Tobacco Smoke Pollution Exposure in Hospitality Venues Around the U.S. and the Effect of Smoke-free Air Policies

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Background

Health Effects of Tobacco Smoke Pollution (TSP)

- The recent 2006 U.S. Surgeon General Report "*The Health Consequences of Involuntary Exposure to Tobacco Smoke*" concludes:
  - Secondhand smoke causes premature death and disease in children and in adults who do not smoke.
  - Children exposed to secondhand smoke are at an increased risk for sudden infant death syndrome (SIDS), acute respiratory infections, ear problems, and more severe asthma.
  - Exposure of adults to secondhand smoke has immediate adverse effects on the cardiovascular system and causes coronary heart disease and lung cancer.
  - The scientific evidence indicates that there is no risk-free level of exposure to secondhand smoke.
  - Eliminating smoking in indoor spaces fully protects nonsmokers from exposure to secondhand smoke. Separating smokers from nonsmokers, cleaning the air, and ventilating buildings cannot eliminate exposures of nonsmokers to second-hand smoke.
- Hospitality venues typically have the highest TSP levels of all workplaces and are a source of significant TSP exposure for workers and venue patrons

Smoke-Free Air Legislation

- 38.5% of Americans are protected by comprehensive statewide smokefree air laws, even more by local laws.

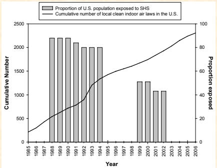
U.S. Statewide Smokefree Workplace Laws

	Smokefree Offices	Smokefree Restaurants	Smokefree Bars	Population (2004 est.)	% of US Population*
California	☑	☑	☑	35,893,799	12.1%
Delaware	☑	☑	☑	830,364	0.3%
New York	☑	☑	☑	19,227,088	6.5%
Connecticut	☑	☑	☑	3,503,604	1.2%
Maine	☑	☑	☑	1,317,253	0.4%
Massachusetts	☑	☑	☑	6,416,505	2.2%
Rhode Island	☑	☑	☑	1,080,632	0.4%
Vermont	☑	☑	☑	621,394	0.2%
Montana	☑	☑	☑†	926,865	0.3%
Washington	☑	☑	☑	6,203,788	2.1%
District of	☑	☑	☑	553,523	0.2%
New Jersey	☑	☑	☑	8,698,879	2.9%
Utah	☑	☑	☑†	2,389,039	0.8%
Puerto Rico	☑	☑	☑	3,894,855	1.3%
Colorado	☑	☑	☑	4,601,403	1.5%
Hawaii	☑	☑	☑	1,262,840	0.4%
Ohio	☑	☑	☑	11,459,011	3.9%
Arizona	☑	☑	☑	5,743,834	1.9%
Smokefree offices, restaurants and bars				*114,624,676*	*38.5%*
Florida	☑	☑	☐	17,397,161	5.8%
Idaho	☑	☑	☐	1,393,262	0.5%
North Dakota	☑	☑	☐	634,366	0.2%
Georgia	☑	☑	☐	8,829,383	3.0%
Arkansas	☑	☑	☐	2,752,629	0.9%
Louisiana	☑	☑	☐	4,515,770	1.5%
Nevada	☑	☑	☐	2,334,771	0.8%
Smokefree offices and restaurants				*152,482,018*	*51.2%*
South Dakota	☑	☐	☐	770,883	0.3%
Maryland	☑	☐	☐	5,558,058	1.9%
Smokefree offices				*158,810,959*	*53.4%*

* Population of 50 U.S. States, the District of Columbia and Purto Rico: 297,550,259 (estimate for July 1, 2004) http://www.census.gov/popest/states/tables/NST-EST2004-01.pdf)

† These smoke-free bar laws go into effect in 2009.

- As the number of smokefree communities has risen, exposure to tobacco smoke pollution has declined.



