Festus Air Quality Monitoring Study

CASE

Campus-Community Alliances for Smoke-Free Environments

Stanley R. Cowan, RS
University of Missouri – Columbia
School of Medicine
Department of Family & Community Medicine

March xx, 2010

Executive Summary

Secondhand smoke (SHS) was classified in 1992 by the U.S. Environmental Protection Agency (EPA) as a cause of cancer in humans. It contains more than 4,800 chemicals of which more than 250 are known to be toxic. For such a substance, there is no minimum safe level of exposure. The 2006 U.S. Surgeon General's Report, reviewing thousands of research studies, finds SHS is a cause for stroke, emphysema, bronchitis, asthma, respiratory infections, Sudden Infant Death Syndrome and other illnesses. SHS is responsible for almost 50,000 deaths per year from heart disease and lung cancer in nonsmokers. The 2006 Surgeon General's Report concluded that policies for smokefree environments are the most effective method of reducing SHS exposure in public places and workplaces.

The purpose of this study was to sample the air quality in public places that have smokefree policies and those that that permit smoking, and compare results to the EPA Air Quality Index. Indoor air quality for fine particulate matter pollution ($PM_{2.5}$ particles) was sampled for six Festus restaurants, bars and public entertainment venues on February 26 and March 8, 2010. Four of those places allowed smoking indoors while two had smokefree policies.

Key findings of this study include:

- Particulate matter air pollution for the four public places that allowed smoking averaged 185 $\mu g/m^3$ (EPA rating of "very unhealthy") even though an average of only 1.8 cigarettes were being smoked at any given time. The two public places that did not allow smoking averaged 12 $\mu g/m^3$ (EPA rating of "good"). The level of particulate matter air pollution was over 15 times higher in places that allowed smoking compared to those that were smokefree.
- Due solely to their occupational exposure, a full-time employee in one of these public places that allowed smoking would exceed the EPA's average annual limit for particulate matter air pollution by 280%.
- On average, only 13% of people were actively smoking in the public places where smoking was permitted. This is less than two-thirds the 22.4% adult smoking prevalence in Jefferson County, and refutes the commonly held misperception that a high percent of employees or customers in bars or public recreational venues smoke.
- Fewer than four burning cigarettes can create levels of pollution to the degree to be classified as "hazardous" or "significant harm" by the EPA.

The findings of this study are consistent with those of similar previous studies that found that over 90% of the fine particle pollution could be attributed to SHS.

Introduction

Secondhand smoke (SHS) contains more than 4,800 chemicals, of which more than 250 are known to be toxic or carcinogenic, and by itself was classified in 1992 by the U.S. Environmental Protection Agency as a human carcinogen. Exposure to SHS is responsible for an estimated 35,000 deaths per year from heart disease and lung cancer in nonsmokers.[1] The U.S. Surgeon General issued reports in 1984 and 2006 concluding SHS was also a cause for stroke, emphysema, bronchitis, asthma, respiratory infections, Sudden Infant Death Syndrome and other illnesses. The Surgeon General also concluded there is no safe level of exposure to SHS.[2,3]

Current Missouri law allows for smoking in most indoor workplaces. Policies prohibiting smoking are the most effective method for eliminating SHS exposure in public places and workplace environments. While many businesses voluntarily establish smokefree policies, the hospitality industry (bars, restaurants, bowling alleys, etc.), representing approximately 10-14% of workplaces, has been slow to enact smokefree policies. Consequently, workers and patrons are exposed to SHS. An increase in state- and city-wide smokefree ordinances across the United States has resulted in declining SHS exposure among the overall U.S. population,[4] but a majority of Missouri municipalities remain without comprehensive smokefree laws.

To protect public health, the U.S. Environmental Protection Agency (EPA) issued National Ambient Air Quality Standards which include fine particulate matter as one of the criteria pollutants. The EPA first issued standards for daily exposure to pollution consisting of particulate matter of 2.5 microns in size ($PM_{2.5}$) in 1971 with periodic revisions, the latest in 2006 and currently in a public comment period. Current EPA standards based on review of thousands of peer-reviewed scientific studies recommend exposure during a 24-hour period to be not greater than 35 $\mu g/m^3$. Further, over the period of a year a person's exposure should not have a daily average of more than 15 micrograms per cubic meter ($\mu g/m^3$). EPA assigned levels for $PM_{2.5}$ ranging from "good" to "hazardous" with accompanying health advisories as presented in Table 1.[5] Because the impact on health is the same regardless of whether the air is in an outdoor or indoor environment, the EPA index is a valuable measure of health risk.

