THE EFFECT OF PENNSYLVANIA'S CLEAN INDOOR AIR ACT ON AIR QUALITY IN THE HOSPITALITY INDUSTRY

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Abstract

This report investigates air quality indoors in Pennsylvania's hospitality industry before and after the Pennsylvania Clean Indoor Air Act (CIAA) of 2008, in 8 Pennsylvania locations in Erie, Harrisburg, Mechanicsburg, Montgomery County, Philadelphia, Pittsburgh, Scranton, State College, and Wilkes-Barre. Pre-CIAA respirable particulate (RSP) air pollution levels measured in 26 smoking venues ranged from Unhealthy to Hazardous. These high air pollution levels from secondhand smoke (SHS) produced an estimated SHS dose for hospitality workers averaging 9 times that of average U.S. adults. Pre-law, the threshold for secondhand smoke irritation was exceeded by 5 to 70 fold, while the adverse odor threshold was exceeded by 20 to 300 times in various venues, discouraging patronage by the nonsmoking majority. Post-CIAA, indoor RSP levels in smoke-free venues declined by nearly 90%. Risk assessment indicates that smoke-free air will save an estimated 52 hospitality workers' lives annually among Pennsylvania's 144,000 hospitality workers, and create healthy indoor air quality for patrons. Exceptions to the CIAA granted on economic grounds do not account for the economic costs of SHS-induced morbidity and mortality to workers and patrons, and run contrary to the experience of this industry in other states with smoke-free workplace laws.

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Introduction

Secondhand smoke (SHS) contains nearly 5000 chemical compounds, at least 172 of which are known toxic substances, containing 33 Hazardous Air Pollutants, 47 Chemicals restricted as Hazardous Waste and 67 Known Human or Animal Carcinogens. 3 chemicals or mixtures in SHS are EPA-regulated Criteria Pollutants and 3 more are OSHA-regulated workplace carcinogens (Repace, 2006a). Exposure to SHS is a known cause of disease, according to a number of lengthy, authoritative, peer-reviewed reports by national and international environmental, occupational, and public health authorities.

The Surgeon General (SG 1986), the National Academy of Sciences (NRC, 1986), the International Agency for Research on Cancer (IARC, 1987, 2004), the National Institute for Occupational Safety and Health (NIOSH 1991), the Environmental Protection Agency (EPA 1992), the Occupational Safety & Health Administration (OSHA, 1994), the National Cancer Institute (NCI 1993, 1998, 1999), the California EPA (Cal EPA 1997, 2005), and the National Toxicology Program (NTP 2000), variously concluded that nonsmokers' exposure to SHS causes fatal heart disease, lung, breast, and nasal sinus cancer, asthma induction and aggravation, middle ear infection, sudden infant death syndrome, and respiratory impairment, as well as irritation of the mucous membranes of the eyes, nose, and throat.

SHS is now widely accepted as the third leading preventable health hazard after active smoking and alcohol (SG, 2004), producing about 50,000 deaths per year in the U.S. (CalEPA, 2005); nevertheless it continues to be a widespread indoor pollutant in many states in the U.S. and abroad. Eliminating exposure to secondhand smoke is an evidence-based strategy cited by the U.S. Centers for Disease Control and Prevention (CDC) that contributes to a reduction in disease, disability and death from secondhand smoke exposure.

On June 13, 2008, Governor Edward Rendell signed into law Senate Bill 246, Pennsylvania's Clean Indoor Air Act (CIAA) to "protect Pennsylvanians from the deadly health effects of secondhand smoke by prohibiting smoking in most public places, including restaurants, workplaces and a portion of casino floors" (Rendell, 2008). The CIAA became effective on September 11, 2008, designating the Department of

Health (DOH) as the lead agency for implementation. The DOH developed a plan to implement the CIAA in cooperation with the Pennsylvania Alliance to Control Tobacco (PACT). The implementation plan focused on providing information and implementation tools to all businesses affected by the CIAA. The CIAA has numerous exceptions, five of which require review and approval by DOH.

One of the most important sources of exposure to air pollution from SHS is the hospitality industry: bars, restaurants, nightclubs, bowling alleys, and gambling facilities such as bingo games and casinos. Indoor air pollution from SHS in such venues has historically been investigated using air quality monitors. Air monitoring studies of SHS in 6 bar/restaurants in Boston, a casino, 6 bars, and a pool-hall in Wilmington, Delaware, and in 14 bars in 3 counties in western New York State, before and after state-wide clean indoor air laws, found that SHS contributes about 90% of the respirable particles (RSP) and carcinogenic particulate polycyclic aromatic hydrocarbons (PPAH) air pollution in bars (Repace and Lowrey, 1980; Repace, 2004; Travers et al, 2004; Repace, et al. 2006b). Measured levels greatly exceeded levels of these contaminants encountered on major truck highways and polluted city streets. The RSP levels from SHS in these venues *de facto* violated the U.S. Annual National Ambient Air Quality Standard (NAAQS) for fine particulate matter, generating significant health risks for bar staff (Repace, 2004; Travers et al., 2004; Repace, et al., 2006b) and patrons (Repace et al., 2006c).

The U.S. Annual National Ambient Air Quality Standard (NAAQS) for RSP. To place RSP into perspective, consider the NAAQS for particulate matter 2.5 microns in diameter or less ($PM_{2.5}$). $PM_{2.5}$ is the RSP size range that encompasses combustion-related fine particulate by-products such as tobacco smoke, chimney smoke, and diesel exhaust. $PM_{2.5}$ is legally regulated only in the outdoor air. To protect public health and welfare, the U.S. Environmental Protection Agency (EPA) issues National Ambient Air Quality Standards (NAAQS) for respirable particulate matter. In September 2006, the EPA promulgated a new 24-hour NAAQS for $PM_{2.5}$ of 35 $\mu g/m^3$ (micrograms per cubic meter) and retained the 1997 annual fine particle standard of 15 $\mu g/m^3$ (EPA, 2006).

The NAAQS for $PM_{2.5}$ is designed to protect against such respirable particle health effects as premature death, increased hospital admissions, and emergency room visits (primarily the elderly and individuals with cardiopulmonary disease); increased respiratory symptoms and disease (children and individuals with cardiopulmonary disease); decreased lung function (particularly in children and individuals with asthma); and against alterations in lung tissue and structure and in respiratory tract defense mechanisms in all persons (EPA, 1997). 90% of U.S. Counties have $PM_{2.5}$ levels below about 16 $\mu g/m^3$.

The Air Quality Index. Air Quality forecasts are provided by State and local agencies, using the U.S. Environmental Protection Agency's (EPA) Air Quality Index (AQI), a uniform index that provides general information to the public about air quality and associated health effects (EPA, 1999). The AQI is an index for reporting daily local air quality. It tells you how clean or polluted your air is, and what associated health effects might be a concern for you. The AQI focuses on health effects you may experience within a few hours or days after breathing polluted air. These index descriptors are described in Table 1. If pollutant levels are expected to be unhealthy, the state and local agencies will release a color-coded health warning or advisory to the local media and post these advisories on their web sites.

In many U.S. communities, AQI values are usually below 100, with values greater than 100 occurring at most several times a year. Typically, larger cities have more severe air pollution problems, and the AQI in these areas may exceed 100 more often than in smaller cities. AQI values higher than 200 are infrequent, and AQI values above 300 are extremely rare (Ellsworth, 2005). In this paper, we will refer to the "break points" of particulate concentration corresponding to the color-coordinated descriptors, e.g. 24-hour average levels ranging from 65.5 to 150.4 are "Code Red" or Unhealthy (Table 1). By measuring $PM_{2.5}$ using air quality monitors, our data measured indoors and outdoors before and after the CIAA can then be understood in health-related terms.

Airborne particles are one of two pollutants that pose the greatest threat to human health in this country, the other being ground level ozone. According to the Pennsylvania Department of Environmental Protection (PA DEP),

> "In Pennsylvania, $PM_{2.5}$ is a significant air pollution problem. Reducing concentrations of $PM_{2.5}$ is important because levels above the health-based standard are a serious human health threat and also can cause or contribute

to other negative environmental impacts. **Health Effects.** Fine particles generally pose greater health risks than larger particles. Because of their small size (less than one-seventh the average width of a human hair), fine particles can lodge deeply into the lungs. Health studies have shown a significant association between exposure to $PM_{2.5}$ and premature mortality. Studies have also linked exposure to $PM_{2.5}$ with other significant health problems including aggravation of respiratory and cardiovascular disease, lung disease, decreased lung function, asthma attacks, increases in respiratory symptoms like coughing and difficult or painful breathing, chronic bronchitis, and certain cardiovascular problems such as heart attacks and cardiac arrhythmia. Individuals particularly sensitive to $PM_{2.5}$ exposure include older adults, people with heart and lung disease, and children. Millions of Pennsylvanians live in areas where the $PM_{2.5}$ health-based standards are exceeded."

Table 1. The AQI: A Daily Air Quality Index

< http://cfpub.epa.gov/airnow/index.cfm?action=static.aqi>

Levels of fine particulate ($PM_{2.5}$) air pollution and corresponding U.S. health advisory descriptors with accompanying simplified color code (US EPA, 1999).

Air Quality Index Levels of Health Concern	$PM_{2.5}$ ($\mu g/m^3$) AQI Break-points	Air Quality Index (AQI) Values	Air Quality Conditions
Air quality satisfactory, air pollution poses little or no health risk.	0.0 - 15.4	0 - 50	Good
Air quality acceptable; however a moderate health concern for small numbers of persons unusually sensitive to air pollution.	15.5- 40.4	51 - 100	Moderate
Sensitive persons may experience health effects. General public not likely to be affected.	40.5 - 65.4	101 -150	Unhealthy Sensitive Groups
Everyone may begin to experience health effects; sensitive groups may experience more serious health effects.	65.5 - 150.4	151 - 200	Unhealthy
Health alert: everyone may experience more serious health effects.	150.5 - 250.4	201 - 300	Very unhealthy
Health warnings of emergency conditions. The entire population is more likely to be affected.	250.5 - 350.4	301 - 400	Hazardous
Air Pollution Emergency	350.5 - 500.4	401- 500	Very Hazardous
Increased Mortality	> 505	500	(Significant Harm)*

*Proposed 2007 (http://www.epa.gov/ttn/caaa/gen/aqi_issue_paper_020707.pdf).

Air Quality Monitoring in Pennsylvania's Hospitality Industry Before Pennsylvania's CIAA in 2006: Studies in Erie, Harrisburg, Mechanicsburg, Philadelphia, Pittsburgh, and Wilkes-Barre.

Methods.

The Air Quality Monitor.

Fine particle concentrations were measured using a continuous particle monitor (SidePak, TSI, MN). The SidePak monitor draws air through a sensor that measures particles based on light scattering. A 2.5 micrometer (µm) impactor is attached to inlet of the monitor to filter out the non-respirable particulate matter. The particle mass data are measured as $PM_{2.5}$ and stored in a data logger. The stored data was downloaded to a computer after the monitoring. The SidePak monitor used in this field survey of RSP was calibrated according to the methods described in Appendix A. Figure 1 shows the SidePak monitor.

Data Collection.

Fine particle ($PM_{2.5}$) air pollution levels using the SidePak personal air monitor were measured in **26** hospitality venues (23 indoor smoking-permitted, 1 outdoors, smoking, 1 separate nonsmoking room, and 1 indoor smoke-free) in Mechanicsburg, Wilkes-Barre, State College, Scranton, Erie, Pittsburgh, Philadelphia, Montgomery County, and Harrisburg, and in 25 outdoor/in-transit locations. All pre-CIAA measurements were conducted in 2006, except for a separate 2007 study that included Scranton. The sampling methodology was conducted according to standard protocols for measuring SHS (Repace, 1987; 2004). The TSI SidePak was calibrated before each day's test, started before entering the venue to capture outdoor data, run during the venue visit and then after departing the venue. Generally, several venues were tested on the same day. Field volunteers kept a time-activity pattern diary in which they recorded the name of each venue or location, and the time when each venue was entered and exited. Inside each venue, they recorded at approximately 10 minute intervals the number of people and the number of burning cigarettes observed. Field personnel were asked to provide at least thirty minutes of observations within each venue, to record the length, width, and height of each venue using an electronic ruler. Photos were taken of many the venues, notations were made of any observations that could be helpful to the analysis.

What Determines SHS Concentrations in Restaurants and Bars?

Concentrations of SHS are directly proportional to the smoker density (number of smokers in a room of a given size) and inversely proportional to the air exchange rate (rate at which smoke-polluted indoor air is replaced with smoke-free outdoor air). Thus, at fixed air exchange and smoking rates, one cigarette smoked in a large room will yield a lower SHS concentration than one smoked in a small room. However, by measuring both concentration and smoker density, it is possible to normalize (adjust) for this effect and thereby generalize the results. Smoker density can be determined by measuring the average number of cigarettes smoked during the observation time, and dividing by the space volume. The total or "effective" air exchange rate, is defined as the sum of pollutant removal by ventilation, surface deposition, and air cleaning (if any).