References: Pirkle JL, Bernert JT, Caudill SP, Sosnoff CS, Pechacek TF. Trends in the exposure of nonsmokers in the U.S. population to secondhand smoke: 1988-2002. Environ Health Perspect 2006;114(6):853-8 *and* American Nonsmokers' Rights Foundation. Municipalities with local clean indoor air laws, cumulative number effective by year (http://no-smoke.org/pdf/ordgraph.pdf).

Objectives

To validate a continuous real-time air monitoring device for measuring exposure to tobacco smoke pollution.

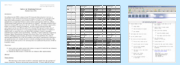
To train researchers across the country to collect data on tobacco smoke exposure.

In a cross-sectional study, to determine the difference in air quality between hospitality venues that permit indoor smoking and those with smoke-free air policies.

In a longitudinal study, to determine the effect of smoke-free air policy implementation on indoor air quality.

Training Researchers

- Researchers from around the country were trained in use of the Sidepak Aerosol Monitor and how to collect exposure data in public places.
- Training was done in person and using a web-based training course at www.tobaccofreeair.org
- This allowed for a large, generalizable sample of hospitality venues around the United States.



$PM_{2.5}$ as a marker of tobacco smoke

- Cigarettes, cigars and pipes are major emitters of respirable suspended particles less than 2.5 microns ($PM_{2.5}$) in diameter that are easily inhaled deep into the lungs.
- $PM_{2.5}$ is a very sensitive marker of tobacco smoke pollution.
- Can measure $PM_{2.5}$ continuously in "real-time" with portable monitors such as the Sidepak.
- There are US Environmental Protection Agency $PM_{2.5}$ standards for outdoor air in place to protect public health. These standards are a useful comparison for this study.
- The EPA has set standards of 15 μg/m³ as the average annual $PM_{2.5}$ exposure limit and 35 μg/m³ as the 24-hour exposure limit.

Air Quality Index Levels of Health Concern	$PM_{2.5}$ (μg/m³)	Meaning
Good	≤15	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	16-40	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	41-65	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	66-150	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	151-250	Health alert: everyone may experience more serious health effects.
Hazardous	≥251	Health warnings of emergency conditions. The entire population is more likely to be affected.

- To ensure accurate (unbiased) measurement of tobacco smoke particles, the Sidepak aerosol monitor was calibrated two ways:
  - 1) using another real-time laser photometer (MIE personal dataRAM (pDR 1200). The pDR was previously calibrated with a piezobalance and gravimetric methods and used in SHS exposure studies
  - 2) in controlled experiments with cigarettes using gravimetric measurements of $PM_{2.5}$ as the reference.
- The Sidepak was used with a custom calibration factor of 0.32 based on these calibration experiments.
- Laboratory and field experiments of multiple collocated Sidepaks showed very good agreement between Sidepaks **with precisions less than 2%**.

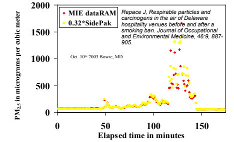
Experiment	No. of collocated Sidepaks	Sample Size	Mean (μg/m³)	Standard deviation (μg/m³)	Uncertainty (μg/m³)[a]	Precision (%)[b]
Controlled	3	169	1688.2	61.5	22.3	1.3
Field	4	111	287.4	17.5	5.3	1.9

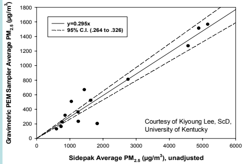
[a] Uncertainty is defined as the square root of the average of the variance of collocated monitors divided by the number of collocated monitors.
[b] Precision is defined as the uncertainty divided by the mean measurement and is expressed as a percentage.

TSI Sidepak Personal Aerosol Monitor

- The SidePak is a real-time laser photometer with built-in sampling pump that continuously measures airborne particle mass-concentration.
- The Sidepak was used with a 2.5 micron impactor and calibrated to a flow rate of 1.7 lpm to measure $PM_{2.5}$.