Table 1. U.S. Environmental Protection Agency – Air Quality Index

Air Quality	$PM_{2.5}$ ($\mu g/m^3$)	Health Advisory
Good	≤ 15	None
Moderate	16-35	Unusually sensitive people should consider reducing prolonged or heavy exertion
Unhealthy for Sensitive Groups	36-55	People with heart or lung disease, older adults and children should reduce prolonged or heavy exertion
Unhealthy	56-150	People with heart or lung disease, older adults and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion
Very Unhealthy	151-250	People with heart or lung disease should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.
Hazardous	≥ 251	People with heart or lung disease, older adults, and children should remain indoors and keep activity levels low. Everyone else should avoid all physical activity outdoors.

The Festus Air Quality Monitoring Study examined indoor air quality in a sampling of smokefree and smoking-permitted public places in Festus, Missouri, to assess the relation between smoking and indoor air pollution. Air quality findings were compared to the EPA Air Quality Index.

Methods

Overview

Indoor air quality for fine particulate matter pollution was sampled for six Festus restaurants and bars on February 22 and March 8, 2010. Particulate matter smaller than 2.5 micrograms ($PM_{2.5}$) was measured. The $PM_{2.5}$ particles are easily inhaled deep into the lungs, are associated with pulmonary and cardiovascular disease and mortality. These venues provide variation in type of public place, size of venue, and location. Four of the places allowed smoking indoors while two had smokefree policies.

Measurement Protocol

An average of 51 minutes was spent in each public place to monitor air for data collection. The number of people inside the venue and the observed number of burning cigarettes were recorded every 10 minutes during the air quality sampling period. A Stanley IntelliMeasure ultrasonic distance estimator (The Stanley Works, New Britain, CT) was used to measure room dimensions, enabling unobtrusive calculation of the volume of each venue. Active smoker density was calculated by dividing the average number of burning cigarettes by the volume of the room in meters. The number of burning cigarettes was divided by the number of people at the venue in 10-minute intervals to determine the percent of people smoking within a venue at any particular time.

A TSI Sidepak AM510 Personal Aerosol Monitor (TSI, Inc., St. Paul, MN) was used to sample and record the levels of particulate matter pollution 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 to assess the real-time concentration of particulate matter smaller than 2.5 micrograms to be recorded as $PM_{2.5}$. The concentrations of particulate matter were recorded as micrograms per cubic meter ($\mu g/m^3$). The Sidepak was zero-calibrated prior to each use by attaching a HEPA filter according to the manufacturer's specifications. The Sidepak was set to a one-minute log interval, which averages the previous 60 one-second measurements.

Air quality sampling was conducted discreetly in order to not disturb the normal behavior of workers or patrons. Study staff ordered food or beverages and assumed normal seating positions in a venue. The monitor was generally located on a table so the air being sampled was within the sitting occupants' normal breathing zone. For each public place, the first and last minute of logged data were removed because they were averaged with outdoor and entryway air. The remaining data points were averaged to provide an average $PM_{2.5}$ concentration within the public place.

Descriptive data including the venue volume in cubic meters (m^3), number of people, number of burning cigarettes, and smoker density (number of burning cigarettes per 100 m^3) were recorded for each public place and averaged for all public places. Additionally, the results are compared to the EPA Air Quality Index.

