Casino Air Monitoring Study
East Saint Louis, Illinois

Mark J. Travers, MS

Department of Health Behavior

Roswell Park Cancer Institute

September 2007

Executive Summary

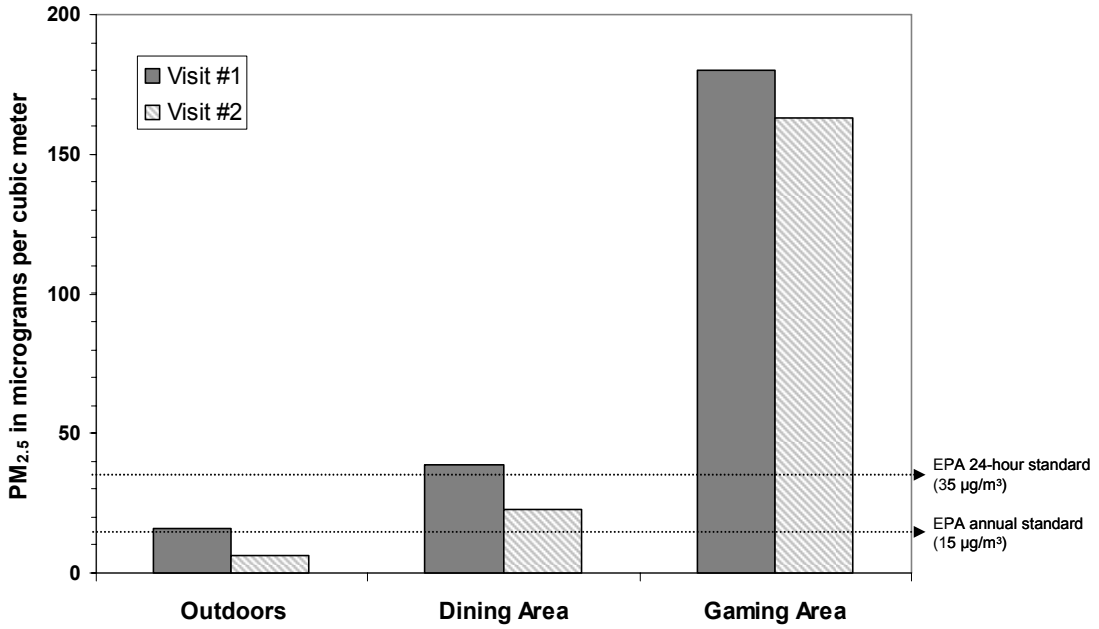
Indoor air quality was assessed in an East Saint Louis casino during two 3-hour visits in August 2007. The concentration of fine particle air pollution, $PM_{2.5}$, was measured with a TSI SidePak AM510 Personal Aerosol Monitor. $PM_{2.5}$ is particulate matter in the air smaller than 2.5 microns in 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:

- The average level of fine particle indoor air pollution on the gaming floor was 172 $\mu g/m^3$, 16 times higher than outdoor background levels.
- Employees and patrons of this casino are exposed to "very unhealthy" levels of fine particle air pollution exposure according to the U.S. Environmental Protection Agency (EPA) Air Quality Index.
- Employees and patrons will exceed USEPA 24-hour standards for $PM_{2.5}$ exposure after 3 hours and 28 minutes on the gaming floor.

Despite the expensive, state-of-the-art, ventilation system installed at this casino, employees and patrons are exposed to harmful levels of fine particle air pollution as a result of indoor smoking. The only way to eliminate the health risks of tobacco smoke pollution exposure is to prohibit indoor smoking.