Air Exchange Rates: Restaurants and bars typically use forced-air mechanical ventilation to provide heating, cooling, and ventilation air. Mechanical ventilation rate design values are specified by the Atlanta, GA,-based American Society of Heating, Refrigeration, and Ventilation Engineers (ASHRAE, 1989, 2004). Assuming most of the venues investigated are 10 or more years old, the ventilation systems would have been designed according to ASHRAE Standard 62-1989, *Ventilation for Acceptable Indoor Air Quality*, specified ventilation rates for odor control "to accommodate a moderate amount of smoking" for premises in which smoking was allowed. These design ventilation rates are based upon building occupancy, i.e., number of occupants per unit floor area. For a given smoking prevalence, this determines the number of smokers per unit floor area, and for a given ceiling height, the smoker density. Thus, for a specific venue, e.g., a bar, the default design occupancy from the ASHRAE Standard can be used to estimate both the smoker density and the ventilation air exchange rate. Assuming a 10-foot ceiling, the default design air exchange rate for a bar is: C_v = (30 ft^3/min-occ)(100 occ/10,000 ft^3)(60 min/hr) = 18 air changes per hour (h^{-1}). These 1989 ventilation rates persisted until 2004, when ASHRAE issued ASHRAE 62.1-2004, which recommended ventilation rates only for non-smoking buildings, on the basis that cognizant health authorities condemned SHS as a cause of mortality.

In 2005, ASHRAE issued a Position Statement on Environmental Tobacco Smoke, which unequivocally ruled out dilution ventilation as a control for SHS (also known as environmental tobacco smoke, or ETS), concluding:

> *...although complete separation and isolation of smoking rooms can control ETS exposure in nonsmoking space in the same building, adverse health effects for the*

occupants of the smoking room cannot be controlled by ventilation. No other engineering approaches, including current and advanced dilution ventilation or air cleaning technologies, have been demonstrated or should be relied upon to control health risks from ETS exposure in spaces where smoking occurs.

Predicting levels of Secondhand Smoke -- The Habitual Smoker Model

It is possible to predict the concentrations of SHS in the air of hospitality venues using the smoker density and the air exchange rate. The Habitual Smoker Model (HSM) (Equation 1) is used to predict SHS concentrations, or to estimate the air exchange rate of a venue if the smoker density and SHS-RSP concentration are measured. This model is described in Repace (2004; 2006b), and assumes a 14 mg/cigarette emission rate and a smoking rate of 2 cigarettes per smoker-hour. Equation 1 gives the SHS-RSP concentration, in units of micrograms of pollutant per cubic meter of air ($\mu g/m^3$), as a function of the active smoker density D_s, in units of average number of burning cigarettes per hundred cubic meters ($BC/100m^3$) in the building and the air exchange rate C_v, in units of air changes per hour (h^{-1}):

$$RSP_{ETS} = 650 \frac{D_s}{C_v} \qquad (\mu g/m^3) \qquad \textbf{(Eq. 1).}$$

Predicted Active Smoker Density, D_s: The number of active smokers is defined as the number of burning cigarettes encountered in a venue averaged over the observation time, when counted every ten minutes, which is the approximate time a cigarette is smoked. The active smoker density is the number of burning cigarettes divided by the space volume expressed in metric units of hundred cubic meters. Pennsylvania smoking prevalence* in 2004 was: Men, 23.0% (95% CI: ± 2.1%), Women, 22.5% (±1.6%), All, 22.7% (± 1.3%) By comparison, the U.S. average in 2004 was: 20.9%, 23.4% in men and 18.5% in women. (MMWR, 2004) **[*** Persons aged >18 years who reported having smoked >100 cigarettes during their lifetime and who currently smoke every day or some days.] If a Pennsylvania bar has a percentage of smokers equal to the 2004 smoking prevalence of 22.7%, the default habitual smoker density is (0.227 smokers/occupant)(100 occupants/10,000 ft^3) = 22.7 smokers per 10,000 ft^3, or in metric units, 22.7 smokers per 283 cubic meters (m^3), of whom 1/3 would be expected to be actively smoking at any one time, which yields a predicted active smoker density at full occupancy of $D_s = (1/3)(22.7)/2.83 =$

2.67 active smokers per 100 m^3. This number is the default smoker density against which the actual smoker density can be compared to generalize the data measured in the study. In 2006 adult smoking prevlance had declined to 22%, and in 2007 to 21%; in the age group 18-44 it was 29% (PA, 2009).

Using Eq. 1, the predicted respirable smoke particulate (RSP) concentration ($PM_{3.5}$) for a Pennsylvania bar under the default conditions (ASHRAE Standard area occupancy and ventilation rate, and the 2004 Pennsylvania smoking prevalence):

$$\text{SHS-RSP}_{\text{PA bar}} = 650(2.67)/(18) = 96\ \mu g/m^3.$$

Assuming a background RSP concentration of 34 $\mu g/m^3$ from outdoor non-SHS sources infiltrating indoors (see Table 5), a field study of fine particle pollution from smoking in the ASHRAE-default occupied and ventilated pub (full occupancy, average smoking prevalence, and ASHRAE Standard ventilation rate) might be expected to show an estimated total RSP concentration of about (96 + 34) = 130 $\mu g/m^3$ with the RSP background added.

$$\textbf{SHS-RSP}_{\textbf{Bar}} + \textbf{Background RSP}_{\textbf{Outdoors}} = \mathbf{96\ \mu g/m^3 + 34\ \mu g/m^3 = 130\ \mu g/m^3}\ \textbf{(Eq. 2)}$$

Using the 15 $\mu g/m^3$ level of the U.S. National Ambient Air Quality standard as a reference level for "Clean Air," the Clean Air reference level is exceeded by a factor of (130/15) = 8.7. In other words, in a bar at full occupancy at Pennsylvania State smoking prevalence, using the ventilation rate as specified by the engineering code, clean air cannot possibly be attained.

More generally, these default predictions will serve as ball-park numbers to expect in this field study, and as a basis for generalizing the results of the field study to similar venues that may have different smoker densities or air exchange rates. If the smoker density in a particular venue is lower -- or the air exchange rate higher -- than the default calculation, the actual concentration will be lower; if the smoker density is higher or the air exchange rate lower, the actual concentration will be higher.

Pre-CIAA Air Quality 2006 Test Results.

Table 2 gives the measured parameters and values for the venues, including area, ceiling height, volume, average number of persons present, persons per thousand square feet to compare with ASHRAE default values (70 persons per 1000 ft^2 for restaurants, and 100 persons per 1000 ft^2 for bars at full occupancy), average number of burning cigarettes, averaging time, estimated smoker prevalence, measured RSP indoors and outdoors, with their respective averaging times, and calculated smoker densities and air exchange rates. **Table 3** summarizes this data for RSP indoors and outdoors, for all venues, and **Table 4** summarizes the data for all smoking venues.

Figure 1. The TSI SIDEPAK used in the Pennsylvania air quality study.

Figure 2 shows the model-calculated air exchange rates for each venue compared to the ASHRAE-equivalent air exchange rate. Figure 2 shows that 96% of the smoking venues were seriously underventilated; only one met the 18 air changes per hour standard consistent with ASHRAE engineering recommendations. This is not surprising, because there is no enforcement of ventilation rates, and since it costs money to heat, cool, and dehumidify, many establishments cut back on ventilation rates. In addition, tobacco tars gum up fan motors, filters, air cleaners, and outside air dampers, and maintenance may be poor or non-existent.

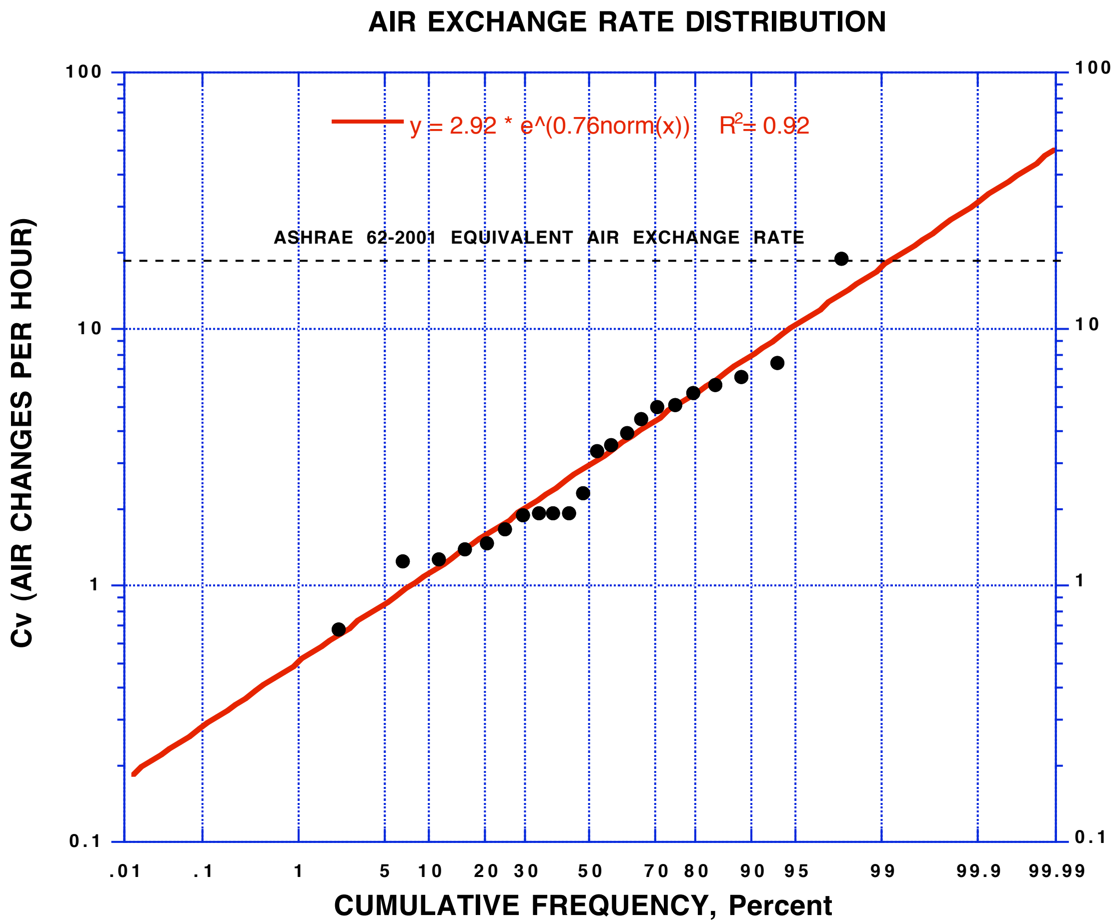

FIGURE 2. Cumulative Frequency logarithmic probability plot of calculated air exchange rates. Less than 1% of the air exchange rates meet the value calculated for venues in compliance with ASHRAE engineering standard recommendations (30 cfm/occ) in force for smoking-permitted venues in 2001. ASHRAE has not recommended ventilation rates for smoking establishments since 2004.

Table 2. 2006 Pennsylvania Indoor/Outdoor Air Quality Survey Results

Venue, 2006 Date, Locale	Area (ft^2)	Ceiling Height (ft)	Volume (m^3)	Ave. # Persons Present[a]	Ave. # Persons per 1000 ft^2	Ave. # Burning Cigarettes[a]	Indoor Averaging Time, min	Estimated Smoker Prevalence %	Ave. Venue RSP, $\mu g/m^3$	Ave. Outdoor/ In-transit Level, $\mu g/m^3$	Out-door Ave. Time, min	D_s, Active Smoker Density	C_v, Est. Air exchange rate, (h^{-1})
Applebee's 8/18 Carlyle Pike, Mechanicsburg	1929	9.41	514	80	41	2	47	7.5	60 (sd 15)	18 (sd 18)	41	0.39	6
Katana 8/21 SM Wilkes-Barre	1318	10	373	22	17	1	61	13.6	90 (sd 47)	13 (sd 3)	49	0.27	2.3
Katana 8/21 NS Wilkes-Barre	1318	10	373	22	17	1	44	13.6	17 (sd 6)	13 (sd 3)	49	0	-
Spag's 8/21 Wilkes-Barre	834	8.83	208	27	32	1.33	63	14.8	314 (sd 74)	13 (sd 3)	49	0.64	1.4
Hun's Café 8/21 Wilkes-Barre	1140	8.75	283	5.33	5	0.33	28	18.5	60 (sd 14)	13 (sd 3)	49	0.12	1.7
Zeno's Pub 8/23 State College	1038	7.58	223	15	14	2.66	31	53	233 (sd120)	14 (sd 4)	50	1.19	3.5
The Deli 8/23 State College	1073	9.33	283	20	19	0.66	45	9.9	22 (sd 8)	14 (sd 4)	50	0.23	19
Adams Apple 8/23 St. College	479	8	109	10	21	0.33	36	9.9	303 (sd52)	14 (sd 4)	50	0.30	0.67
Bill Pickles 8/23 State College	1572	16.33	727	23	15	1	63	13	62 (sd49)	14 (sd 4)	50	0.14	1.9
Applebee's 8/24 Erie	1629	9	415	47	29	0	46	0	21 (sd2.3)	38 (sd 28)	46	0.00	0
Max&Ermas 8/24 Erie	1901	13	700	143	75	1	62	2	65 (sd27)	38 (sd 28)	46	0.14	3.4
Zem Zem Bingo 8/24 Erie	8553	16	3875	125	15	12.33	150	30	179 (sd 52)	38 (sd 28)	46	0.32	1.5
FoxHound 8/24 Erie	3266	14-16	1314	139	43	3.66	39	7.9	66 (sd 8)	38 (sd 28)	46	0.28	6.5
PF Changs 8/25 Pittsburgh	2210	15	939	53	24	0.33	69	1.9	66 (sd 12)	68 (sd 14)	110	0.04	-
Hard Rock 8/25 Pittsburgh	1477	24.33	1017	90	61	3	56	10	116 (sd 15)	68 (sd 14)	110	0.29	3.9
Red Star 8/25 Pittsburgh	5000	19	2690	112	22	7	85	19	204 (sd 22)	68 (sd 14)	110	0.26	1.2