Results

The locations were visited on a weekday during mid-day (11 a.m. – 2 p.m) or evening (6:45 p.m. – 10 p.m.). The average time spent per location was 51 minutes (range 40-62 minutes). Four of the

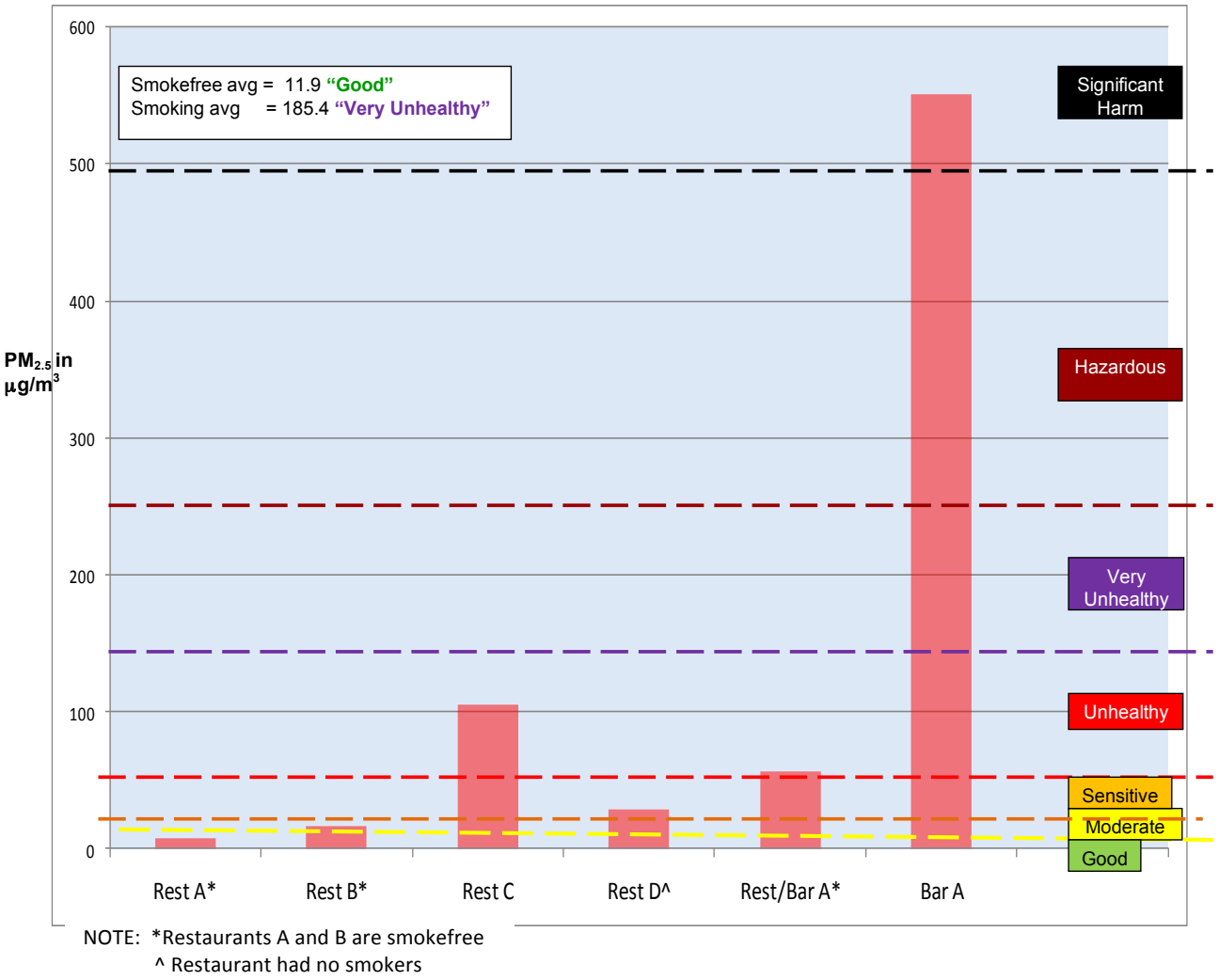
sampled public places allowed smoking and $PM_{2.5}$ levels in these venues averaged 185.4 μg/m^3 (range: 29.4 – 550.7 μg/m^3). The two smokefree venues sampled had an average $PM_{2.5}$ level of 11.9 μg/m^3(range 7.5 – 16.2 μg/m^3). The level of particulate matter air pollution was 15.6 times higher in those public places that allowed smoking compared to the smokefree venues. On average, 1.8 cigarettes (range: 0 – 5 cigarettes) were burning during the monitoring timeframe at smoking venues. This represents an overall average of 13.3% of patrons. Table 2 provides additional details of the monitored venues.

