NEW ORLEANS, LOUISIANA

INDOOR AIR QUALITY MONITORING STUDY

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EXECUTIVE SUMMARY

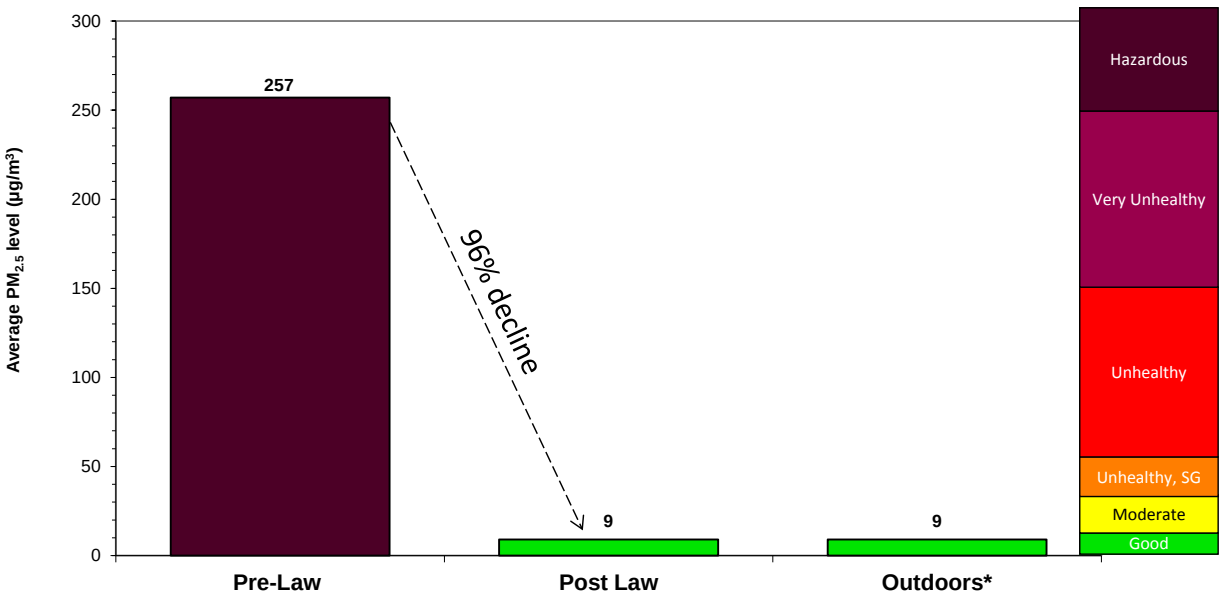
On April 22nd, 2015, the city of New Orleans smoke-free air ordinance went into effect, prohibiting smoking in most indoor public places including bars and casinos. In April 2015, indoor air quality was assessed in 13 bars and one casino both before the law went into effect. The same venues were visited in June, after the law was in effect.

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:

- Before the smoke-free air law, the average level of fine particle air pollution, or $PM_{2.5}$, was 257 $\mu g/m^3$ in the 10 places permitting smoking. This level is "Hazardous" according to the US EPA Air Quality Index.
- After the law, there was no smoking observed in these 10 locations and the level of fine particle air pollution dropped 96% to 9 $\mu g/m^3$, or "Good" according the US EPA Air Quality Index.
- $PM_{2.5}$ levels in the 4 smoke-free locations were moderately low pre-law (36 $\mu g/m^3$) and remained low during post-law sampling (7 $\mu g/m^3$).
- Fine particle air pollution was virtually eliminated in the casino where $PM_{2.5}$ levels dropped from 111 $\mu g/m^3$ to 1 $\mu g/m^3$ when smoking was eliminated, a reduction of 99%.
- Workers and patrons in New Orleans hospitality venues are no longer exposed to harmful levels of particulate air pollution as a result of the smoke-free air legislation

Figure 1. Average Level of Indoor Air Pollution in New Orleans Locations Sampled with Smoking Observed at Baseline



*Used for comparison purposes. Based on the 2014 average $PM_{2.5}$ level from the EPA monitoring sites in New Orleans, Louisiana (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 (*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 secondhand 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 also causes respiratory infections, more severe 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 how the level of fine particle air pollution in New Orleans, Louisiana bars and casinos changed after the implementation of the smoke-free air ordinance, effective April 22nd, 2015.