Table 2. 2006 Pennsylvania Indoor/Outdoor Air Quality Survey Results (continued)

Venue, 2006 Date, Locale	Area (ft^2)	Ceiling Height (ft)	Volume (m^3)	Ave. # Persons Present[a]	Ave. # Persons per 1000 ft^2	Ave. # Burning Cigarettes[a]	Averaging Time, min	Estimated Smoker Prevalence, %	Ave. Venue RSP, $\mu g/m^3$	Average Outdoor/ In-transit Level, $\mu g/m^3$	Out-door Ave. Time, min	D_s, Active Smoker Density	C_v, Est. Air exchange rate, (h^{-1})
Primanti Br 8/25 Pittsburgh	534	20	302	11	21	1.33	63	36	217 (sd 54)	68 (sd 14)	110	0.39	1.9
Jon's B&G 9/28 Philly 3rd & So.	900	outdoor	∞	25	28	1	51	12	27 (sd 2)	26 (sd 6)	218	0.00	-
Corner Bar, 9/28 Philadelphia	1440	10	408	10	7	0.33	31	9.9	33 (sd 2)	26 (sd 6)	218	0.27	7.4
Last Stop 9/28 Philly Alleg Ave	500	9	127	13	26	2	19	46	206 (sd 30)	26 (sd 6)	218	1.56	5.6
Donnas Bar 9/28 Philly Alleg Ave	300	14	119	13	43	1.33	17	31	190 (sd 27)	26 (sd 6)	218	0.12	4.4
Boat House 9/28 Mont'y County	2000	12	680	43	22	1.5	59	10.5	100 (sd 33)	26 (sd 6)	218	1.19	1.9
McGrath's 10/4 Dtn Harrisburg	576	12	196	17	30	3.2	71	56	264 (sd 129)	53 (sd 9)	23	0.23	5
Molly B's 10/4 Dtn Harrisburg	817	15	347	38	47	1.33	35	10.5	103 (sd 20)	53 (sd 9)	23	0.30	4.9
Kokomo's 10/4 Dtn Harrisburg	2070	10.5	615	54	26	3	37	16.7	218 (sd 69)	53 (sd 9)	23	0.14	1.9
Fire House 10/4 Dtn Harrisburg	1200	15	510	57	48	1.5	56	7.9	202 (sd 31)	53 (sd 9)	23	0.29	1.3

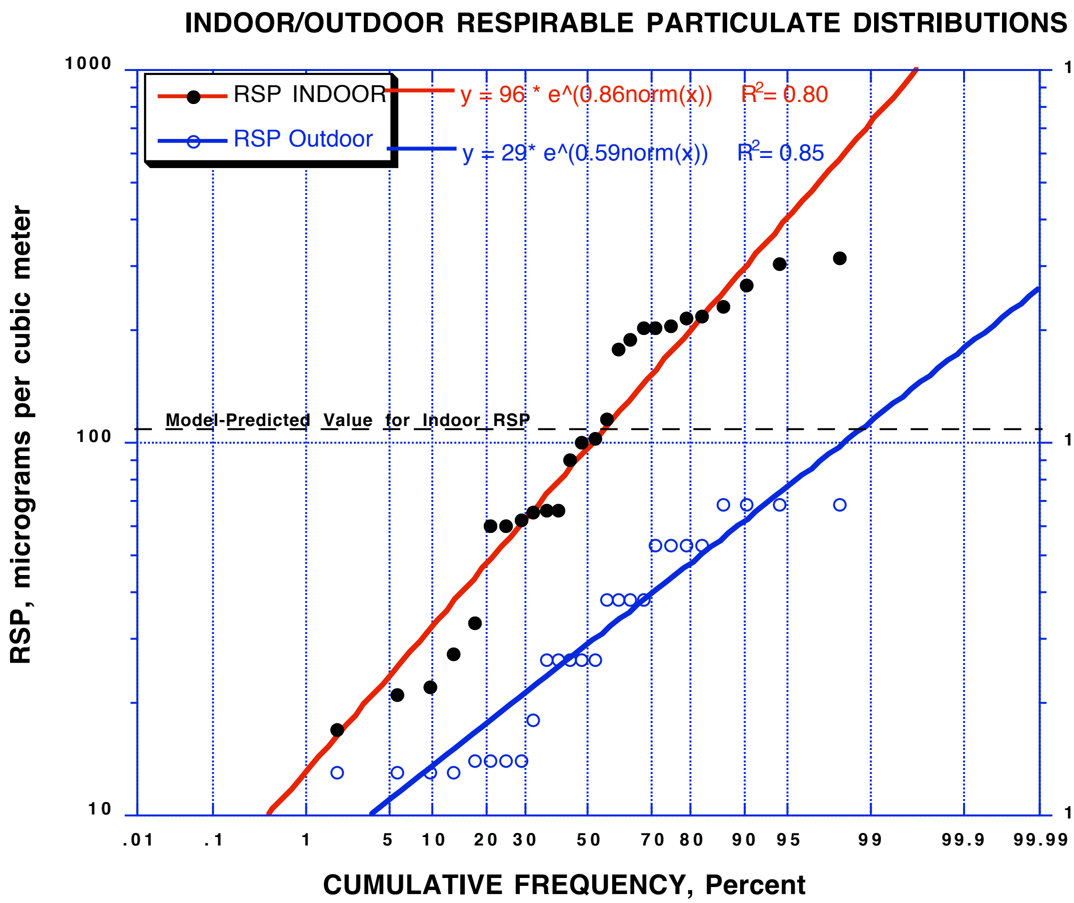

FIGURE 3. Indoor/Outdoor Respirable Particle concentrations plotted on a logarithmic probability graph yield straight lines. In all cases, the indoor levels are far higher than outdoors, due to tobacco smoke pollution.

Figure 3 plots the indoor and outdoor RSP vs. the Pennsylvania Air Quality Index levels, showing that for the 23 venues in which smoking occurred, 3 were in the Hazardous range, 8 were in the Very Unhealthy range, 9 were in the Unhealthy range, and 3 were in the Unhealthy for Sensitive Groups range. By contrast, the 2 nonsmoking venues and the outdoor smoking area were in the Moderate AQI Range. On the other hand, 29% of the combined outdoor/in-transit measurements for all Cities sampled were in the Unhealthy range, while 71% were in the Unhealthy for Sensitive Populations range. No areas were found to have Good air quality. Figure 3 shows that the distribution of measured indoor air RSP values exceeds the distribution of measured outdoor air RSP values at every percentile.

Table 3. RSP Levels, all Venues, Smoking, Nonsmoking vs.Outdoors.

Statistic	RSP Indoors	RSP Outdoors
Minimum	17	13
Maximum	314	68
Number of Venues	26	26
Mean	**132**	**34**
Median	102	26
Std Deviation	93	20

Table 4. RSP Levels, Smoking Venues vs. Outdoors.

Statistic	RSP Indoors	RSP Outdoors
Minimum	22	13
Maximum	314	68
Number of Venues	23	26
Mean	**147**	**34**
Median	116	26
Std Deviation	89	20
Model-Predicted Values	**130**	**34**

Figure 4 plots SHS-RSP values vs. irritation from SHS using an index derived by Junker et al. (20001) from chamber experiments. Figure 4 shows that 100% of the venues sampled have SHS levels that cause eye, nose, and throat irritation to nonsmokers. 70% of the venues sampled have SHS-RSP levels that exceed the irritation threshold by 10 to 70 times. Biener et al. (2000) found that there were more nonsmokers in Massachusetts who avoided patronizing smoky restaurants and bars than there were smokers in the state due to concerns about their poor indoor air quality. The lack of an adverse economic impact in the hospitality industry due to Massachusetts' smoke free workplace law one year (Connolly et al., 2005) later may be due in part to reductions in odor and irritation from SHS, make these venues more attractive to nonsmokers.

Figure 5 plots the estimated SHS-RSP values vs. Active Smoker Density showing model-calculated air exchange rates. Figure 5 shows why pubs that have similar smoker densities D_s may have different RSP values due to different ventilation practices. For example, for smoker densities between 0.2 and 0.3 active smokers per hundred cubic meters in figure 5, there are 9 venues whose concentrations vary over an order of magnitude from 10 μg/m^3 to 300 μg/m^3, which is explained by air exchange rates that vary from 18 h^{-1} to 0.67 h^{-1}. Ventilation rates are not regulated after installation, nor are there any requirements to inspect and maintain systems to certify that they are operating properly.

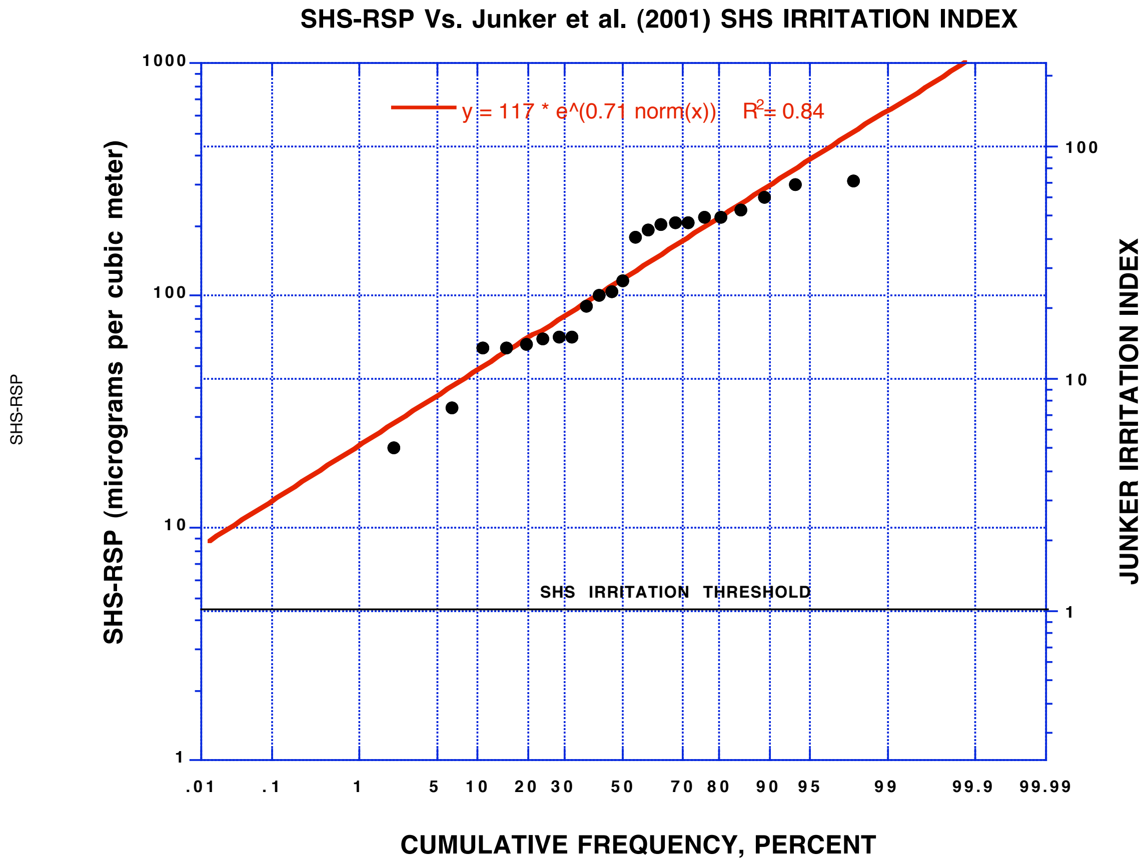

FIGURE 4. SHS-RSP vs. Junker et al. (2001) irritation index. Numerically, the threshold for irritation is at 4.4 μg/m^3 SHS-RSP. 100% of the smoking venues sampled have SHS levels that cause eye, nose, and throat irritation to nonsmokers. Venues sampled have irritation levels that exceed the irritation threshold by 5 to 70 times. The Odor Threshold of 1 μg/m^3 SHS-RSP is exceeded by 20 to 300 times.