Table 2. Smokefree and Smoking Establishments in Festus

Public Place	Volume m^3	Average # people	Average # burning cigarettes	Active smoker density	% burning cigarettes to # people	Average $PM_{2.5}$ level (μg/m^3)	EPA Air Quality Index category
SMOKEFREE ESTABLISHMENTS							
Rest A	271	21.3	0	0	0	7.5	Good
Rest B	805	32.0	0	0	0	16.2	Moderate
Average	538	26.7	0	0	0	11.9	Good
SMOKING ESTABLISHMENTS							
Rest C	252	6.0	2.7	1.06	45.2	104.6	Unhealthy
Rest D	816	10.2	0	0.00	0.0	29.4	Moderate
Rest/Bar A	192	10.3	1.0	0.52	9.2	56.8	Unhealthy
Bar A	2808	28.4	3.6	0.11	13.1	550.7	Significant Harm
Average	1017	13.7	1.8	0.42	13.3	185.4	Very Unhealthy

Figure 1 is a presentation of the air quality data of the two smokefree and four smoking venues with comparison to the EPA Air Quality Index standards.

Figure 1 – Air Quality Measures for Festus, Feb-Mar, 2010



NOTE: *Restaurants A and B are smokefree
^ Restaurant had no smokers

Discussion

Particulate matter pollution is a complex mixture of extremely small particles that when breathed in can reach the deepest regions of the lungs. Exposure to $PM_{2.5}$ is linked to a variety of significant health problems, ranging from aggravated asthma to premature death in people with heart and lung disease. This study found $PM_{2.5}$ pollution to be 15.6 times higher in public places that permitted smoking compared to a smokefree public place (185.4 $\mu g/m^3$ vs. 11.9 $\mu g/m^3$). The average air quality in the sampled smokefree public places was classified as "good" by the EPA Air Quality Index. Of the four smoking-allowed venues: one had air quality that classified as "moderate"; two as "unhealthy"; and one as "significant harm".

Counts of the number of people and of the number of burning cigarettes conducted every 10 minutes revealed that on average only 13.3% of the people in these public places were actively smoking at any given time, less than two-thirds (59%) the adult smoking prevalence of 22.4% for

Jefferson County.[6] Despite commonly held misperceptions that a high percent of employees or customers in bars or public recreational venues smoke, this study finds only an average of 1.8 cigarettes were actually smoked at any given time; and yet, these few cigarettes create levels of pollution to the degree to be rated as "very unhealthy" per the EPA index.

The findings of this study are consistent with those of similar previous studies. A study of eight hospitality venues in Delaware before and after a statewide smokefree law was implemented found about 90% of the fine particle pollution could be attributed to tobacco smoke.[7] Similarly, a study of 22 hospitality venues in western New York found a 90% reduction in $PM_{2.5}$ levels in bars and restaurants and an 84% reduction in large recreation venues (e.g., bingo halls, bowling alleys).[8] Similar findings of reductions of more than 90% of $PM_{2.5}$ levels in public places were reported after several communities in Kentucky implemented smokefree workplace ordinances.[9] The current study in Festus finds 95% lower particulate matter pollution in the smokefree public venue compared to those public venues that allow smoking.

Other studies have directly assessed the effects of SHS exposure on human health. One study found that respiratory health improved rapidly in a sample of bartenders after a state smokefree workplace law was implemented in California, as well as after national smokefree laws were implemented in Ireland and Scotland.[10,11,12] Additional studies found a significant reduction in cotinine (a metabolic byproduct of nicotine) and of polycyclic aromatic hydrocarbons (a known human carcinogen found in SHS) in the bodies of hospitality industry workers or customers.[13,14] Experimental studies examining blood chemistries of smokers and nonsmokers find negative effects of even brief (minutes to hours) exposures to SHS on the cardiovascular system.[15,16]

Additional studies report an average of a 17% reduction in hospital admissions for acute myocardial infarctions (heart attacks) within the first year after implementation of a smokefree ordinance or law in the communities.[17,18 ,19 ,20 ,21 ,22 ,23 , 24, 25, 26, 27,] Of note are reports in which hospitalizations for heart attacks were reduced by 28% in Pueblo, Colorado, within the first 18 months after their smokefree ordinance was implemented; and that the decline continued to a 41% reduction within the first 36 months after the time the ordinance was implemented. However, rates in surrounding Pueblo County and adjacent El Paso County, which had no smokefree ordinances, remained virtually flat for the same periods.[28,29]