Calibration of Sidepak Aerosol Monitor: Adjusted Data

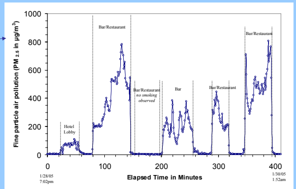

MIE dataRAM
0.32*SidePak
Repace J, Respirable particles and carcinogens in the air of Delaware hospitality venues before and after a smoking ban. Journal of Occupational and Environmental Medicine, 46:9, 887-905.
Oct. 10th 2003 Bowie, MD
PM2.5 in micrograms per cubic meter
Elapsed time in minutes



Cross-Sectional Air Quality Study

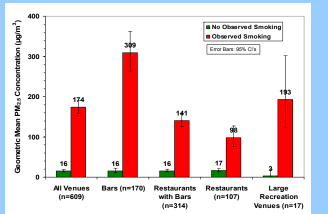
- Air quality, as measured by $PM_{2.5}$, and the presence of smoking and smoke-free air policies was assessed in 609 hospitality venues across the U.S.
- Venues visited included bars, restaurants, restaurants with bars, and large recreation venues such as pool halls, bowling centers, bingo halls, and dance halls.
- Visits were for a minimum of 30 minutes.
- The number of people and the number of burning cigarettes were recorded every 15 minutes and the volume of the venue was measured with a sonic measuring device.

Example Plot of Real-Time Continuous $PM_{2.5}$ Monitoring

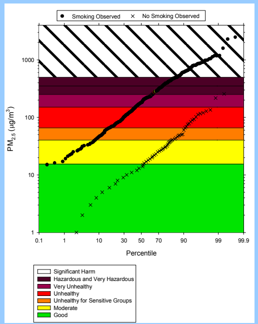


- Continuous real-time plots show the change in $PM_{2.5}$ minute-by-minute as an individual moves between different microenvironments and as conditions in these microenvironments change. These plots show:
  - Low background levels are observed outdoors.
  - Much higher levels of indoor air pollution are seen in places where indoor smoking is permitted and observed.
  - Peak exposure levels where smoking is permitted can reach levels far in excess of the average recorded level.
- Across all venues sampled, the average $PM_{2.5}$ concentration was highly correlated with the active smoker density or average number of active smokers per 100 cubic meters (Spearman's rho = 0.75, p<0.001).
- **Overall, places with no observed smoking had 91% less indoor air pollution (95% C.I.: 89% to 92%) than places with observed smoking.**
- This dramatic difference was seen across all types of venues.
- The high level of indoor air pollution seen in many locations, in particular bars, is rarely if ever seen in outdoor air.

Mean $PM_{2.5}$ Concentrations by Observed Smoking Status and Type of Venue



Log-probability Plot of $PM_{2.5}$ Concentrations in Venues With (n=447) and Without (n=162) Smoking, Compared to EPA Air Quality Index



- Employees working in places where smoking is permitted are routinely exposed to fine particle air pollution exceeding safe levels determined by the EPA

Annual Employee Exposures to Fine Particulate Matter in U.S. Hospitality Venues by Type of Venue and Smoking Status

				Percent of hospitality venues with employee exposure in this AQI or worse*									
				Smoke-Free					Smoking Permitted				
$PM_{2.5}$ (μg/m³)	Air Quality Index (AQI)	Category	Color Code	All Venues	Bars	Restaurants With Bars	Restaurants	Large Rec Venues	All Venues	Bars	Restaurants With Bars	Restaurants	Large Rec Venues
0.0 - 15.4	0 - 50	Good	Green	100	100	100	100	100	100	100	100	100	100
15.5 - 40.4	51 - 100	Moderate	Yellow	23	31	18	22	0	92	99	90	82	100
40.5 - 65.4	101 - 150	Unhealthy for sensitive groups	Orange	4	6	2	2	0	55	82	47	22	76
65.5 - 150.4	151 - 200	Unhealthy	Red	2	6	0	2	0	34	62	25	9	35
150.5 - 250.4	201 - 300	Very unhealthy	Violet	0	0	0	0	0	9	20	6	0	0
250.5 - 350.4	301 - 400	Hazardous	Maroon	0	0	0	0	0	2	4	1	0	0
350.5 - 500.4	401 - 500	Very Hazardous	Maroon	0	0	0	0	0	1	3	0	0	0
> 500.4	> 500	(Significant Harm)†	—	0	0	0	0	0	1	2	0	0	0