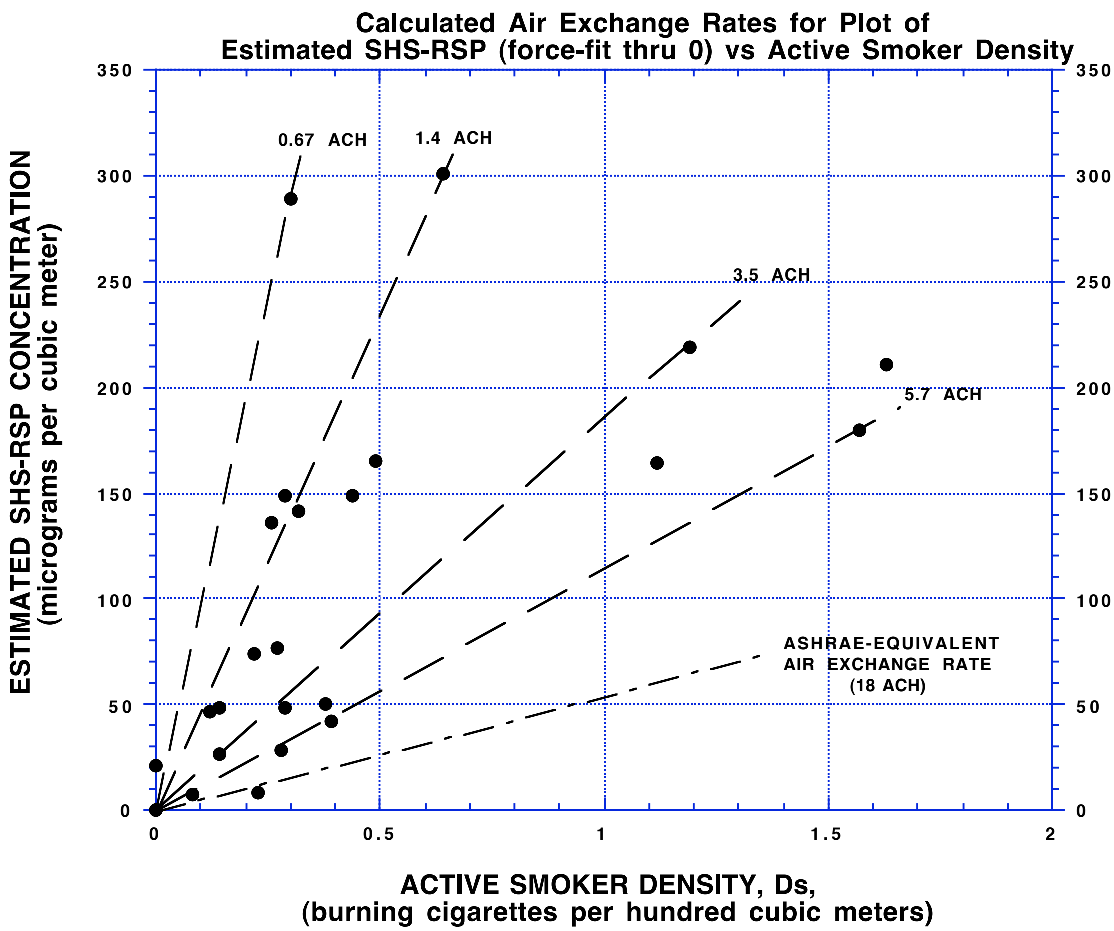

FIGURE 5. Plot of estimated SHS-RSP values vs. Active Smoker Density showing model-calculated air exchange rates. Only a single venue was ventilated according to code-equivalent (18 air changes per hour).

Table 5. Smoker Density Values from Figure 5.

Statistic	Finite D_s Values
Minimum	0.04
Maximum	1.19
Smoking Venues	23
Mean	0.36
Median	0.28
Std Deviation	0.30

Table 5 shows the active smoker density D_s (number of burning cigarettes per hundred cubic meters of space volume) ranges from 0.04 to 1.19 for the 23 smoking venues, with an average value of 0.36 (SD 0.30). This just 13%

of the expected smoker density of 2.67 AS/100 m^3 for a bar at maximum occupancy. In other words, at the times these venues are filled to maximum capacity, the air quality would be far poorer. In fact at the 3.96 ach average air exchange rate measured in this study (**Table 6**), at the maximum smoker density, the expected SHS concentration would be SHS-RSP = 650(2.67/3.96) = 440 $\mu g/m^3$, and at the minimum air exchange rate and maximum smoker density, the SHS-RSP_{max} would be 650(2.67/0.67) = 2590 $\mu g/m^3$, deep into the Significant Harm Zone. Since there are no controls over smoking, and no enforcement of ventilation rates, such a situation can occur. Thus it is to be expected that the highest values observed in this study do not constitute an upper bound to the SHS concentration. **Table 6** shows the range in air exchange rates C_v.

Table 6. Air Exchange Rate Values.

Statistic	Estimated Air Exchange Rate Values (ach)
Minimum	0.67
Maximum	18.7
Points	22
Mean	3.96
Median	2.82
Std Deviation	3.83

Figure 6 graphically depicts the data from 23 smoking venues and 3 nonsmoking venues in the 2006 pre-CIAA study, in comparison to the outdoors, and showing nonsmoking areas. The left axis gives the measured RSP levels in micrograms per cubic meter during the visit, the right axis compares these short term measurements to the AQI to place the concentrations in perspective as corresponding to more or less polluted air. The horizontal axis describes the location of the venue (city or town), the location (indoors or out or separate nonsmoking room). **Figure 7** combines the results of Figure 6 into a single plot showing the average RSP levels indoors in the smoking and nonsmoking areas, and outdoors.

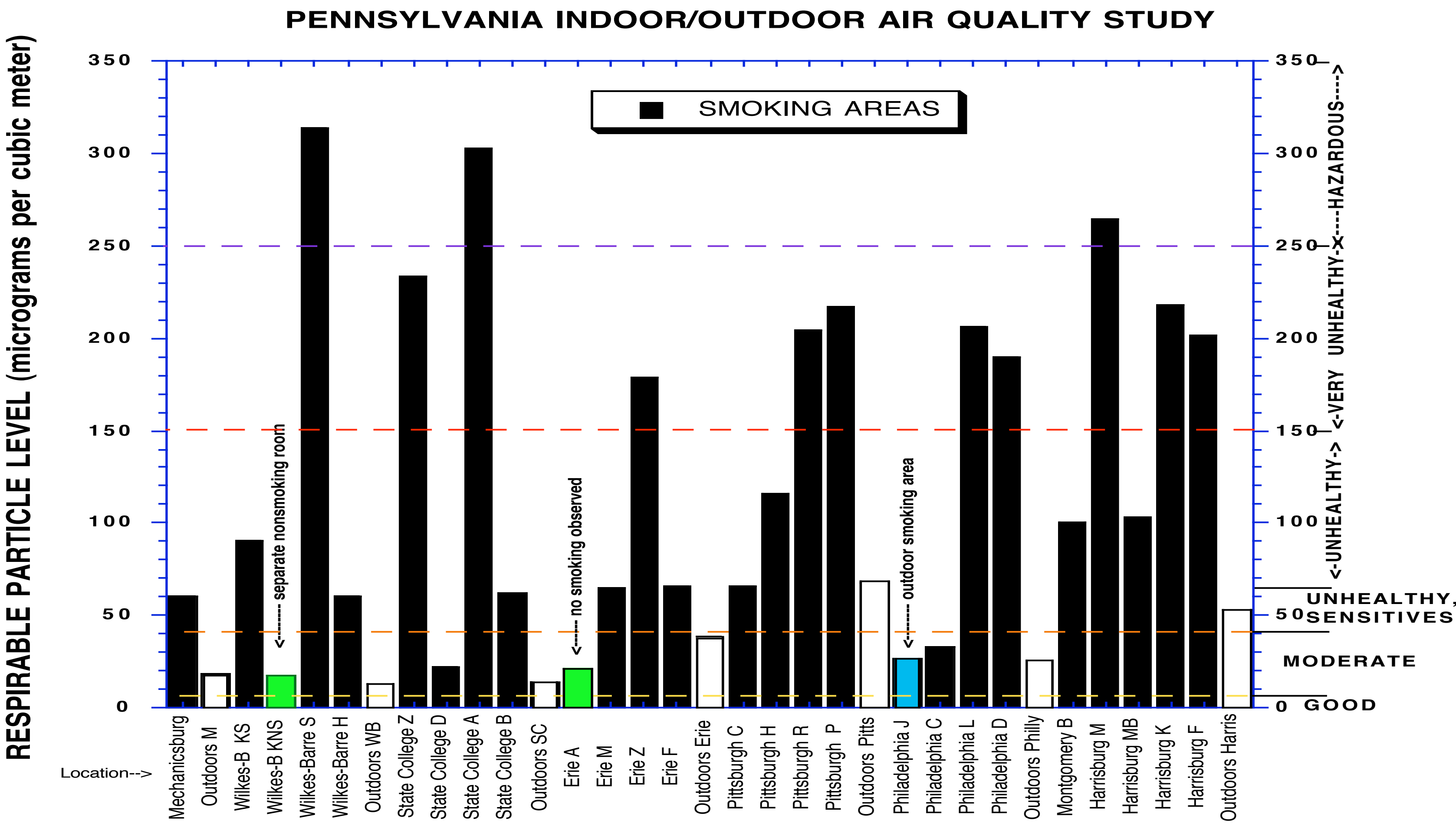

Figure 6. Indoor vs. Outdoor Air RSP. Black: smoking venues; White: outdoors/intransit; Green: nonsmoking venues.

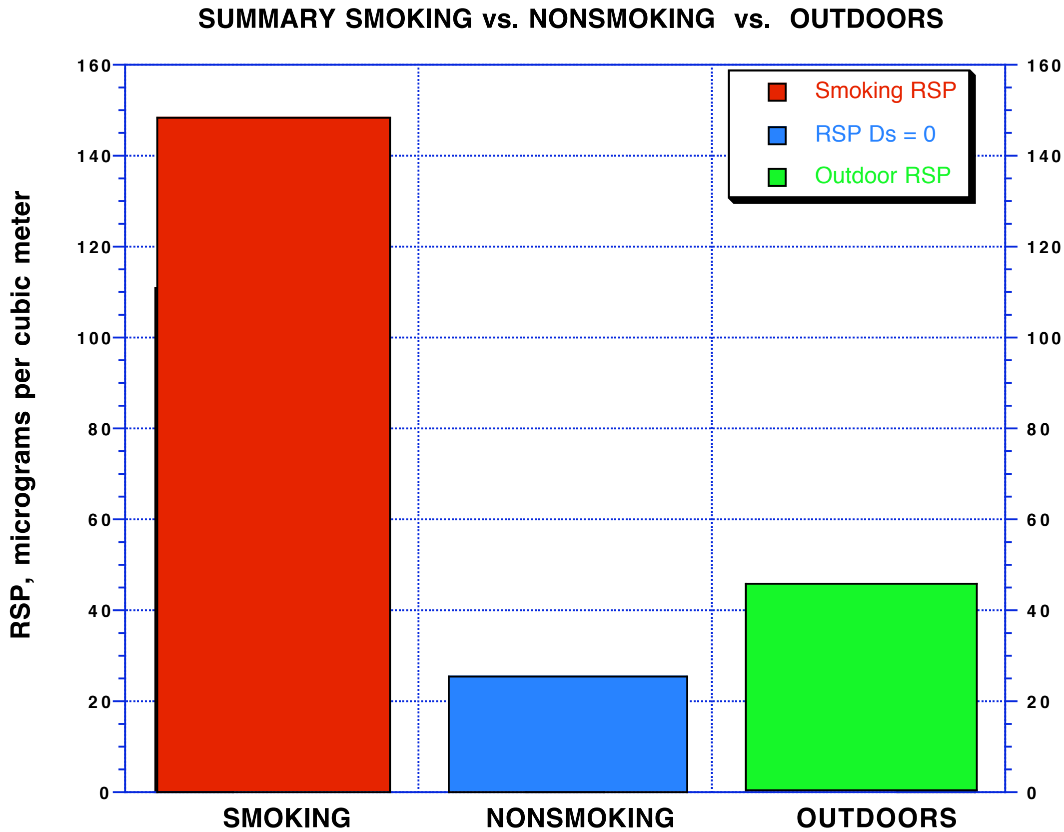

Figure 7. Summary Plot. Indoor vs. Outdoor Air Quality in 26 venues in 8 Pennsylvania Cities and Towns in the 2006 pre-CIAA study. On average, smoking venues were 8 times as polluted as nonsmoking, and more than 4 times as polluted as outdoors & in-transit.

Exposure to respirable particulate matter causes significant health problems, including: aggravated asthma; chronic bronchitis; reduced lung function; irregular heartbeat; heart attack; and premature death in people with heart or lung disease. This summarizes the first part of this investigation in 2006, which studied $PM_{2.5}$ air quality indoors in 23 venues permitting smoking in Pennsylvania's hospitality industry, in comparison to outdoor air quality by means of real-time air quality monitoring. The levels of PM measured in 2 smoking venues range from Unhealthy for Sensitive Groups to Hazardous on the AQI index, whereas nonsmoking venues are only moderately polluted with RSP, and less than outdoor/ levels. Thresholds for irritation were exceeded by 10 to 70 fold. The median SHS odor threshold of 1 $\mu g/m^3$ SHS-RSP is exceeded by 7 to 350 times. **Figure 7** shows that $PM_{2.5}$ from SHS is 6 times as great in smoking venues than in nonsmoking, and more than 3 times as great as outdoors/in-transit locations.