Fine Particle Air Pollution in an East Saint Louis Casino



Introduction

Secondhand smoke (SHS) contains at least 250 chemicals that are known to be toxic or carcinogenic, and is itself a known human carcinogen,[1] responsible for an estimated 3,000 lung cancer deaths annually in *never smokers* in the U.S., as well as more than 35,000 deaths annually from coronary heart disease in *never smokers,* and respiratory infections, asthma, Sudden Infant Death Syndrome, and other illnesses in children.[2] Although population-based data show declining SHS exposure in the U.S. overall, SHS exposure remains a major public health concern that is entirely preventable.[3, 4] Because requiring smoke-free environments is the most effective method for reducing SHS exposure in public places,[5] Healthy People 2010 Objective 27-13 encourages all states and the District of Columbia to establish and to enforce smoke-free air laws in public places and worksites.[6]

Currently in the U.S., 22 states, Washington, DC, and Puerto Rico have enacted strong smoke-free laws that include restaurants and bars. The states are Arizona, California, Colorado, Connecticut, Delaware, Hawaii, Illinois, Maine, Maryland, Massachusetts, Minnesota, Montana, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oregon, Rhode Island, Utah, Vermont, and Washington (Montana and Utah laws include bars in 2009; Illinois, Maryland, and Oregon laws go into effect in Jan. 2008, Feb. 2008, and Jan. 2009 respectively). Well over 50% of the U.S. population is now protected from secondhand smoke in all public places.[7] Florida, Idaho, Louisiana, Nevada, and North Dakota have smoke-free laws that exempt stand-alone bars. Nine Canadian provinces and territories also have comprehensive smoke-free air laws in effect. Hundreds 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 and England.

Gaming casinos are a type of venue that is often excluded from comprehensive smoke-free air legislation. Examples include Atlantic City casinos which were originally exempt from the New Jersey smoke-free air act and Native American casinos that are not subject to state smoke-free air laws in states such as New York and California. Studies have shown that tobacco smoke pollution exposure is high for workers and patrons of casinos just as in other hospitality venues.[8, 9]

The purpose of this study was to determine the amount of tobacco smoke derived fine particle air pollution in an East Saint Louis Casino. The casino studied reportedly has a state-of-the-art ventilation system.

Methods

The casino was visited two times during the month of August 2007. The first visit was for a total of 170 minutes and the second was for 182 minutes. Visits occurred in the evenings starting at approximately 6PM. Continuous $PM_{2.5}$ measurements were taken outside the casino, in the buffet dining area inside the casino, and on the gaming floor of the casino.

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. A sonic measuring device was used to estimate room dimensions and hence the volume of each of the venues. The active smoker density was calculated by dividing the average number of burning cigarettes by the volume of the room in meters.

A TSI SidePak AM510 Personal Aerosol Monitor (TSI, Inc., St. Paul, MN) was used to sample and record the levels of respirable suspended particles in the air. The SidePak uses a built-in sampling pump to draw air through the device where the particulate matter in the air scatters the light from a laser. This portable light-scattering aerosol monitor was fitted with a 2.5 μm impactor in order to measure the concentration of particulate matter with a mass-median aerodynamic diameter less than or equal to 2.5 μm, or $PM_{2.5}$. Tobacco smoke particles are almost exclusively less than 2.5 μm with a mass-median diameter of 0.2 μm.[10] The Sidepak was used with a calibration factor setting of 0.32, suitable for secondhand smoke. This calibration factor was determined in an experiment with the SidePak collocated with another light-scattering instrument that had been previously calibrated against standard pump-and-filter gravimetric methods and used in SHS exposure studies.[11] Klepeis et al. found a similar SHS calibration factor for the Sidepak when compared to a Piezobalance (Kanomax, Inc.) which provides direct measurements of RSP mass concentrations.[12] This calibration factor has also been confirmed by another researcher who compared Sidepak measurements of SHS to gravimetric measurements using a Personal Environmental Monitor (PEM for PM2.5, MSP Corporation, Shoreview, MN).[13] In addition, the SidePak was zero-calibrated prior to each use by attaching a HEPA filter according to the manufacturer's specifications.

TSI SidePak AM510 Personal Aerosol Monitor

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 visit, 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.

$PM_{2.5}$ 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 mortality.