* The Air Quality Index is based on the 24-hr average outdoor $PM_{2.5}$ concentration while annual employee exposure assumes they are exposed to the measured $PM_{2.5}$ concentration for 8 hours per day, 250 days per year, and are exposed to background $PM_{2.5}$ levels of 11.5 μg/m³ during non-work times.

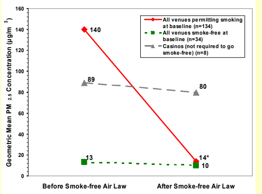
† This category exists but is not part of the AQI (Personal communication from Ellsworth, T., USEPA Air Protection Division to Repace, J., Jan 24, 2005).

U.S. Environmental Protection Agency, Guideline for reporting of daily air quality - Air Quality Index (AQI). 1999, USEPA Office of Air Quality Planning and Standards: Research Triangle Park, NC AND Repace, J., E. Hughes, and N. Benowitz, Exposure to second-hand smoke air pollution assessed from bar patrons' urinary cotinine. Nicotine Tob Res, 2006. 8(5): p. 701-11.

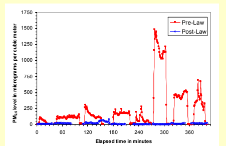
Longitudinal Air Quality Study

- Air quality, as measured by $PM_{2.5}$, was measured in 181 hospitality venues in 8 different states before and after the implementation of a smoke-free air law.
- Venues visited included bars, restaurants, restaurants with bars, and large recreation venues such as pool halls, bowling centers, bingo halls, and dance halls.
- Visits were for a minimum of 30 minutes and were done on the same day and time before and after the smoke-free air law.
- Of the 176 places visited with complete data, 134 were places that went from allowing smoking to being smoke-free, 34 were smoke-free at baseline, and 8 were casinos that were exempt from the smoke-free air legislation.
- **Places that went smoke-free showed a 90% reduction in indoor air pollution (95% C.I.: 88% to 92%).**
- Places that were smoke-free at baseline had low indoor air pollution levels that remained unchanged after the law.
- Places that were exempt from the smoke-free air laws (casinos) showed no change in indoor air pollution after the law as levels continued to be high.

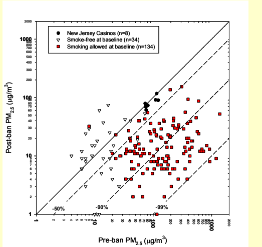
Change in Indoor Fine Particle Air Pollution after Smoke-free Air Law Implementation



Example Plot of Pre- and Post-Law $PM_{2.5}$ Monitoring (New Jersey bars and restaurants)

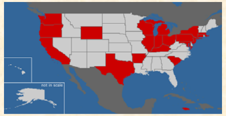


Log-log Scatter Plot Comparing Pre- and Post-Law $PM_{2.5}$ Concentrations



Conclusions

- This was the largest study of its kind, measuring air quality in almost 800 hospitality venues across the U.S.
- The TSI Sidepak Aerosol Monitor was shown to be a valid and useful tool in measuring tobacco smoke pollution exposure.
- Indoor smoking was shown to cause about 90% of indoor fine particle air pollution.
- Places with indoor smoking have harmful to hazardous levels of fine particle air pollution.
- Smoke-free air legislation is an effective means to eliminate tobacco smoke pollution exposure and has been implemented effectively in communities around the U.S. (compliance rates were over 95% in this study).
- Smoke-free air policies are the only proven means to eliminate exposure to toxic and carcinogenic tobacco smoke pollution.



Air monitoring done in 20 States and Puerto Rico (in red)

Acknowledgments

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- A special thanks goes to all the volunteers who participated in collecting data for this study.