POST CLEAN INDOOR AIR ACT MEASUREMENTS.

The second part of this investigation, performed in Philadelphia and Scranton in 2007 was also a real-time air quality monitoring study in ten venues. Scranton and Philadelphia adopted smoke-free ordinances in 2007. The Scranton ordinance went into effect January 8, 2007. The Philadelphia ordinance went into effect January 8, 2007. Of the 5 venues studied in Scranton, one was out of compliance, and of the 4 studied in Philadelphia, two were out of compliance. **Figure 8** summarizes the Philadelphia-Scranton results for 7 smoke-free compliant Philadelphia & Scranton and 3 non-compliant hospitality venues, before and after a smoking ban. Air Pollution Levels dropped by 84% in smoke-free-law-compliant venues, from an average of 167 $\mu g/m^3$ to 26 $\mu g/m^3$, (an average decrease of 141 $\mu g/m^3$) compared to 19 $\mu g/m^3$ outdoors, and increased by almost 10% in the non-compliant ones (Repace, 2007).

The third and final investigtion was performed in Erie, Harrisburg, Pittsburgh, and Wilkes-Barre February and March of 2009, approximately six months after Pennsylvania's State-wide CIAA went into effect. The levels of RSP indoors and outdoors were studied for 17 of the previous 23 venues studied in 2006 pre-CIAA. All of the venues were smoke-free. **Table 9** summarizes those results, with the 2006 RSP measurements repeated from Table 4 for easy comparison. **Figure 9** plots the data from **Table 6**, comparing the RSP measurements in the 17 pre-ban smoking venues in 2006 (red bars) with those same venues smoke-free in 2009 (blue bars) as a result of compliance with Pennsylvania's CIAA, and to outdoor RSP measurements in 2009 (white bars). It is seen that in every case, The CIAA has decreased RSP pollution. The average for all venues is summarized in **Figure 10** shows that indoor air pollution levels in these now smoke-free venues have decreased by 87%.

Further, it is seen that there is little difference between the post-CIAA indoor RSP 17 $\mu g/m^3$ (sd 12 $\mu g/m^3$) and the outdoor levels 13 $\mu g/m^3$ (sd 5.5 $\mu g/m^3$), indicating that SHS RSP pollution exceeds non-SHS RSP indoor sources by a factor of (126-17)/(17-13) ~ 27-fold. **Or in other words, more than 96% of the RSP indoor air pollution from indoor sources in these venues came from SHS, and in the absence of SHS pollution, 13/17 or**

76% of the RSP pollution comes from outdoor air pollution. Figure 11 compares the distribution of RSP in the 17-Venues Pre-CIAA in 2006 when they were smoke-filled, and Post-CIAA in 2009 when they were smoke-free, vs. contemporaenously measured outdoor RSP outside the premises in 2009. There is little difference between the indoor and outdoor RSP levels post-CIAA, but during the smoking era, about 85% of the RSP levels indoors corresponded to Unhealthy levels of air pollution (above 40.5 μg/m^3), while 70% of the RSP levels during the smoke-free era corresponded to Good Air Quality (less than 15.4 μg/m^3).

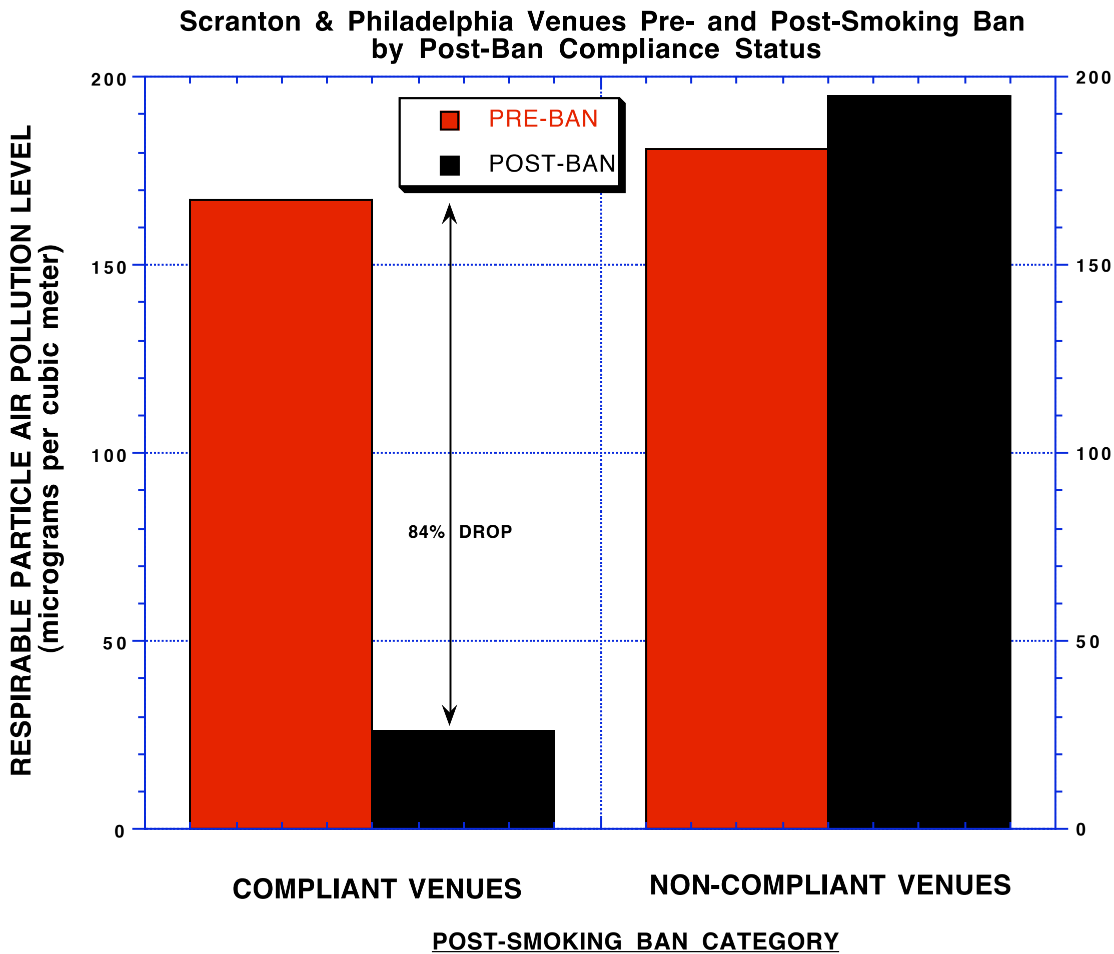

Figure 8. Air Pollution in 7 smoke-free compliant Philadelphia & Scranton and 3 non-compliant hospitality venues, before and after a 2007 smoking ban. (Repace, 2007).

Table 6. 2009 Pennsylvania Indoor/Outdoor Air Quality Survey Post-Ban Results

Venue, 2009 Date, Locale	Area (ft^2)	Ceiling Height (ft)	Volume (m^3)	Ave. # Persons Present	Ave. # Persons per 1000 ft^2	Ave. Smoker density Pre-ban (2006) (Table 7)	Ave. Pre-Ban (2006) RSP $\mu g/m^3$ (Table 7)	Post-ban Indoor Averaging Time, min	Ave. Post-Ban (2009) RSP, $\mu g/m^3$	Ave. 2009 Postban Outdoor/ In-transit RSP Level, $\mu g/m^3$	Outdoor Ave. Time, min
Katana 2/27/09 Wilkes-Barre	1318	10	373	40	30	0.27	90 (sd 47)	50	**18 (sd 11)**	**12 (sd 2.4)**	30
Zeno's Pub 2/26/09 St College n=33	1038	7.58	223	7	7	1.19	233 (sd120)	33	**14 (sd 3.1)**	**23 (sd 6.0)**	36
The Deli 2/26/09 St. College n=50	1073	9.33	283	18	17	0.23	22 (sd 8)	50	**17 (sd4.0)**	**23 (sd 6.0)**	36
Bill Pickles 2/26/09 State College	1572	16.33	727	11	7	0.14	62 (sd49)	34	**22 (sd3.4)**	**23 (sd 6.0)**	36
Applebee's 2/19/09 Erie n= 57	1629	9	415	75	46	0.00	21 (sd2.3)	57	**6.7 (sd 1.2)**	**8.7 (sd 4.2)**	89
Max&Ermas 2/19/09 Erie n=61	1901	13	700	53	28	0.14	65 (sd27)	61	**9.5 (sd 0.57)**	**8.7 (sd 4.2)**	89
Zem Zem Bingo 2/19/09 Erie n=48	8553	16	3875	67	8	0.32	179 (sd 52)	48	**11 (sd 4.0)**	**8.7 (sd 4.2)**	89
Fox& Hound 2/19/09 Erie n=58	3266	14-16	1314	53	16	0.28	66 (sd 8)	58	**9.4 (sd 0.53)**	**8.7 (sd 4.2)**	89
PF Changs 2/20/09 Pittsburgh n=35	2210	15	939	133	60	0.04	66 (sd 12)	35	**6.29 (sd 1.1)**	**12 (sd 5.8)**	54
Hard Rock 2/21/09 Pittsburgh n=61	1477	24.33	1017	75	51	0.29	116 (sd 15)	61	**13 (sd 2.7)**	**12 (sd 5.8)**	54
Red Star 2/21/09 Pittsburgh n=47	5000	19	2690	16	3	0.26	204 (sd 22)	47	**18 (sd 3.8)**	**12 (sd 5.8)**	54

Table 6 (continued). 2009 Pennsylvania Indoor/Outdoor Air Quality Results

Venue, 2009 Date, Locale	**Area (ft^2)**	**Ceiling Height (ft)**	**Volume (m^3)**	**Ave. # Persons Present[a]**	**Ave. # Persons per 1000 ft^2**	**Ave. Smoker density Pre-ban (2006) (Table 7)**	**Ave. Pre-Ban 2006 Venue RSP, $\mu g/m^3$ (Table 7)**	**Post-Ban Averag-ing Time, min**	**Ave. Post-Ban Venue RSP, $\mu g/m^3$**	**Ave. Post-ban Outdoor $\mu g/m^3$**	**Out-door Ave. Time, min**
Primanti Bro 2/21/09 Pitts	534	20	302	52	97	0.39	217 (sd 54)	83	**38 (sd 8.7)**	**12 (sd 5.8)**	54
Corner Bar/ East End* Philadelphia	1440	10	408	10	7	0.27	33 (sd 2)	23	**13 (sd 0.8)**	**11 (9.1)**	139
Last Stop Philly *	500	9	127	5	10	1.56	206 (sd 30)	32	**52 (sd 42)**	**11 (9.1)**	139
McGrath's 3/7/09, DnTn Harrisburg	576	12	196	32	56	0.23	264 (sd 129)	45	**24 (sd 3.6)**	**20 (sd 4.5)**	24
Molly B's 3/1/09, Dn-Tn Harrisbrg	817	15	347	28	34	0.30	103 (sd 20)	54	**8.6 (sd 0.90)**	**8.4 (sd 2.6)**	24
Fire House 3/1/09, DnTn Harrisburg	1200	15	510	51	43	0.29	202 (sd 31)	41	**10.1 (SD 0.94)**	**8.4 (sd 2.6)**	24
Means (All 17 Venues)							**126 (sd 82)**		**17 (sd 12)**	**13 (sd 5.5)**	

*Philadeliphia study conducted in .

