Title: The Impact of State-wide Smoking Bans on Acute Myocardial Infarction Hospital Admissions in California and Other States

David W. Kuneman (1) and Michael J. McFadden (2)
(1) Director of Research, The Smokers' Club, INC.
(2) Pennsylvania Smokers Action Network (PASAN), Mid-Atlantic Director of The Smokers' Club, INC.

Both authors can be contacted. Corresponding author and guarantor: David W. Kuneman

Abstract:

State populations' hospital admissions for acute myocardial infarctions (AMIs) were examined before and after widespread smoking bans. States with widespread bans were also compared with states without such bans and with the country overall as controls. Publicly available government data was used to determine admissions rates. Results indicated no statistically significant decreases in AMI admissions on statewide levels after ban implementations.

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Introduction: Recently, reports of observed substantial declines in incidence of admission for AMI through ERs have been widely publicized in the popular media. One such report concerned a published peer-reviewed study conducted in Helena, Montana (1) which found a statistically significant drop in admissions after implementation of their ban, and claimed a statistically significant return to pre-ban levels after the ban was lifted. Similar small population reports have made headlines in the news but have not yet been formally published and reviewed.

The Helena authors were actually quite cautious in interpreting the results within the body of their study, concluding that "Laws to enforce smoke-free workplaces and public places ***may*** be associated with an effect on morbidity from heart disease," (emphasis added) and expressing concern about the small study size. However, media statements and representations have often overlooked such limitations and simply presented the findings as proof of a need to "protect nonsmokers" from tobacco smoke.

The present study addresses the limited size concern by examining more populous jurisdictions with bans. We believe if the magnitude of the Helena effect was common that it would have been noticed when Los Angeles banned smoking in 1993, or when New York City imposed a ban in 1995. California was one of the first states with a restaurant ban (1995), and a bar ban was added in 1998, yet according to the American Heart Association's "Rates by State fact sheet" (2) California was ranked #27 among states in percent change from 1991 to 2001 for age-adjusted death rates for total cardiovascular disease. Despite assuming a strong leadership role in combating public smoking in the 1990s California has actually ranked almost exactly at the median point of USA heart attack trend rates.

The Helena study already provides a review of research linking secondhand smoke to heart disease, and it will not be repeated here. However a more recent, and much longer term cohort study, sometimes referred to as the U.C.L.A. study (3) found no link between spousal exposure and heart disease among 35,000 Californians over 38 years. Upon publication, this study was accompanied by an editorial comment (4) concluding that more large comprehensive datasets were needed to finally settle the questions concerning the impact of secondhand smoke exposure on public health.

An editorial, published in 1998 in the New England Journal of Medicine (5) noted that over the last 30 years, mortality from coronary heart disease has declined by more than 50 percent in the United States. Yet the incidence of myocardial infarction remained unchanged or increased slightly. The authors concluded it is likely that opposing dynamics of many elements influencing trends in occurrence rates were offsetting each other, but that the contributions of those elements to declining fatality rates were mostly additive. For these reasons, we believe continuing the previously established use of a protocol of measurement of incidence of admission for AMI provides more reliable data than the use of mortality data to assess the impact of bans on public cardiovascular health.

Materials And Methods: Data on state-specific emergency room admissions for AMI are publicly available at the Healthcare Cost and Utilization Project (HCUP) (6). HCUP is a family of health care databases that researchers and policymakers use to identify, track, analyze and compare hospital statistics at the national, regional and state levels. These data are available from 1997 to 2003, inclusive, but California's 2003 data are unavailable without an IRB review by the Committee for the Protection of Human Subjects. AMI admissions data are available in this system and can be used to study states with and without smoking bans. We specifically searched for number of diagnoses of AMI for all patients, all hospitals and admitted from the ER.

However, not all states participate in HCUP. Some states which have enacted smoking bans do participate, but enacted their bans in 2004 and their data are not yet available. Other states, such as Utah and Vermont participate, but enacted their bans before HCUP was initiated and data before those bans are not available for comparisons after the bans were enacted. California, Florida, New York, and Oregon however enacted their bans while contributing data to HCUP, and therefore afforded an opportunity to examine the question of whether their ER admissions for AMI declined in a manner similar to the reported Helena effect. HCUP also provide data for the U.S.A. overall, and some states which did not have widespread local bans or a state-wide ban. These will be utilized as controls. The USA control data over these seven years comprised approximately 3.5 million AMIs. The combined AMI data of Iowa, New Jersey, South Carolina, and Arizona were utilized as a control: these states had few smoking bans and a total of roughly 220,000 AMIs over the course of our study.

