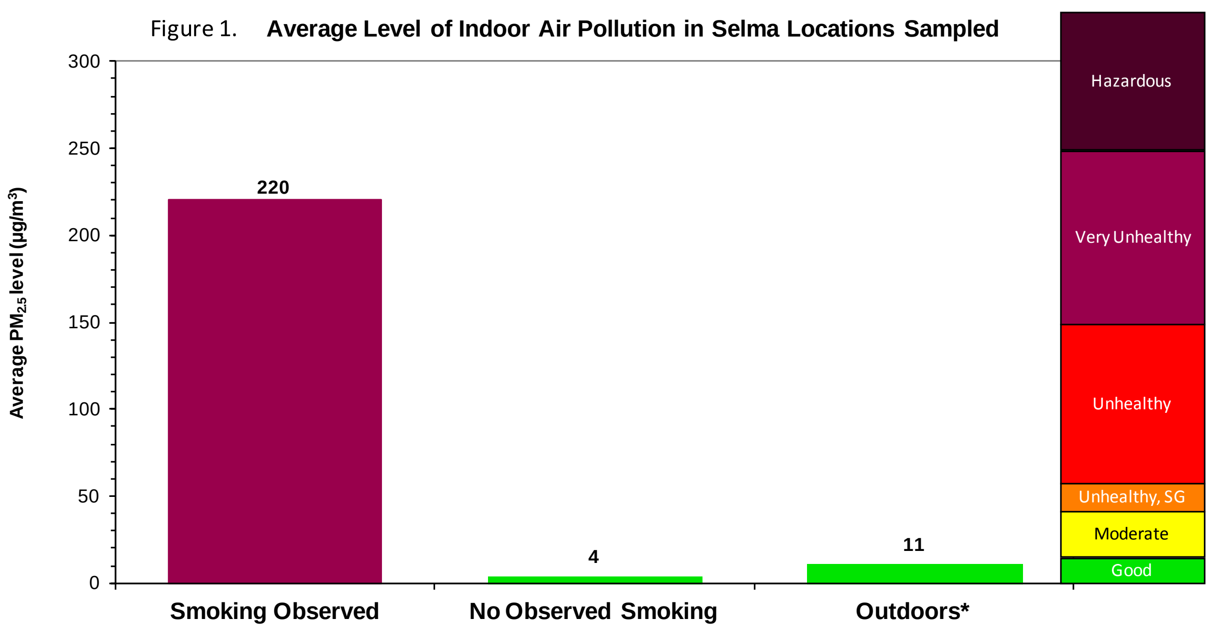
On April 26th & 27th, 2013, indoor air quality was assessed in 6 restaurants and bars in Selma, Alabama. Effective September, 2003, the Alabama Clean Indoor Air Act prohibits smoking in a public place or at a public meeting including hospitals, schools, most retail businesses, elevators, buses and taxicabs except in designated areas. Permitting smoking is up to the owner's discretion at bars, restaurants and most workplaces.

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 3 locations with observed smoking, there were, on average, 2.7 cigarettes burning during the visits. This translates to an average of 0.81 burning cigarettes per 100 cubic meters of air in these places.
- In the 3 locations with observed smoking the level of fine particle air pollution was very unhealthy ($PM_{2.5}$ = 220 μg/m^3). This level of particle air pollution is 20 times higher than outdoor air in Alabama and 55 times higher than the smoke-free locations.
- Employees working full time in the locations with indoor smoking are exposed to levels of air pollution 5 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. **Average Level of Indoor Air Pollution in Selma Locations Sampled**



*Used for comparison purposes. Based on the 2011 average $PM_{2.5}$ level from the EPA monitoring sites in Montgomery County, 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

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 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 U.S., 30 states, Washington D.C., Puerto Rico, and U.S. Virgin Islands have passed strong smoke-free air laws that include restaurants and bars. The states are Arizona, California, Colorado, Connecticut, Delaware, Hawaii, Illinois, Iowa, Kansas, Maine, Maryland, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oregon, Rhode Island, South Dakota, Utah, Vermont, Washington, and Wisconsin. 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. 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.

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

On April 26th & 27th, 2013, indoor air quality was assessed in 6 restaurants and bars in Selma, Alabama. There were 3 locations with no observed smoking and 3 locations with observed smoking. Alabama law does not preempt the passage of local smoke-free laws. At the time of this study there was no local smoke-free air law in Selma, Alabama.

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

TSI SIDEPAK AM510 PERSONAL AEROSOL MONITOR

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.[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