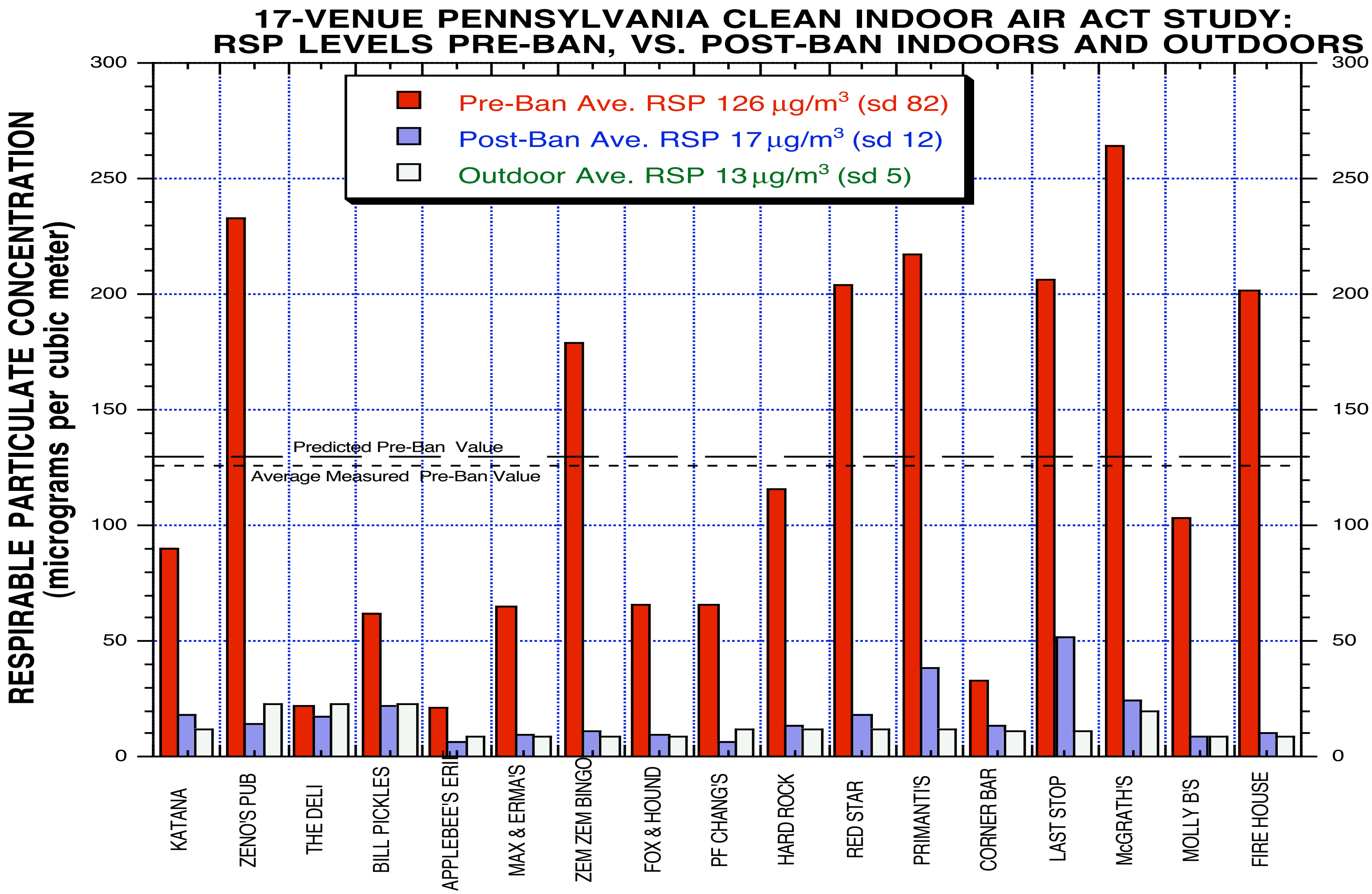

Figure 9. Comparison of 2006 Pre-CIAA Law and 2009 Post-CIAA Law RSP in 17 venues plus Outdoors.

Pennsylvania Indoor/Outdoor Air Quality Survey Pre-Ban/Post-Ban Results

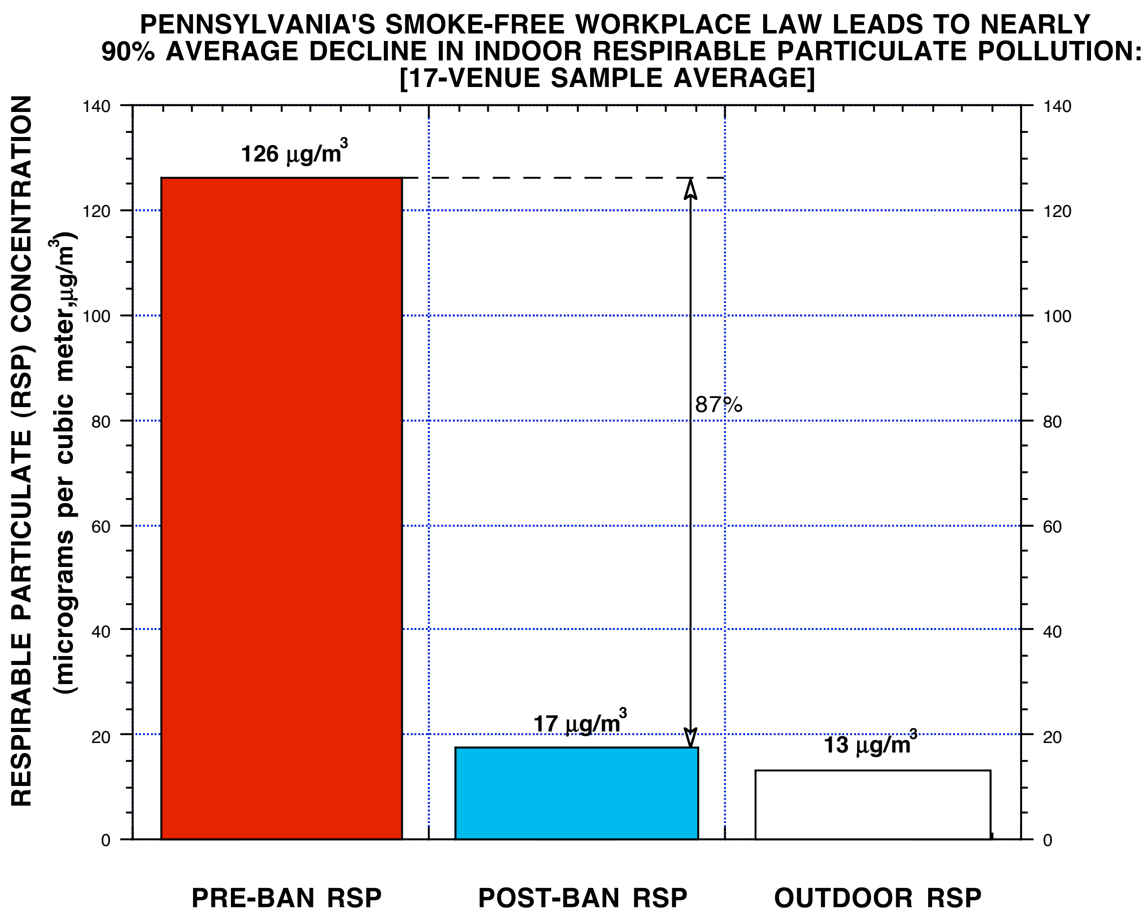

Figure 10. 17 Venue summary, pre-ban RSP (2006) vs post-ban (CIAA) RSP (2009) vs outdoor RSP (2008). Secondhand smoke contributes an estimated 87% to indoor air pollution in the absence of Pennsylvania's Clean Indoor Air Act, with outdoor RSP contributing another 10%, and non-SHS RSP from all other internal sources contributing 3%. Air Pollution Levels dropped by 87% in smoke-free-law-compliant venues, from an average of 126 $\mu g/m^3$ to 17 $\mu g/m^3$, (an average decrease of 109 $\mu g/m^3$).

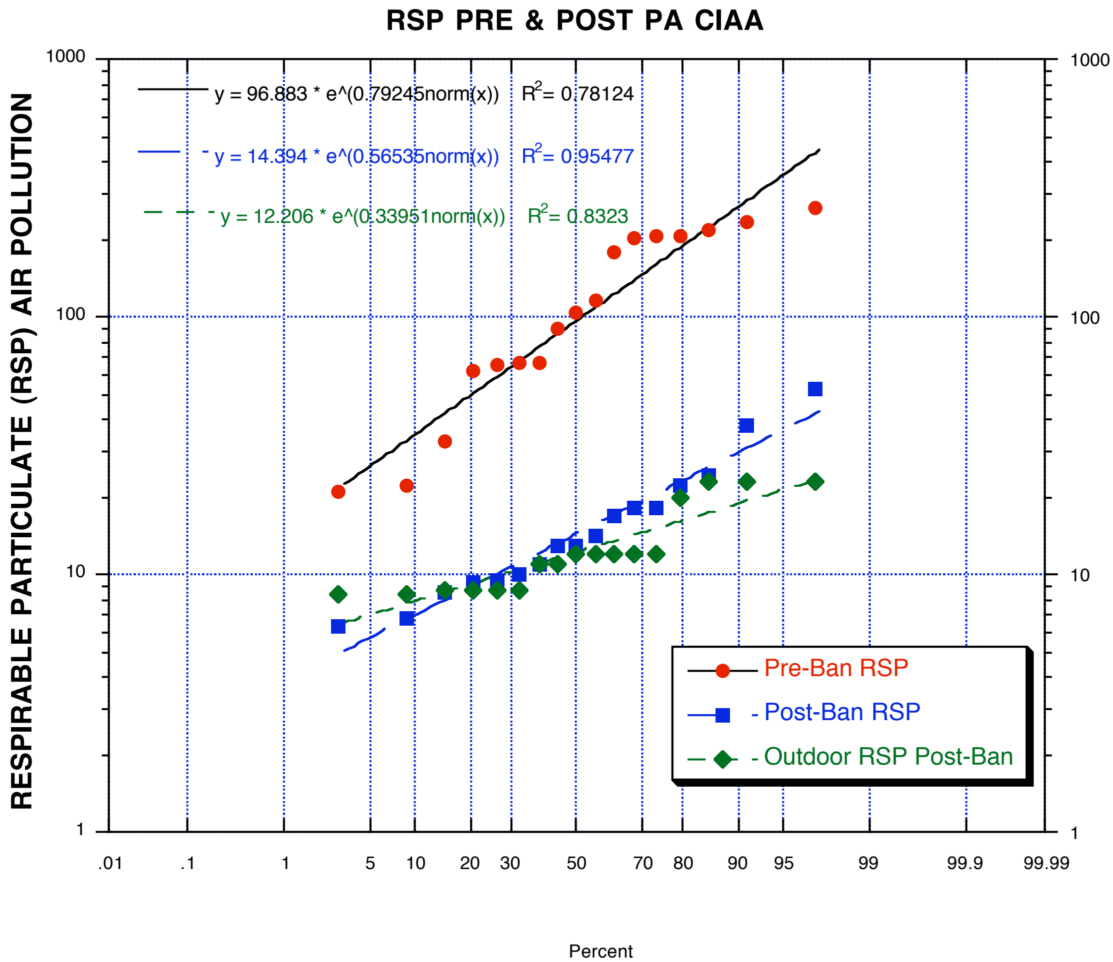

Figure 11. 17-Venue comparison of Pre-CIAA (2006) and Post-CIAA RSP (2009) vs. Outdoor RSP (2009).

Discussion. The 87% decrease obtained in the 17-venue post-CIAA 2009 study are quite similar to the 84% decrease in indoor RSP levels obtained in the 2007 study in the Philadelphia and Scranton in the 7 smoke-free-compliant venues, while the 3 that did not comply with the smoking ban actually suffered an increase in RSP levels. Thus, between the present study summarizing post-ban results from the 17 venues in Wilkes-Barre, State College, Erie, Pittsburgh, and Harrisburg, together with the 7 venues in the Philadelphia-Scranton study, this totals 24 compliant venues with similar results. If the RSP values pre-ban for all 24 venues are combined in a weighted average, the result is (167 μg/m^3)(7/24)+ (126 μg/m^3)(17/24) = 138 μg/m^3, well up into the Unhealthy zone as shown in Table 1. By comparison, pre-smoking-ban RSP levels in 6 Boston pubs before a city-wide smoking ban averaged 179 μg/m^3, 23 times higher than post-ban levels, which averaged 7.7 μg/m^3 (Repace, et al., 2006).

In order to understand the impact of such levels on the relative exposure of Pennsylvania's hospitality workers compared to the average SHS of the general adult population, this exposure can be converted into a dose equivalent, and compared with a national survey of adult SHS conducted by the U.S. Centers for Disease Control (**Table 7**).

Table 32. Cotinine

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for the non-smoking U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval) 50th	75th	90th	95th	Sample size
Total, age 3 and older	99-00	*	.059 (<LOD-.070)	.236 (.190-.300)	1.02 (.750-1.25)	1.96 (1.60-2.62)	5999
	01-02	.062 (.050-.077)	†	.163 (.123-.224)	.932 (.737-1.17)	2.19 (1.83-2.44)	6813
Age group							
3-11 years	99-00	*	.109 (.063-.180)	.500 (.259-1.09)	1.88 (.997-3.44)	3.37 (1.42-4.79)	1174
	01-02	.110 (.076-.160)	.071 (<LOD-.124)	.570 (.306-1.01)	2.23 (1.60-2.78)	3.21 (2.53-4.01)	1414
12-19 years	99-00	*	.107 (.080-.160)	.540 (.428-.660)	1.65 (1.48-1.92)	2.56 (2.09-3.39)	1773
	01-02	.086 (.059-.126)	.051 (<LOD-.109)	.352 (.189-.580)	1.53 (1.09-2.12)	3.12 (2.47-3.99)	1902
20 years and older	99-00	*	< LOD	.167 (.140-.193)	.630 (.530-.810)	1.48 (1.28-1.66)	3052
	01-02	.052 (<LOD-.063)	†	.113 (.090-.150)	.623 (.465-.770)	1.38 (1.11-1.84)	3497
Gender							
Males	99-00	*	.080 (.059-.109)	.302 (.220-.394)	1.20 (.950-1.49)	2.39 (1.66-3.22)	2789
	01-02	.075 (.059-.095)	†	.230 (.165-.316)	1.17 (.932-1.42)	2.44 (2.23-2.97)	3149
Females	99-00	*	< LOD	.179 (.148-.220)	.850 (.597-1.14)	1.85 (1.33-2.45)	3210
	01-02	.053 (<LOD-.066)	†	.123 (.092-.180)	.711 (.537-.990)	1.76 (1.32-2.16)	3664
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	.138 (.110-.176)	.506 (.370-.726)	1.21 (.900-1.70)	2241
	01-02	.060 (<LOD-.084)	†	.157 (.080-.308)	.727 (.452-1.19)	2.11 (1.14-2.98)	1877
Non-Hispanic blacks	99-00	*	.131 (.111-.150)	.505 (.400-.625)	1.43 (1.18-1.75)	2.34 (1.84-3.50)	1333
	01-02	.164 (.136-.197)	.132 (.106-.161)	.570 (.436-.760)	1.77 (1.54-2.01)	3.12 (2.47-4.25)	1599
Non-Hispanic whites	99-00	*	.050 (<LOD-.070)	.210 (.150-.310)	.950 (.621-1.40)	1.92 (1.48-3.02)	1950
	01-02	.052 (<LOD-.068)	†	.119 (.087-.180)	.800 (.571-1.11)	1.88 (1.49-2.30)	2845

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.
* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.
† 83% of measurements had a LOD of 0.015 ng/mL and 17% of measurements had a LOD of 0.050 ng/mL. See note in text.