Results

During the first visit to the casino the average $PM_{2.5}$ level outside of the casino was 16 $\mu g/m^3$, the average $PM_{2.5}$ level in the dining area of the casino was 39 $\mu g/m^3$, and the average $PM_{2.5}$ level in the gaming area was 180 $\mu g/m^3$. The estimated volume of the dining area was 892 m^3 and the average smoker density in this area was 0.06 burning cigarettes per 100 m^3. Only one lit cigarette was observed in this area during monitoring. The estimated volume of the gaming area was 4,955 m^3 and the average smoker density was 1.29 burning cigarettes per 100 m^3. An average of 64 burning cigarettes was observed in this area during monitoring.

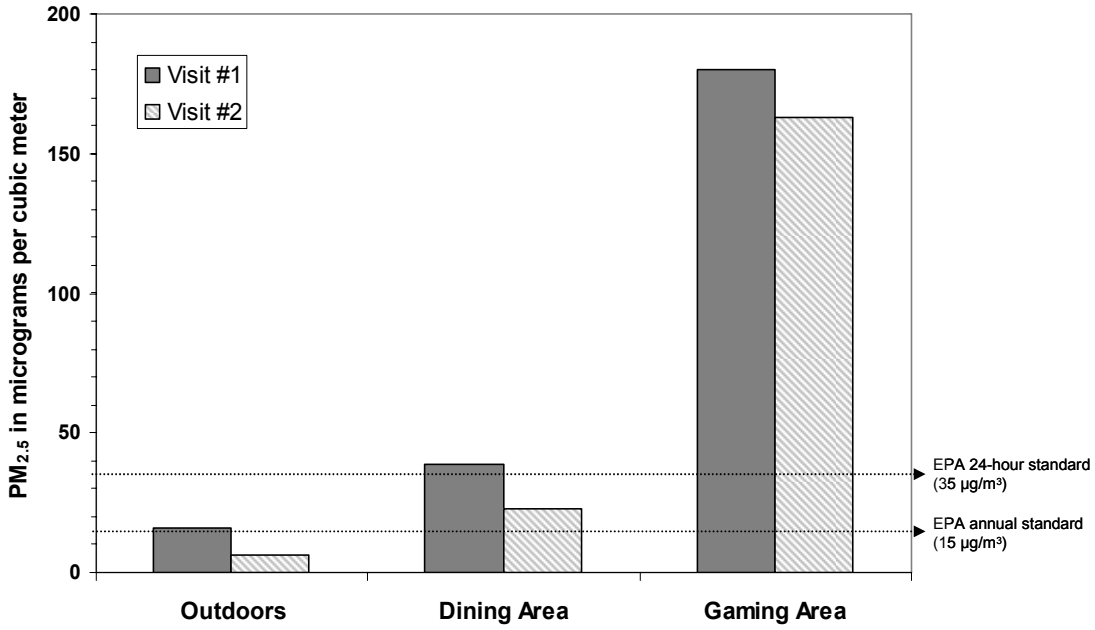
During the second visit to the casino the average $PM_{2.5}$ level outside of the casino was 6 $\mu g/m^3$, the average $PM_{2.5}$ level in the dining area of the casino was 23 $\mu g/m^3$, and the average $PM_{2.5}$ level in the gaming area was 163 $\mu g/m^3$. The average smoker density in the dining area was 0.00 burning cigarettes per 100 m^3 as no lit cigarettes were observed. The average smoker density of the gaming area was 1.17 burning cigarettes per 100 m^3. An average of 58 burning cigarettes was observed in this area during monitoring. The $PM_{2.5}$ data for both visits are shown in Figure 1 (next page).

Using the averages of the two visits, the outdoor average was 11 $\mu g/m^3$, the dining area average was 31 $\mu g/m^3$, and the gaming area average was 172 $\mu g/m^3$. The dining area had $PM_{2.5}$ levels 2.8 times higher than outdoor levels and the gaming area had $PM_{2.5}$ levels 15.6 times higher than outdoor levels.

As a reference, the 2007 average outdoor $PM_{2.5}$ level for East Saint Louis measured using the EPA's Federal Reference Method is 12.3 $\mu g/m^3$ (http://www.epa.gov/air/data/). This is very similar to the average measured outdoor $PM_{2.5}$ level of 11 $\mu g/m^3$ from the two visits in this study.