Although California banned smoking in restaurants January 1995 and data are not available through HCUP for the years 1991 to 1998, the California Department of Health's Office of Statewide Health Planning and Development (OSHPD) was conducting a similar in-state hospital performance study based on AMI admissions and 30-day survival rates in most public hospitals. (7)

Approximately 40,000 AMIs from about 400 California hospitals were included for each year between 1991 and 1998. These approximately 320,000 AMIs were used to draw conclusions about the impact of the California restaurant ban in 1995. Omitted from this database were federal hospitals, very small hospitals where individual patient information could be ascertained from the data, and other hospitals without ERs. Since OSHPD is the California agency which contributed these California data to HCUP after 1996, we believe the HCUP data were comparable to the pre-1997 data.

Statistical Methods: We compared trend lines before bans took effect with trend lines after bans took effect. We also compared these trend lines to control states and the USA overall. We found that after 2001 or 2002 most states' and the USA overall's admissions began to drop irrespective of smoking ban status. The exception was South Carolina, although Oregon was still almost linear. These nonlinear trends were found to fit quadratic equations with the general formula: $-ax^2 +bx -c$ = AMI admissions where x = the year in question. We used xuru.org (8) to derive a regression equation predicting expected pre and post-ban data points based on the overall equation. We then compared the expected AMI number to the actual AMI data for post-ban years. For California and the USA overall, we found the period 1993 to 1997 to be linear and used a linear equation of the general formula mx-b= AMI admissions to predict where pre- and post-ban data points would be expected for California. We calculated 95% confidence intervals from the formula: $CI = SDt/N^{1/2}$ where SD is standard deviation calculated from the difference of the expected AMI value derived from the respective equation and the actual AMI data. If actual AMI data for years immediately following bans had been one confidence interval lower than the expected number calculated from the equations, we would have been 95% confident the bans had a significant effect in lowering the anticipated AMI admissions.

Results: California's restaurant ban took effect in January 1995 and a bar ban was added in January 1998. During the years following those bans there was no abrupt decline in hospital admissions through ERs for AMI into California's hospitals (Table I and II). The observed change in admissions between 1997 and 1998 was of the same relative magnitude as the USA and the control states. Using our equation to calculate the value of the 1997 CA data point gave an expected number of 40,231 AMIs. Both this number and the actual data, 40608, are lower than the 1998 data-point, 43044, or any of the data for 1999 through 2002. California's standard deviation of 356 AMI's would have enabled us to detect a decline of 373 or more AMIs with 95% confidence. Since there was a post ban increase of 2,436 we can definitely conclude with greater than 95% confidence that there was no decrease in the year(s) following the implementation of California's total smoking ban in bars.

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Table I presents the state-specific data from HCUP. All AMI admissions for all patients,, standard deviation, 95% confidence interval, % confidence interval, and quadratic formula.

	1997	1998	1999	2000	2001	2002	2003	SD	95%CI	% CI
CA	40608	43044	44639	46340	46498	45691	NA	356	373	0.8
$-392.8148(\text{year})^2+1571937(\text{year})-1572569000$= California AMIs										

OR	4632	4621	4853	4957	4927	5125	5054	64	60	1.2
$-8.791357(year)^2+35249.29(year)-35328230$= Oregon AMIs										
FL	33180	36081	37103	39421	40967	40077	39783	568	530	1.4
$-322.5758(year)^2+1291434(year)-1292526000$= Florida AMIs										
NY	29316	28828	30636	32236	32225	31728	31888	621	579	1.9
$-137.076(year)^2+548843.4(year)-549351300$=New York AMIs										
USA	441497	468771	462767	479000	487010	499730	485953	7216	7216	1.4
$-1525.752(year)^2+6110850(year)-6118209000$=USA AMIs										
SC	6254	6211	5881	6291	6092	6399	6454	127	118	1.9
$29.26875(year)^2-117032.6(year)+116996300$= South Carolina AMIs										
AZ	7042	7252	7062	7653	7859	7015	7293	282	263	3.6
$-44.07586(year)^2+176341.9(year)-176372800$= Arizona AMIs										
NJ	13664	14430	15087	15529	15548	15833	14702	212	198	1.3
$-145.224(year)^2+581123.9(year)-581336300$= New Jersey AMIs										
IA	4476	4898	4776	4770	4723	4608	4459	103	96	2.1
$-34.56976(year)^2+138254.6(year)-138225400$= Iowa AMIs										

TABLE I

Oregon banned smoking in all restaurants which allowed children effective July 2001. While this ban is not as strict as California's, patrons and workers in banned restaurants should have been protected by the Helena effect and some partial decline of Oregon's hospital admission trend should have been realized. After the implementation of their partial restaurant ban in 2001, both 2002 and 2003 had higher AMIs. If that data had shown a decline of 60 or more AMIs from pre-ban levels we could have been 95% confident that a 1.2% decline in AMI admissions had occurred. Since the year 2002 actually saw a post-ban increase of 198 AMIs we can say with more than 95% confidence that no post-ban decline occurred.