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Table 7. NHANES Serum Cotinine Levels (CDC, 2005).

Dose Assesssment

The 24-hr average SHS-RSP exposure is estimated from Table 4 from the difference between the pre-ban smoking venues and post-ban smoke-free RSP values:, the SHS-RSP = 147 $\mu g/m^3$ – 34 $\mu g/m^3$ = 113 $\mu g/m^3$. Assuming that the average hospitality worker is exposed to this concentration for 8 hours daily, the 24-hour average SHS-RSP concentration is R = (8/24)(113 $\mu g/m^3$) = 38 $\mu g/m^3$.

This H= 24 hour SHS-RSP exposure may be converted to serum cotinine P and urine cotinine U using the Rosetta Stone Equations (Repace, Al-Delaimy, and Bernert, 2006). For serum cotinine, to compare to the average US Adult (**Table 7**): P = RH/1667 = (38)(24)/(1667) = 0.55 nanograms of cotinine per milliliter of blood serum (ng/ml). By comparison, the average (males and females combined) serum cotinine level for the typical adult is 0.064, a ratio of nearly 9:1, demonstrating that Pennsylvania hospitality workers were an estimated 9 times as exposed to SHS pollution than the average American adult. The urine cotinine equivalent is U = 6.5 P = (6.5)(0.55 ng/ml) = 3.58 ng/ml. Assuming that the average urine cotinine level for the 144,000 bartenders, wait staff and food and beverage assistants is approximated by U = 3.58 ng/ml for the 24 venues studied before and after Pennsylvania's smoke-free workplace law. By comparison, Hedley et al. (2006) found levels of urine cotinine in 170 Hong Kong catering workers averaging about 13 ng/ml above nonsmoking controls. We can estimate the number of lives saved from SHS by Pennsylvania's CIAA as follows.

Risk Assessment

Increased risk of lung cancer death (LCD) and coronary heart disease death (CHD) combined is estimated according to the model of Repace et al. (1993; 1998), Hedley et al. (2006). According to this model, a health-based standard for passive smoking, based on SHS-RSP levels, was developed for the United States (Repace and Lowrey, 1985b). The 40-year working lifetime (WLT_{40}) risk level of 4 deaths (combined lung cancer and heart disease) per 1000 nonsmokers at risk occurs at 1 nanogram of cotinine per milliliter of urine (Repace et al., 1998), where 90% of this risk obtains for coronary heart disease, and 10% for lung cancer. This model assumes SHS exposure of a worker for 40 hours per week, 250 days per year at work. For exposure to a working lifetime average of U = 3.58 ng/ml, the estimated mortality risk is then:

Estimates from the Occupational Employment Statistics Survey

http://data.bls.gov/oes/datatype.do

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Occupational Employment Statistics (OES)

Occupational Employment Statistics

(For more information or help)

Area: Pennsylvania
Period: May 2007

Occupation (SOC code)	Employment(1)
Bartenders(353011)	30690
Combined Food Preparation and Serving Workers, Including Fast Food(353021)	117430
Counter Attendants, Cafeteria, Food Concession, and Coffee Shop(353022)	16590
Waiters and Waitresses(353031)	98280
Food Servers, Nonrestaurant(353041)	9430
Dining Room and Cafeteria Attendants and Bartender Helpers(359011)	15120

Footnotes:
(1) Estimates for detailed occupations do not sum to the totals because the totals include occupations not shown separately. Estimates do not include self-employed workers.

SOC code: Standard Occupational Classification code -- see http://www.bls.gov/soc/home.htm

Data extracted on April 21, 2009

Quick Links

Table 8. Occupational Employment, Pennsylvania Hospitality Industry. The total of the following occupational employment in Pennsylvania's hospitality industry in 2007 for the following categories was: 30,690 bartenders, 98280 waiters and waitresses, and 15,120 dining attendants and bartender helpers, totalling 144,090 workers.

SHS-Risk = Dose-Response times Dose = (400 deaths)/(100,000 workers-40 years-ng/ml) X (3.58 ng/ml) = (36 deaths per year/100,000 workers). For 144,000 workers at risk, this yields an estimated ~ 52 hospitality workers' lives saved per year by Pennsylvania's CIAA. By comparison, 36 per 100,000 is ~16 times the annual occupational mortality rate among Leisure and Hospitality workers for the U.S. in 2007 of 2.2 per 100,000 from all other causes (BLS, 2009).

In summary, the nearly 90% decline in air pollution from SHS would save an estimated 52 hospitality workers' lives every year. However, the exceptions to the CIAA on putative economic grounds will increase mortality among workers. The CIAA has numerous exceptions, five of which require review and approval by DOH. Exceptions include two types of drinking establishments, two types of cigar bars, and tobacco shops. In 2008, the Pennsylvania Department of Health (DOH) received a total of 3,224 applications for exceptions – 2,290 bars and 663 bar/restaurants. The remaining 271 are an assortment of cigar bars, tobacco shops and incomplete applications. Approvals and notification have been issued to 1,727 bars, and are listed by county on the DOH web site. The CIAA also provides for a number of exceptions including up to 50 percent of gaming floors of casinos and up to 25 percent of hotel and motel rooms; designated quarters within full service truck stops; tobacco manufacturer cigar exhibitions, non-profit fund raisers (which feature tobacco products) and private clubs, including fire, ambulance and rescue companies. These exceptions are part of the CIAA and do not require review and approval by the DOH (PA DOH, 2008).

Such concerns are misplaced: when New York City's Smoke-Free Air Act went into effect on March 30, 2003, questions were raised about how the law would affect the City's restaurants and bars. Would the law hurt business? Would some establishments have to lay off workers or close? The report, issued one year later in 2004 concluded that (NYC, 2004):

- **Business tax receipts in restaurants and bars were up 8.7%;**
- **Employment in restaurants and bars increased by 10,600 jobs (about 2,800 seasonally adjusted jobs) since the law's enactment;**
- **97% of restaurants and bars were smoke-free;**
- **New Yorkers overwhelmingly supported the law;**
- **Air quality in bars and restaurants improved dramatically;**
- **Levels of cotinine, a by-product of tobacco, decreased by 85% in nonsmoking workers in bars and restaurants; and**
- **150,000 fewer New Yorkers were exposed to second-hand smoke on the job.**

Moreover, this occurred despite the fact that upstate New York, New Jersey, and Connecticut did not have smoke-free laws at that time. Furthermore, economic calculations solely based on real or imagined losses to industry do not take into account the cost of morbidity and mortality to hospitality workers injured by SHS. The U.S. EPA has estimated the cost of a life lost to pollution at $6 million, and at 52 workers' lives lost per year to SHS, this amounts to an estimated $312 million loss to the families of Pennsylvania hospitality workers.

Furthermore, SHS causes an estimated 40,000-60,000 heart disease and lung cancer deaths annually in the U.S., (CalEPA, 2006) with no safe level of exposure (SG, 2006). Even brief SHS exposure increases risk of heart attack or cancer (CDC, 2009). The Centers for Disease Control (CDC, 2009) has stated that "Studies conducted in several communities, states, regions, and countries have found that implementing smoke-free laws is associated with rapid and substantial reductions in hospital heart attack admissions. These reductions appear to be more pronounced among nonsmokers than among smokers." CDC concluded that these findings suggest that smoke-free policies can result in reductions in AMI hospitalizations that are sustained over a 3-year period and that these policies are important in preventing morbidity and mortality associated with heart disease. This effect likely is mediated through reduced SHS exposure among nonsmokers and reduced smoking, with the former making the larger contribution (MMWR, 2009).

Conclusions.

1. In 2006, Indoor vs. Outdoor Air Quality was measured in 23 smoking and 3 nonsmoking venues in 8 Pennsylvania Cities and Towns using an air quality monitor for $PM_{2.5}$ (fine-particle air pollution). On average, smoking venues were 8 times as polluted with respirable particles (soot) as nonsmoking venues, and 4 times as polluted as outdoors and in-transit locations.

2. All smoking venues had SHS levels in the range that causes eye, nose, and throat irritation to nonsmokers. Venues sampled had irritation levels that exceeded the median SHS irritation threshold by 5 to 70 times. The median SHS adverse odor threshold was exceeded by 20 to 300 times, discouraging patronage among the 77% of Pennsylvania adults who don't smoke.

3. Despite the air pollution caused by smoking, the hospitality venues were poorly ventilated. Less than 1% of the air exchange rates were in compliance with ASHRAE engineering standard recommendations in force for smoking-permitted venues in 2001. Since 2004, ASHRAE has recommended ventilation rates only for smoke-free buildings because of the health hazard from SHS.

4. Of the 23 smoking venues studied, 3 had Hazardous levels of air pollution, 8 had Very Unhealthy levels, 9 had Unhealthy levels, and the remaining 3 were Unhealthy for Sensitive Groups.

5. The 2 nonsmoking venues had Moderate air quality.

6. The State of Pennsylvania's Department of Environmental Protection

has stated that Pennsylvania has a significant outdoor air $PM_{2.5}$ problem. These measurements supported this. In 2006, 29% of the combined outdoor/in-transit air quality measurements had Unhealthy air, while 71% were Unhealthy for Sensitive Populations. None had Good air quality.

7. However, these studies show that the indoor air quality in Pennsylvania's hospitality industry was far worse due to tobacco smoke pollution.

8. By mapping SHS exposure into dose, it appears that Pennsylvania hospitality workers were exposed to an estimated 9 times as much SHS pollution than the average American adult.

9. In 2008, Pennsylvania passed a state-wide Clean Indoor Air Law for its hospitality industry to protect workers and the public from harmful secondhand smoke. In 2009, 17 of the original 23 smoky venues were re-measured in a smoke-free condition. Fine Particle air pollution ($PM_{2.5}$) had dropped by an average of 87% in the 17 venues tested compared to pre-CIAA conditions.

10. Risk assessment shows that the elimination of air pollution from SHS in Pennsylvania's bars and restaurants from the CIAA will save an estimated 52 hospitality workers' lives every year. Each life saved is worth $6 million. However exceptions to the CIAA will diminish this result. In addition, a number of studies have shown that smoke-free laws significantly diminish heart attacks among the general population.

11. Pennsylvania's CIAA prohibits smoking in many public places and workplaces, but allows some restaurants, bars and casinos to continue to allow smoking in parts of individual establishments on dubious economic grounds not substantiated by data collected elsewhere.

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Appendix A.

SidePak Monitor Calibration. J.L. Repace, August 8, 2006.

SidePak AM 510, Serial #10606084 Outdoor Air Calibration

August 3, 2006: Bowie Maryland, Code Orange Day, Outdoor Background $PM_{2.5}$, 60.1% Relative Humidity; T = 94° F.

Table A1. Outdoor $PM_{2.5}$ measured by SidePak with a Factory Calibration Factor of 1.00 [Flow rate set to 1.7 liters/min, corresponding range, 123] vs. MIE 1200 AN and Piezobalance (PZB), flow rate set to 4.0 lpm for $PM_{2.5}$, as calibrated in Repace (2004).

Statistic, $PM_{2.5}$ Background	**Value, August 3, 2006 Calibration Experiment**	**Value, August 3, 2006 Calibration Experiment**	**Value, August 3, 2006 Calibration Experiment**
MIE 1200 AN Stats	MIE "A" Values, $\mu g/m^3$	PZB R1& R2 Values, $\mu g/m^3$	SidePak S1 Values, $\mu g/m^3$
Minimum	44	30	123
Maximum	58	80	161
Data Points	38 one-minute samples	20 two-minute samples	38 one-minute samples
Mean	**50.3**	**50.5**	**135**
Median	50	50	134
RMS	50.331	52.678	135.16
Std Deviation	2.5289	15.381	6.6088
Variance	6.3951	236.58	43.676
Std Error	0.16223	3.4393	1.0721

Table A2. MIE/SidePak Ratio, 1 minute data points; Mean Ratio on outdoor background $PM_{2.5}$ only is 0.370.