The real-time plots showing the $PM_{2.5}$ level from each visit minute-by-minute during sampling are presented in the Appendix, Figures 2 and 3, starting on page 10. The real-time plots throughout sampling reveal the following results: 1) low background levels are observed outdoors; 2) very high levels of $PM_{2.5}$ are seen in the gaming area; 3) peak exposure levels can far exceed the average recorded levels in the gaming area; and 4) in the dining area, $PM_{2.5}$ levels elevated from outdoor background levels indicate there may be significant tobacco smoke derived particle exposure in this area despite little or no smoking in this area.

Figure 1. Fine Particle Air Pollution in an East Saint Louis Casino



Discussion

The EPA cited over 80 epidemiologic studies in creating a particulate air pollution standard in 1997.[14] The EPA has recently updated this standard and, in order to protect the public health, the EPA has set limits of 15 $\mu g/m^3$ as the average annual level of $PM_{2.5}$ exposure and 35 $\mu g/m^3$ for 24-hour exposure.[14, 15] 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 casino sampled works 8 hours, 250 days a year, is exposed to 172 $\mu g/m^3$ on the job (the average on the gaming floor of the 2 visits), and is exposed only to background particle levels of 12 $\mu g/m^3$ during non-work times. For a full-time employee their average annual $PM_{2.5}$ exposure would be 49 $\mu g/m^3$. The EPA average annual $PM_{2.5}$ limit is exceeded by 3.3 times due to their occupational exposure.

Assuming an average $PM_{2.5}$ exposure in the casino of 172 $\mu g/m^3$, and exposure outside the casino to average outdoor levels of 12 $\mu g/m^3$, to exceed the 24-hour EPA exposure limit, a patron or employee would have to spend 3 hours and 28 minutes on the gaming floor of this casino. Based on the latest scientific evidence, the EPA staff currently proposes even lower $PM_{2.5}$ standards to adequately protect the public health,[16] making the high $PM_{2.5}$ exposures of people in smoking environments even more alarming.

The U.S. Surgeon General has concluded, “Separating smokers from nonsmokers, cleaning the air, and ventilating buildings cannot eliminate exposures of nonsmokers to secondhand smoke.”[17] The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has concluded, “adverse health effects for the

occupants of the smoking room cannot be controlled by ventilation."[18] Despite these unmitigated conclusions by preeminent authorities on the inability of ventilation to control tobacco smoke pollution exposure, some parties continue to mistakenly claim ventilation is a viable solution to protect smokers from tobacco smoke pollution. For the casino monitored in this study, casino representatives have stated, "There was an additional $3,000,000 spent on taking care of the HVAC system. We're able now, at any given time, to bring in 50 percent outside fresh air into the building itself." Regarding cigarette smoke exposure, "…the additional expense that was put into this facility to eliminate those concerns." While the casino has used the installation of an expensive ventilation system to lobby for an exemption to the pending smoke-free air legislation in Illinois, this study confirms what the science has already shown: ventilation is in no way an effective means to eliminate tobacco smoke pollution exposure. In fact this study shows fine particle air pollution levels on the gaming floor 16 times higher than outdoor levels. The average $PM_{2.5}$ level seen on the gaming floor was 172 $\mu g/m^3$, "very unhealthy" according to the EPA's Air Quality Index (see Appendix).

Previous studies have evaluated air quality by measuring the change in levels of respirable suspended particles (RSP) between smoke-free hospitality venues and those that permit smoking. In Indiana, an 89% decrease in $PM_{2.5}$ was documented in Bloomington locations that went smoke-free after that town implemented a smoke-free air ordinance.[19] A similar 85% reduction in $PM_{2.5}$ levels was seen in Indianapolis locations that went smoke-free, however levels were unchanged in the locations that were exempt from the Indianapolis ordinance.[20] 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.[21] 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.[11] 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.[22] 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 smoke-free air laws, even though compliance with the laws was less than 100%.[23] New Jersey casinos were shown to have 91% less tobacco smoke-derived particle air pollution during the State government shutdown when smoking on casino gaming floors stopped.[8] Fong et al. showed a 67% reduction in fine particle air pollution after an Ontario casino went smoke-free. This study also found that in patrons spending four hours in the casino, there was a 98% reduction in a marker of nicotine exposure, and a 52% reduction in a marker of carcinogen exposure after the casino went smoke-free.