It is hypothesized that: 1) particle levels will decline significantly in a cohort of establishments permitting smoking at baseline that are sampled before and after the smoke-free air law; 2) there will be no significant change in particle pollution levels in a cohort of establishments that are smoke-free at baseline that are sampled before and after the law; and 3) 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 April, 2015, indoor air quality was assessed in 13 bars and one casino in New Orleans, Louisiana. On April 22nd, 2015 New Orleans prohibited smoking in most indoor public places including bars and casinos. These 13 bars and one casino were revisited after the law went into effect in June.

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

The first and second hypotheses are assessed using the Wilcoxon signed-rank test to compare the difference in the mean levels of $PM_{2.5}$ in establishments with observed smoking and those with no observed smoking before and after the New Orleans smoke-free air law came into effect. The third hypothesis is tested by using all 14 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 New Orleans location visited and tested is shown in Table 1. The average $PM_{2.5}$ level in the 10 locations with observed indoor smoking pre-law was 257 $\mu g/m^3$. The $PM_{2.5}$ level in these same 10 locations was 96% lower (9 $\mu g/m^3$) after the law went into effect (p=0.005). While There was no significant difference in $PM_{2.5}$ levels in the places that had no observed smoking pre-law (36 $\mu g/m^3$ pre-law, 7 $\mu g/m^3$ post-law, p=0.14).

Looking at all 14 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 indoor particle pollution levels. This association was statistically significant (r_s=0.65, p<0.01).

The two locations with the highest $PM_{2.5}$ levels pre-law but with no observed indoor smoking (venues 1 and 2 in Table 1) had observed smoking on adjacent patio/outdoor spaces that may have contributed to the indoor $PM_{2.5}$ levels.

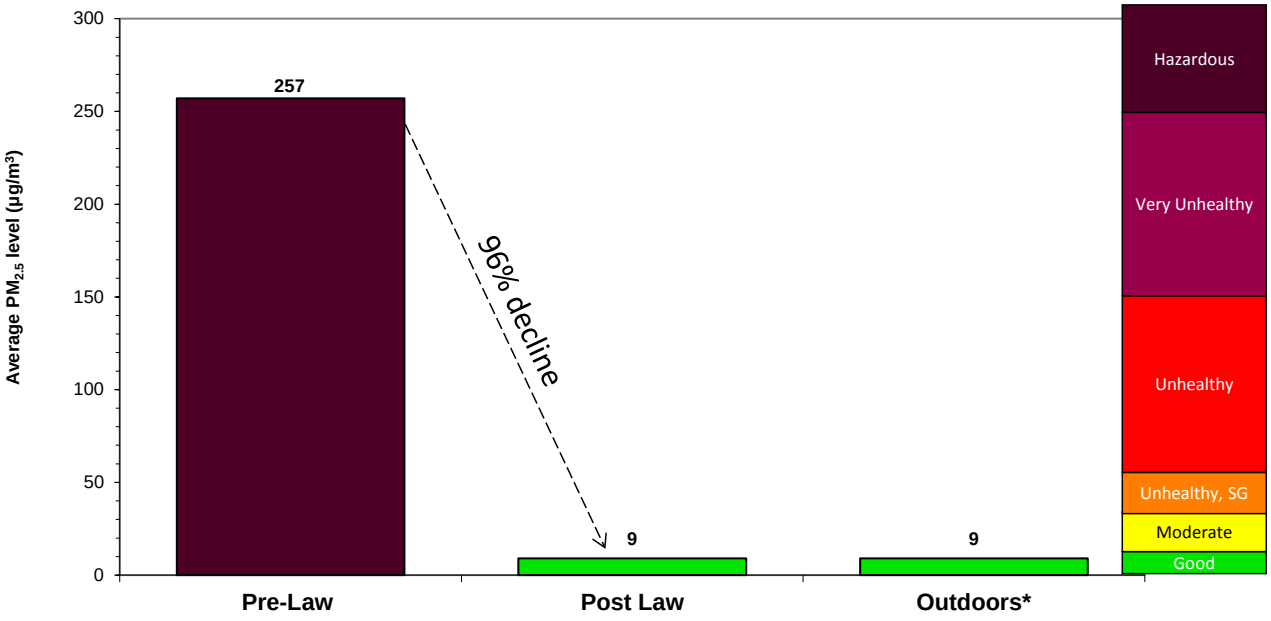
Figure 2 on page 11 shows a real-time plot of the $PM_{2.5}$ levels in each of the 10 post-law locations visited that had smoking at baseline. This plot shows low $PM_{2.5}$ levels in all location post-law, similar to outdoor background levels. The pre-law mean $PM_{2.5}$ of 257 $\mu g/m^3$ in these locations is shown as a reference line along with reference lines for the EPA Air Quality Index levels of "Good", "Very Unhealthy", and "Hazardous".