Statistic, $PM_{2.5}$ Background	**Value,August 3, 2006 Calibration Experiment, Ratio MIE/SidePak**
Minimum	0.29814
Maximum	0.41406
Data Points	38
Mean	0.36996
Median	0.37359
RMS	0.37064
Std Deviation	0.022622
Variance	0.00051177
Std Error	0.0036698

SidePak AM 510 Indoor Air Calibration Serial #10606084 August 4, 2006: Bowie Maryland, Comfort Inn Hotel, Bowie MD. Room 505, Indoor Background $PM_{2.5}$ in units of micrograms per cubic meter ($\mu g/m^3$), **plus Secondhand Smoke $PM_{2.5}$**. Two Marlboro Medium 100s Smoldered Simultaneously. 53.4% Relative Humidity; T = 75.2^o F.

Table A3. Indoor SHS plus Background Aerosol as measured by MIE 1200 AN (MIE "A") Calibrated Nephelometer vs. SidePak S1 AM510 with Factory Calibration of 1.00 [Flow rate set to 1.7 liters/min, corresponding range 129] using TSI].

Statistic, $PM_{2.5}$ SHS + Background	MIE Standard Value, August 4, 2006 Calibration Experiment, $\mu g/m^3$	Pre-calibrated SidePak Value, August 4, 2006 Calibration Experiment, $\mu g/m^3$	PZB R2 Standard Value, August 4, 2006 Calibration Experiment, $\mu g/m^3$
Minimum	29	68	20
Maximum	590	1514	50
Data Points	63 one-minute samples	68 one-minute samples	5 two-minute samples (background only)
Mean	254.57	651.49	30
Median	264	661.5	20
RMS	312.24	793.84	32.558
Std Deviation	182.25	456.97	14.142
Variance	33215	2.0883e+05	200
Std Error	22.961	55.416	6.3246

Table A4. MIE/SidePak Ratio, 1 minute data points; Mean Ratio on SHS + Background $PM_{2.5}$ is 0.400.

Statistic, $PM_{2.5}$ SHS + Background	Value, August 4, 2006 Calibration Experiment
Ratio MIE/SP	**Ratio MIE/SidePak**
Minimum	0.27011
Maximum	0.5
Data Points	63 one-minute samples
Mean	0.40066
Median	0.39412
RMS	0.40174
Std Deviation	0.029665
Variance	0.00088004
Std Error	0.0037375

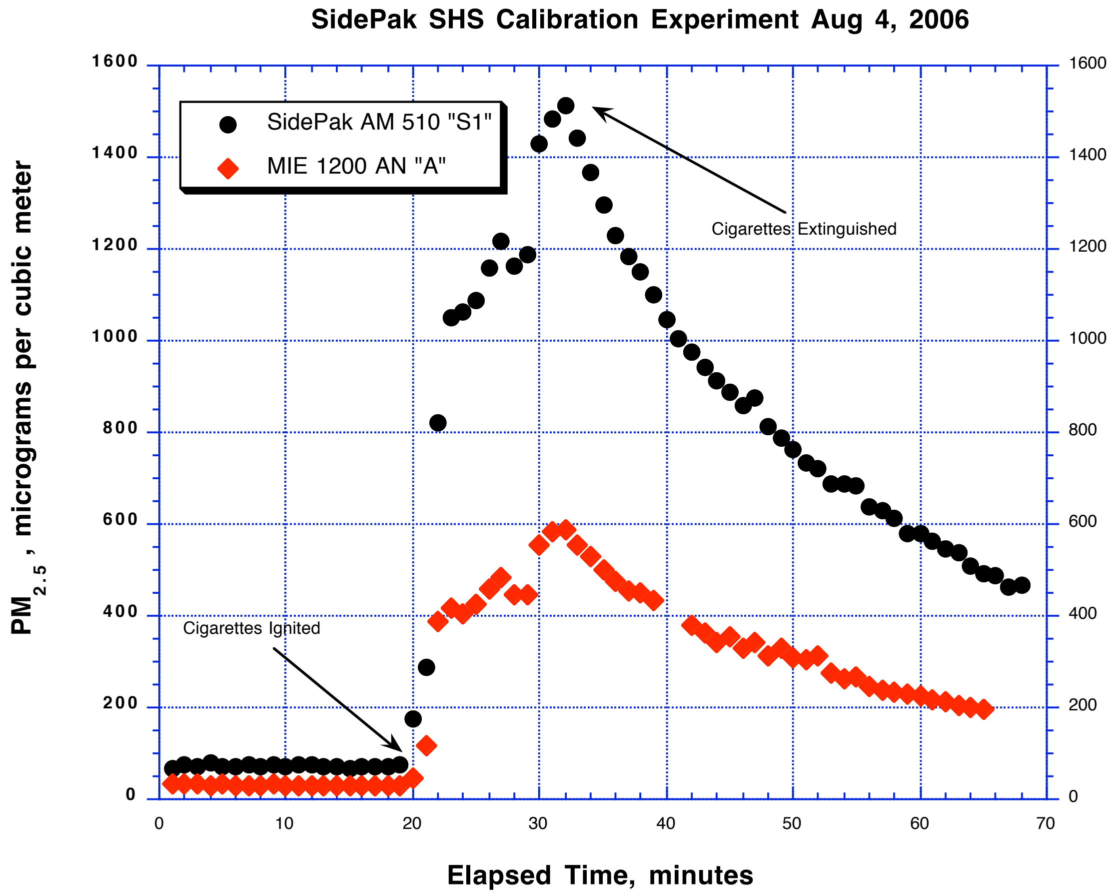

Figure A1. Plot of 1 minute-average Calibrated MIE "A" vs Uncalibrated SidePak S1 on August 4, 2006 Smoldered Marlboro Experiment. Flow Rate of SidePak Adjusted "129" range, corresponding to 1.7 lpm measured; Flow rate of MIE "A" adjusted to 4.8 lpm nominal, corresponding to 4.0 lpm measured.

Instrument Flow Rates were measured using TSI Model 4146 Mass Flowmeter Calibrator. Decay rate calculations show an effective air exchange rate of 0.50 air changes per hour (h^{-1}) ($n = 16$) for the SidePak decay, and 0.54 h^{-1} for the MIE ($n = 14$).

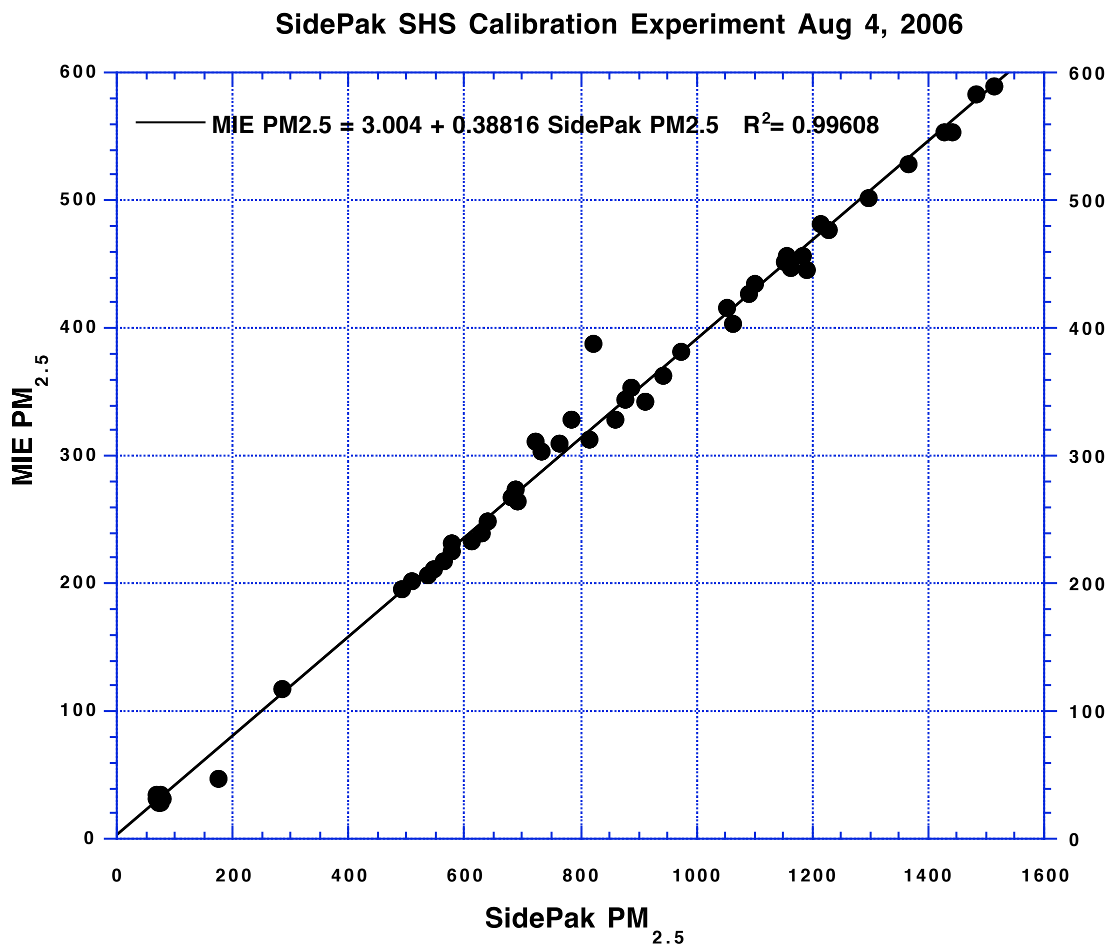

Figure A2. Linear Regression of Data from Figure 1: MIE vs. SidePak yields a calibration factor of 0.388 for the SidePak (Serial #10606084).

<u>**Conclusions**</u>**: Recommended Calibration Factor is 0.388 for SidePak AM510, Serial #10606084, designated "S1:" i.e., when operated with the factory calibration factor of 1.00, data must be multiplied by <u>0.388</u> to yield micrograms per cubic meter of a mixture of SHS & Background $PM_{2.5}$. SidePak nominal flow rate should be set to 129.** Calibration Standard is MIE "A" (Serial # 5290) calibrated in Silicon Valley Experiments against gravimetric & Piezobalance reference instruments (Repace, 2004). When measuring outdoor $PM_{2.5}$ alone, the calibration factor is 0.370. Using a factor of 0.388 for outdoor data overestimates outdoor levels by 5%. Accordingly, the instrument calibration factor should remain set at 1.00, and can be adjusted later in the data analysis.

Reference: Repace JL. Respirable Particles and Carcinogens in the Air of Delaware Hospitality Venues Before and After a Smoking Ban. Journal of Occupational and Environmental Medicine, 46:887-905 (2004). PDF file attached.

Figure A3. August 3, 2006 Calibration Experiment, showing data-logging computer, MIE 1200 AN, SidePak AM 510, Kanomax Model 3511 Piezobalance, TSI 4146 Flow-rate calibrator, HEPA zeroing filter, and Langan Instruments data-logger, CO_2, CO, RH, and Temperature monitors.

Figure A4. August 4, 2006 Calibration Experiment in a smoking hotel room. Co-located Monitors on bed; radio-synchronized atomic clock is in foreground.

Figure A5. August 4, 2006 Calibration Experiment. Smoldering cigarettes on coffee table. Mixing fan is at top right, Langan monitors on end table, at right.

Appendix B.

About the author: J.L. Repace, MSc., Biophysicist

I was asked to analyze air quality data collected by The Pennsylvania Alliance to Control Tobacco, American Lung Association of Pennsylvania, and to write this summary report on its results. I am president of Repace Associates, Inc., Secondhand Smoke Consultants, a Maryland Corporation. Since March 1998, I have been an international consultant on secondhand smoke (SHS), also known as environmental tobacco smoke (ETS). I have published 81 scientific papers, 73 of which concern the hazard, exposure, dose, risk, or control of SHS. I have received numerous awards, including the Surgeon General's Medallion from Dr. C. Everett Koop, the Cahan Distinguished Professor Award from the Flight Attendant Medical Research Institute, the Innovator Award from the Robert Wood Johnson Foundation, and a Lifetime Achievement Award from the American Public Health Association. I am also a visiting Assistant Clinical Professor at the Tufts University School of Medicine. I have consulted on SHS throughout the U.S. and Canada, as well as in Europe, South America, and the Pacific Region.

From February 1979 to September 1986, I served as a senior policy analyst in the Office of Air and Radiation at the U.S. Environmental Protection Agency (EPA) in Washington, DC. on the science policy staff of the Assistant Administrator in charge of the nation's air programs. From September 1986 to February 1998, I served as a senior policy analyst in the Indoor Air Division. During my tenure, I also served for periods of the order of one year on detail as a staff scientist to the EPA's Office of Research and Development, and to the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA). From 1963 to 1979, I held consecutive posts at the Grasslands and Delafield Hospitals in New York as a Health Physicist, at the RCA Sarnoff Laboratory in Princeton, New Jersey, as a Research Associate, and as a Research Physicist in the Ocean Sciences and Electronics Divisions at the Naval Research Laboratory in Washington, DC. I earned the BSc. (1962) and MSc. in Physics (1968) from the Brooklyn Polytechnic Institute (now Polytechnic University), in New York City. My full Curriculum Vitae is posted on www.repace.com.