Other studies have directly assessed the effects SHS exposure has on human health. One study found that respiratory health improved rapidly in a sample of bartenders after a state smoke-free workplace law was implemented in California[24], and another study reported a 40% reduction in acute myocardial infarctions in patients admitted to a regional hospital during the 6 months that a local smoke-free ordinance was in effect.[25]

Smoke-free 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.[26] Farrelly et al. also showed a significant decrease in both salivary cotinine concentrations and sensory symptoms in hospitality workers after New York State's smoke-free law prohibited smoking in their worksites.[27]

The effects of passive smoking on the cardiovascular system in terms of increased platelet aggregability, 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.[28]

The hazardous health effects of exposure to second-hand smoke are now well-documented and established in various independent research studies and numerous international reports. The body of scientific evidence is overwhelming: there is no doubt within the international scientific community that second-hand smoke causes heart disease, lung cancer, nasal sinus cancer, sudden infant death syndrome (SIDS), asthma and middle ear infections in children and various other respiratory illnesses. There is also evidence suggesting second-hand smoke exposure is also causally associated with stroke, low birthweight, spontaneous abortion, negative effects on the development of cognition and behavior, exacerbation of cystic fibrosis, cervical cancer, and breast cancer in pre-menopausal women. The health effects of secondhand smoke exposure are detailed in recent reports by the California Environmental Protection Agency[29] and the U.S. Surgeon General[17].

Conclusions

This study documented harmful levels of tobacco smoke-derived fine particles in an East Saint Louis casino. These high concentrations of $PM_{2.5}$ were found despite the reported installation of a multi-million dollar state-of-the-art ventilation system. Fine particle air pollution levels in this casino were far above safe levels established by the U.S. Environmental Protection Agency (EPA) and are in the "very unhealthy" range of the EPA Air Quality Index. The only way to eliminate the harms of tobacco smoke pollution exposure and make the air safe to breathe in this casino is to eliminate indoor smoking.

Appendix

U.S. Environmental Protection Agency Air Quality Index		
Air Quality Index Levels of Health Concern	**$PM_{2.5}$ ($\mu g/m^3$)**	**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.**

Real-time plots of $PM_{2.5}$ levels in this study start on the following page.