A recurring theme is demonstrated by a growing body of evidence showing that smokefree policies are proven to provide health benefits for both smokers and nonsmokers. Health benefits are especially greater among non-smokers as seen in studies that found reductions of 30% - 60% among non-smokers for hospitalization for heart attack within the first year of law for smokefree workplaces and public places.[19,30] Further, a recent Swiss study found a 50% reduction for such hospitalizations among people previously diagnosed with coronary heart disease.[30] Such evidence reinforces the Centers for Disease Control & Prevention recommendation that physicians advise their patients at risk of or with known coronary heart disease to avoid places where they may be exposed to secondhand smoke.[31]

Current city ordinance for Festus does not address smoking in public places within the city.

Conclusions

Public places in Festus allowing smoking had more than 15 times the fine particulate matter air pollution of a smokefree public place. Average air quality was rated "good" by EPA standards only in the public places that were smokefree. Employees in public places that allow smoking are

exposed to 280% the established annual EPA exposure standard to protect human health from fine particle air pollution.

This study demonstrates that hospitality workers and customers in Festus public places and workplaces where smoking is allowed are exposed to hazardous levels of an air pollutant known to cause heart disease, cancer and other diseases. Peer-reviewed studies have demonstrated that policies prohibiting smoking in public places and workplaces dramatically reduce SHS exposure and improve employee and public health.

References

[1] U.S. Environmental Protection Agency. Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders, 1992.

[2] The Health Consequences of Involuntary Smoking: A Report of the Surgeon General, U.S. Department of Health and Human Services. 1986.

[3] *The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General*, U.S. Dept of Health & Human Services, Centers for Disease Control & Prevention, 2006

[4] Centers for Disease Control and Prevention, "State-Specific Prevalence of Current Cigarette Smoking Among Adults and Secondhand Smoke Rules and Policies in Homes and Workplaces—United States, 2005", MMWR, Oct. 27, 2006. 55(42); 1148-1151.

[5] U.S. Environmental Protection Agency, 40 CFR Parts 51 and 58, [EPA-HQ-OAR-2007-0195; FRL-RIN 2060-AO11, Air Quality Index Reporting and Significant Harm Level for Fine Particulate Matter, http://www.epa.gov/oar/particlepollution/pdfs/20090115fr.pdf accessed August 5, 2009

[6] Missouri Department of Health & Senior Services, 2007 County Level Survey, Tobacco Use for Jefferson County Adults, http://www.dhss.mo.gov/County_level_study/header.php?chkBox=A&cnty=099&profile_type=4&pth=/web/data/County_level_study/

[7] 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): pp. 887-905.

[8] Centers for Disease Control and Prevention, "Indoor Air Quality in Hospitality Venues Before and After the Implementation of a Clean Indoor Air Law – Western New York 2003", MMWR, Nov. 12, 2004. 53(44); 1038-1041.

[9] Hahn, Ellen J., DNS, RN, et.al. "Smoke-free Laws and Indoor Air Pollution in Lexington and Louisville", Louisville Medicine, March 205, Vol. 52, No. 10, pp. 391-409

[10] Eisner, M.D., et.al., "Bartenders' respiratory health after establishment of smoke-free bars and taverns" JAMA, 1998. 280(22): pp. 1909-14.

[11] Allwright, Shane, et.al., "Legislation for smoke-free workplaces and health of bar workers in Ireland: before and after study", BMJ, 12 November, 2005;331:1117

[12] Ayers, J.G., et.al., "Bar workers' health and environmental tobacco smoke exposure (BHETSE): symptomatic improvement in bar staff following smoke-free legislation in Scotland" Occup Environ Med 2009;0:1-8, doi:10.1136/oem.2008.040211

[13] Hahn, E.J., et.al., "Effects of a smoke-free law on hair nicotine and respiratory symptoms of restaurant and bar workers", Journal of Occupational and Environmental Medicine, 2006; 48(9): 906-913.