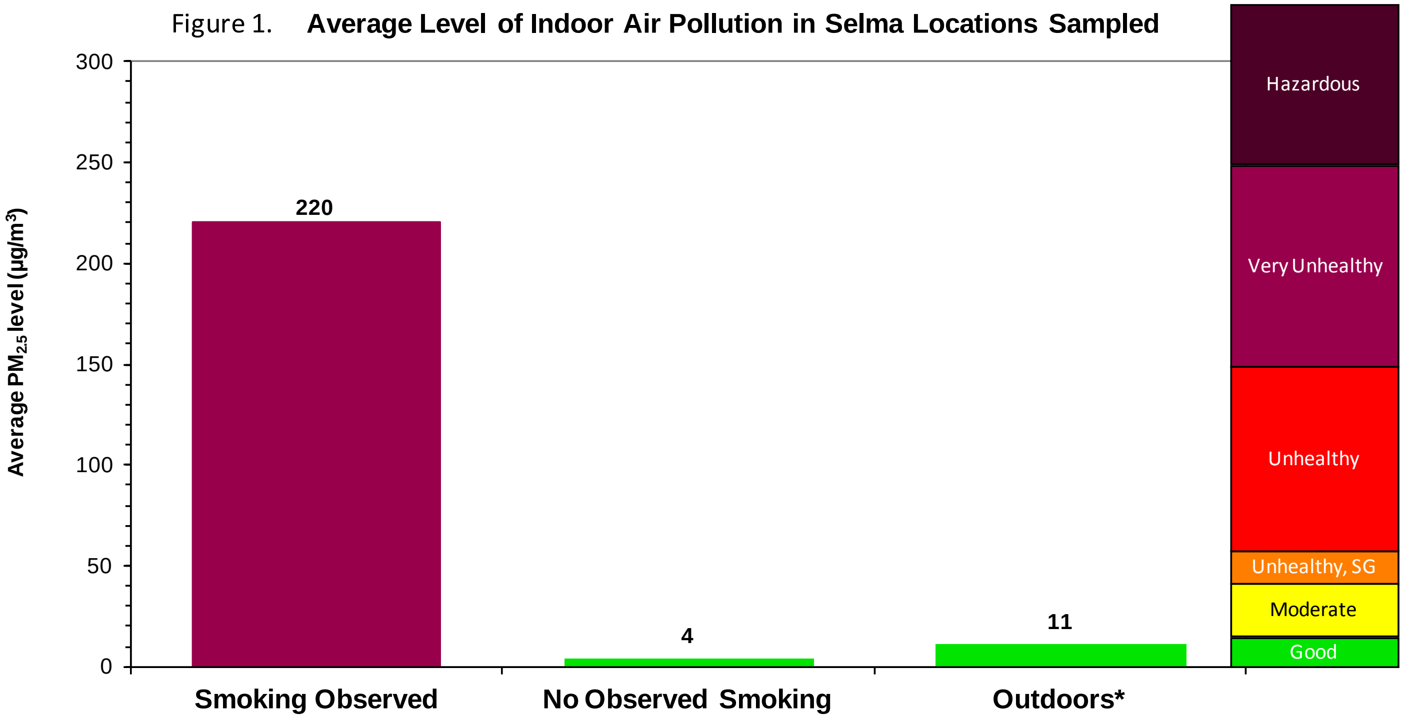
To evaluate the first hypothesis, statistical significance is assessed using the Mann-Whitney U test on the $PM_{2.5}$ concentrations in the observed smoking versus no observed smoking locations. The second hypothesis is tested by using all 6 sample visits and correlating the average smoker densities 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 3 locations with indoor smoking was 220 µg/m^3 (Figure 1). The $PM_{2.5}$ concentrations in places with smoking were higher than no observed smoking locations where the mean $PM_{2.5}$ concentration was 4 µg/m^3 (U=1.00, p=0.050).

In the 3 locations with observed smoking the average number of burning cigarettes was 2.7 which corresponds to an average smoker density (ASD) of 0.81 burning cigarettes per 100 m^3. Looking at all 6 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. Due to small sample size, this association was not statistically significant.(r_s=0.759, p=0.080).

Figure 1. **Average Level of Indoor Air Pollution in Selma Locations Sampled**



*Used for comparison purposes. Based on the 2011 average $PM_{2.5}$ level from the EPA monitoring sites in Montgomery County, Alabama (http://www.epa.gov/airdata/ad_rep_mon.html) The color-coded EPA Air Quality Index is also shown to demonstrate the magnitute of the measured particle levels

The real-time plot showing the level of indoor air pollution in each venue sampled is presented in Figure 2, on page 11. The real-time $PM_{2.5}$ plot reveals 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 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 Selma, Alabama Bars and Restaurants

Venue Number	Size (m^3)	Average # people	Average # burning cigs	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
No Observed Smoking					
1	1041	32	0.0	0.00	3
2	264	7	0.0	0.00	1
3	730	12	0.0	0.00	9
Average (n=3)	**678**	**17**	**0.0**	**0.00**	**4**
Smoking Observed					
4	137	13	1.5	1.09	29
5	581	26	3.0	0.52	202
6	431	75	3.5	0.81	428
Average (n=3)	**383**	**38**	**2.7**	**0.81**	**220**

*Average number of burning cigarettes per 100 cubic meters.

DISCUSSION

The EPA cited over 80 epidemiologic studies in creating a particulate air pollution standard in 1997.[12] Based on more recent evidence, the EPA has recently updated this standard and, in order to protect the public health, the EPA has set limits of 12 $\mu g/m^3$ as the average annual level of $PM_{2.5}$ exposure and 35 $\mu g/m^3$ for 24-hour exposure.[13] 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 220 $\mu g/m^3$ (the average level in all 3 Selma sites with observed smoking) on the job, and is exposed only to background particle levels of 11 $\mu g/m^3$ during non-work times. For a full-time employee their average annual $PM_{2.5}$ exposure is 59 $\mu g/m^3$. The EPA average annual $PM_{2.5}$ limit is exceeded by 5 times due to their occupational exposure.

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 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.[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 birth weight, 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 Selma bars and restaurants with observed indoor smoking are exposed to very unhealthy 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 Selma 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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Figure 2.

Selma, Alabama Air Quality Monitoring Study