Figure 2

East Saint Louis Casino Air Monitoring Study
Visit #1 August 2007

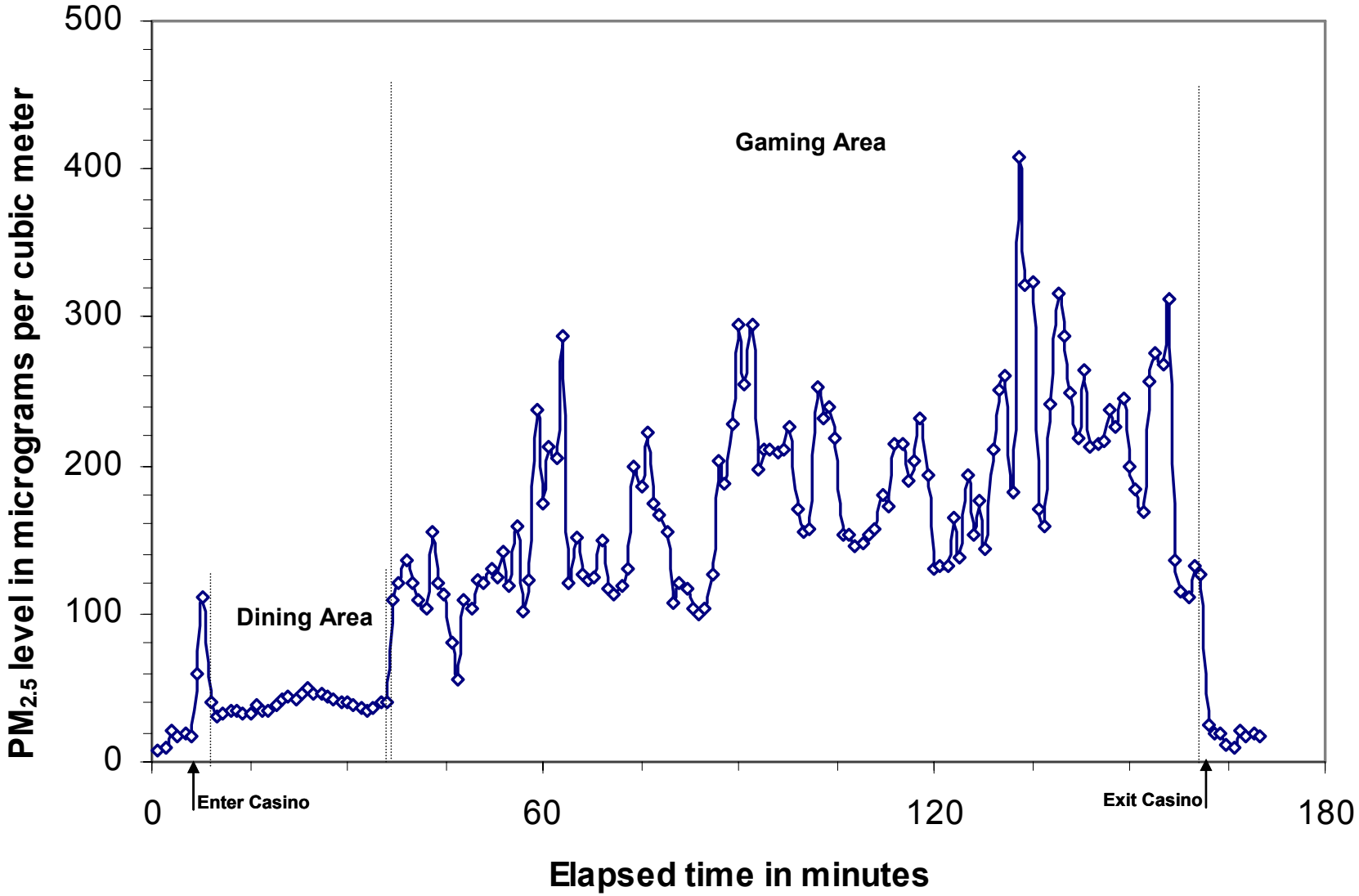
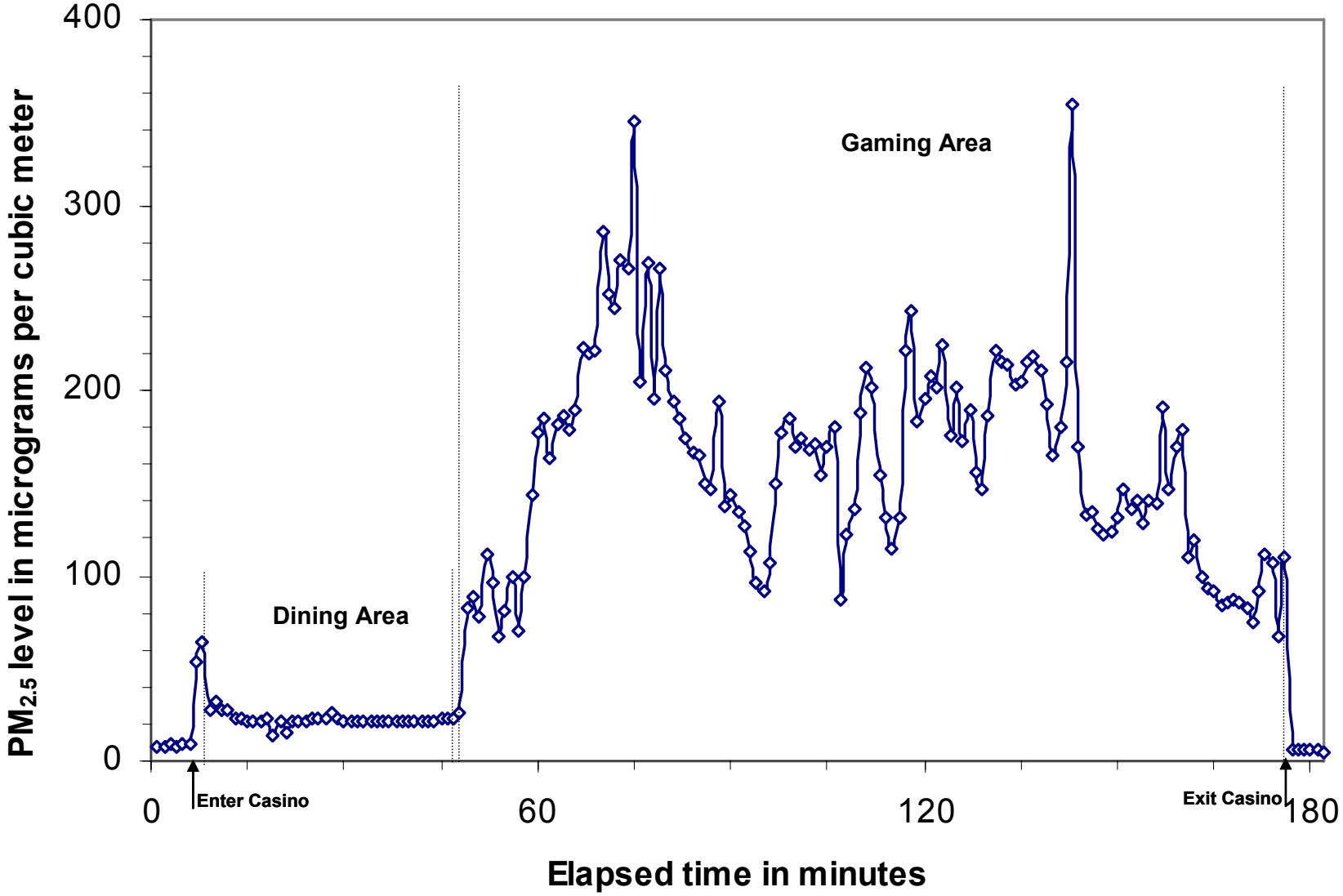