Table 1. Change in Indoor Fine Particle Air Pollution in New Orleans, LA

Venue Number	Pre-Law				Post-Law		
	Size (m^3)	Average # burning cigs	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)	Average # burning cigs	Active smoker density*	Average $PM_{2.5}$ level ($\mu g/m^3$)
No Observed Smoking Pre-Law							
1	874	0.0	0.00	112	0.0	0.00	12
2	138	0.0	0.00	20	0.0	0.00	5
3	276	0.0	0.00	4	0.0	0.00	1
4	178	0.0	0.00	6	0.0	0.00	8
Average	**367**	**0.0**	**0.00**	**36**	**0.0**	**0.00**	**7**
Smoking Observed Pre-Law							
5	10684	12.0	0.11	111	0.0	0.00	1
6	1508	4.0	0.29	99	0.0	0.00	14
7	2203	4.0	0.20	131	0.0	0.00	9
8	544	2.0	0.43	289	0.0	0.00	22
9	72	2.0	2.78	78	0.0	0.00	7
10	452	9.0	1.92	505	0.0	0.00	8
11	193	1.0	0.69	293	0.0	0.00	6
12	185	2.0	1.26	247	0.0	0.00	4
13	255	2.0	0.78	500	0.0	0.00	6
14	453	4.0	0.77	312	0.0	0.00	8
Average	**1655**	**4.2**	**0.92**	**257**	**0.0**	**0.00**	**9**

*Average number of burning cigarettes per 100 cubic meters.

Figure 1. Average Level of Indoor Air Pollution in New Orleans Locations Sampled with Smoking Observed at Baseline



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DISCUSSION

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 $\mu g/m^3$ as the average annual level of $PM_{2.5}$ exposure and 35 $\mu g/m^3$ 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 post law works 8 hours, 250 days a year, is exposed to 9 $\mu g/m^3$ (the average level in the 10 New Orleans sites with smoking observed at baseline) on the job, and is exposed to background particle levels of 9 $\mu g/m^3$ during non-work times. For a full-time employee their average annual $PM_{2.5}$ exposure is 9 $\mu g/m^3$. Therefore, these employees have annual particle exposure levels below the level set by the EPA to protect public health. This is in contrast to employees in New Orleans, before the city implemented the smoke-free air law, where workers were exposed to average $PM_{2.5}$ levels in the workplace of 257 $\mu g/m^3$. Assuming the same low background levels of 9 $\mu g/m^3$, this translates to an average annual exposure of 65 $\mu g/m^3$, 5 times higher than the safe level set by the EPA.

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), more severe 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 New Orleans bars and casinos are currently not exposed to hazardous levels of air pollution resulting from indoor smoking. New Orleans's smoke-free air ordinance that prohibits smoking in most indoor public places is a proven means to significantly reduce exposure to toxic tobacco smoke pollution, which will improve quality of life and health outcomes for New Orleans workers, entertainers, residents and visitors.

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.

New Orleans Air Quality Monitoring Study: Post-Law Sampling in Bars with Observed Smoking at Baseline