[14] Anderson, Kristin E., et.al., "Metabolites of a Tobacco-Specific Lung Carcinogen in Nonsmoking Casino Patrons", Cancer Epidemiology Biomarkers & Prevention, December, 2003; 12: 1544-1546.

[15] Burghuber, O.C., *et. al*., *Platelet sensitivity to prostacyclin in smokers and non-smokers.* Chest. 1986 Jul;90(1):34-8.

[16] Otsuka,R., et.al, *"Acute Effects of Passive Smoking on the Coronary Circulation in Healthy Young Adults"* JAMA 286:436-441, 2001

[17] Sargent, Richard P., M.D., et.al, "Reduced incidence of admissions for myocardial infarction associated with public smoking ban: before and after study", British Medical Journal, April 5, 2004.

[18] Khuder, S.A., et.al., "The impact of a smoking ban on hospital admissions for coronary heart disease", Prev Med (2007), doi:10.1016/j.ypmed.2007.03.011

[19] Seo, Dong-Chul, et.al., "Reduced Admissions for Acute Myocardial Infarction Associated with a Public Smoking Ban: Matched Control Study", J. Drug Education, 37(3) 217-226, 2007

[20] Cronin E, Kearney P, Kearney P, Sullivan P. Impact of a national smoking ban on the rate of admissions to hospital with acute coronary syndromes. European Society of Cardiology 2007 Congress; September 4, 2007; Vienna, Austria. Poster 3506. [submitted by Dr Edward Cronin of Cork University for publication in peer-reviewed journal]

[21] Pell, Jill P., M.D., et.al. "Smoke-free Legislation and Hospitalization for Acute Coronary Syndrome" N Engl J Med 2008: 359: 428-91

[22] Juster, Harlan R., Ph.D., et.al., "Declines in Hospital Admissions for Acute Myocardial Infarction in New York State After Implementation of a Comprehensive Smoking Ban", Am Journal of Public Health, Vol. 97, No. 11, Nov. 2007.

[23] Cesaroni, Giulia, et. al., "Effect of the Italian Smoking Ban on Population Rates of Acute Coronary Events" Circulation, doi:10.1161/CIRCULATIONAHA.107.729889 February 11, 2008.

[24] "Reduced Secondhand Smoke Exposure After Implementation of a Comprehensive Statewide Smoking Ban – New York, June 26, 2003 – June 30, 2004" Morbidity & Mortality Weekly Report, Vol. 56/No.28, July 20, 2007.

[25] Lightwood, James, PhD, et.al., "Declines in Acute Myocardial Infarction After Smoke-Free Laws and Individual Risk Attributable to Secondhand Smoke", Circulation, October 6, 2009; 120:1373-1379

[26] Meyers, David G., MD, "Cardiovascular Effects of Bans on Smoking in Public Places", Journal of the American College of Cardiology, 54:14, 2009

[27] Secondhand Smoke Exposure and Cardiovascular Effects: Making Sense of the Evidence, Report Brief, Institute of Medicine, October 2009, http://www.iom.edu/en/Reports/2009/Secondhand-Smoke-Exposure-and-Cardiovascular-Effects-Making-Sense-of-the-Evidence/Report-Brief-Secondhand-Smoke.aspx

[28] Bartecchi, Carl, M.D., et.al., "Reduction in the Incidence of Acute Myocardial Infarction Associated with a Citywide Smoking Ordinance" Circulation, Oct 3, 2006

[29] Reduced Hospitalizations for Acute Myocardial Infarction After Implementation of a Smoke-Free Ordinance – City of Pueblo, Colorado, 2002-2006" Morbidity & Mortality Weekly Report, Vol. 57/No.51&52, January 2, 2009.

[30] Trachsel, Lukas D., et.al., "Reduced incidence of acute myocardial infarction in the first year of implementation of a public smoking ban in Graubuenden, Switzerland", Swiss Medical News, January 7, 2010 http://www.smw.ch/dfe/set_current.html

[31] Pechacek, Terry F. and Babb, Stephan, "Commentary: How acute and reversible are the cardiovascular risks of secondhand smoke?" BMJ 328:980-983, April 24, 2004.