Figure 3 East Saint Louis Casino Air Monitoring Study
Visit #2 August 2007



References

1. National Toxicology Program, *9th Report on Carcinogens 2000*. 2000, U.S. Department of Health and Human Services, National Institute of Environmental Health Sciences: Research Triangle Park, NC.
2. CDC, *Annual smoking-attributable mortality, years of potential life lost, and economic costs - United States, 1995-1999.* MMWR, 2002. **51**(14): p. 300-320.
3. U.S. Department of Health and Human Services, *Second national report on human exposure to environmental chemicals*. 2003, US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Environmental Health: Atlanta, GA.
4. U.S. Department of Health and Human Services, *Reducing tobacco use: a report of the Surgeon General*. 2000, US Government Printing Office: Washington, DC.
5. Hopkins, D.P., et al., *Reviews of evidence regarding interventions to reduce tobacco use and exposure to environmental tobacco smoke.* Am J Prev Med, 2001. **20**(2 Suppl): p. 16-66.
6. U.S. Department of Health and Human Services, *Healthy People 2010: Objectives for Improving Health (Volume 2)*. 2000, U.S. Government Printing Office: Washington, DC.
7. American Nonsmokers' Rights Foundation. *Summary of 100% Smokefree State Laws and Population Protected by 100% U.S. Smokefree Laws*. 2007 7/3/2007 [cited 2006 7/9/2007]; Available from: http://www.no-smoke.org/pdf/SummaryUSPopList.pdf.
8. Travers, M.J., et al., *New Jersey Air Monitoring Study 2006: Effect of the NJ Smoke-Free Air Act*. 2006, Roswell Park Cancer Institute and New Jersey GASP: Buffalo, NY.
9. Fong, G.T., et al. *The Impact of the Smoke-Free Ontario Act on Air Quality and Biomarkers of Exposure in Casinos: A Quasi-Experimental Study*. in *Ontario Tobacco Control Conference*. 2006. Niagara Falls, Ontario.
10. Klepeis, N.E., et al., *Determining Size-Specific Emission Factors for Environmental Tobacco Smoke Particles.* Aerosol Science and Technology, 2003. **37**: p. 780-790.
11. Repace, J., *Respirable particles and carcinogens in the air of Delaware hospitality venues before and after a smoking ban.* J Occup Environ Med, 2004. **46**(9): p. 887-905.
12. Klepeis, N.E., W.R. Ott, and P. Switzer, *Real-Time Measurement of Outdoor Tobacco Smoke Particles.* Journal of the Air & Waste Management Association, 2007. **57**: p. 522-534.
13. Lee, K., *Comparison of TSI Sidepak Aerosol Monitor to gravimetric analyses of secondhand smoke particles.*, M.J. Travers, Editor. 2006.
14. U.S. Environmental Protection Agency, *National ambient air quality standards for particulate matter; final rule.* Federal Register, 1997. **62**(138): p. 38651-38701.
15. U.S. Environmental Protection Agency. *National Ambient Air Quality Standards (NAAQS)*. 2007 [cited 2007 August 1]; Available from: http://www.epa.gov/air/criteria.html.
16. U.S. Environmental Protection Agency. *Draft Staff Paper for Particulate Matter Fact Sheet*. 2005 [cited 2006 October 4]; Available from: http://www.epa.gov/airlinks/pdfs/pmstaff2_fact.pdf.
17. U.S. Department of Health and Human Services, *The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General*. 2006, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health: Atlanta, GA.
18. ASHRAE, *Environmental Tobacco Smoke Position Document*. 2005, American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc.
19. Travers, M.J. and A. Hyland, *Indiana Air Monitoring Study, December 2004 – January 2005*. 2005, Roswell Park Cancer Institute: Buffalo.
20. Travers, M.J. and A. Hyland, *Indianapolis Air Monitoring Study 2006*. 2006, Roswell Park Cancer Institute: Buffalo.
21. Ott, W., P. Switzer, and J. Robinson, *Particle concentrations inside a tavern before and after prohibition of smoking: evaluating the performance of an indoor air quality model.* J Air Waste Manag Assoc, 1996. **46**: p. 1120-1134.
22. Travers, M.J., et al., *Indoor Air Quality in Hospitality Venues Before and After the Implementation of a Clean Indoor Air Law-Western New York, 2003.* Morbidity and Mortality Weekly Report (MMWR), 2004. **53**(44): p. 1038-1041.

23. Travers, M.J., A. Hyland, and J.L. Repace, *7-City Air Monitoring Study (7-CAMS), March-April 2004*. 2004, Roswell Park Cancer Institute: Buffalo.
24. Eisner, M.D., A.K. Smith, and P.D. Blanc, *Bartenders' respiratory health after establishment of smoke-free bars and taverns.* JAMA, 1998. **280**(22): p. 1909-14.
25. Sargent, R.P., R.M. Shepard, and S.A. Glantz, *Reduced incidence of admissions for myocardial infarction associated with public smoking ban: before and after study.* BMJ, 2004. **328**(7446): p. 977-80.
26. Menzies, D., et al., *Respiratory symptoms, pulmonary function, and markers of inflammation among bar workers before and after a legislative ban on smoking in public places.* Jama, 2006. **296**(14): p. 1742-8.
27. Farrelly, M.C., et al., *Changes in hospitality workers' exposure to secondhand smoke following the implementation of New York's smoke-free law.* Tob Control, 2005. **14**(4): p. 236-41.
28. Barnoya, J. and S.A. Glantz, *Cardiovascular effects of secondhand smoke: nearly as large as smoking.* Circulation, 2005. **111**(20): p. 2684-98.
29. California Environmental Protection Agency, *Proposed Identification of Environmental Tobacco Smoke as a Toxic Air Contaminant*. 2005, California Environmental Protection Agency, Air Resources Board, Office of Environmental Health Hazard Assessment.