Data were also examined for Florida and New York. These states both banned smoking in bars and restaurants effective July, 2003. Florida bans smoking in all bars where more than 10% of sales are food or where the business is in a building which also houses another kind of business. New York's ban is almost universal.

Longer term conclusions from these data were limited by the availability of only 2003 data representing the impact of only one-half of a year after a ban… a period similar to that studied by the Helena authors. Yet, preliminary results seem to agree with the findings for California and Oregon. The Helena effect would have predicted an approximately 15 or 20% decline in admissions for the year 2003 in Florida and New York. But data clearly do not show such a decline. If Florida's 2003 AMI admission data-point had been lower than 38759, we would have been 95% confident that at least a 3.3% decline relative to the 2002 data-point had occurred. If New York's 2003 AMI admission data-point had been lower than 31306, we would have been 95% confident that at least a 1.4% decline relative to the 2002 data-point had occurred. We did not detect any decline which could have been associated with these state-wide smoking bans.

Despite California's bar and restaurant bans both being in effect after 1997, California's AMI admissions trend continued upward. Despite their bar and restaurant bans, California's incidence of ER admissions for AMI increased more rapidly than the USA overall or the sum of the control states through 2001.

Oregon's AMI admissions were essentially identical during 2002 and 2003 while the USA overall and all control states except South Carolina were declining.

Prior to the implementation of bans in Florida, Oregon and New York, annual increases in AMI admissions were comparable to the USA overall and most control states. This would indicate that the prevalence of factors contributing to the rise in AMI admissions in these states was similar to that of the country as a whole. We would expect that, with nothing out of the ordinary, any operating Helena effect would have clearly observable in Florida, Oregon and New York. South Carolina had a lower rise in AMI admissions than other states and the USA despite an almost total lack of smoking bans.

Figure I displays relative time trends of AMI admissions for all the states we studied and for the USA overall. In all, it appears the rate of rise in AMI admissions peaked between 2001 and 2002 regardless of whether they were states with smoking bans or without. The presence or absence of statewide smoking bans did not play a role in the "peaking" of the AMI admission data during 2001 to 2002.

Figure 1: Relative Comparisons of AMI Admissions from 1997 through 2003 for CA, FL,NY,OR,USA, (AZ,NJ, SC as Sum of Control States)

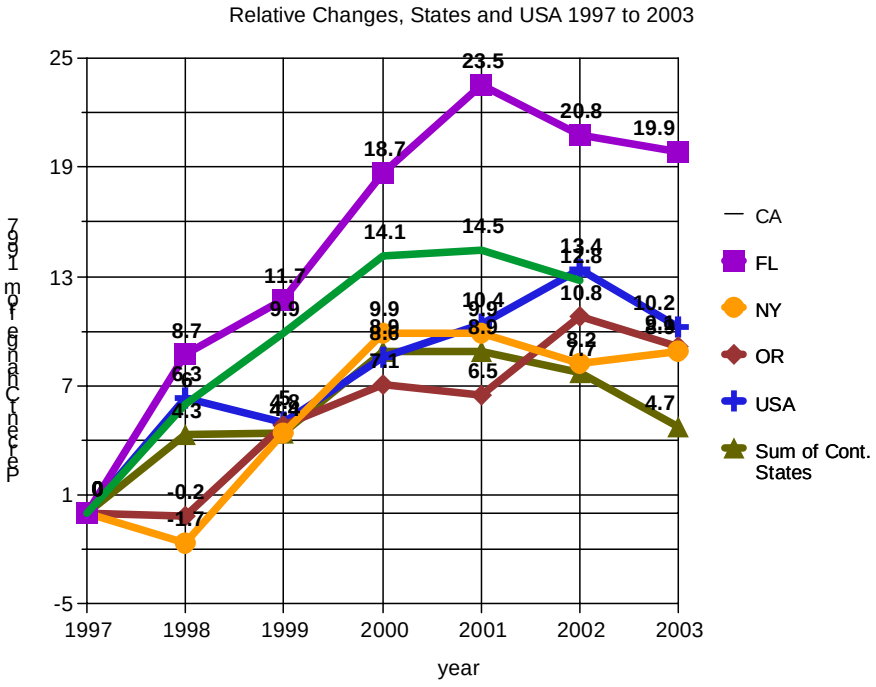

Figure 1

California HCUP data are not available prior to the enactment of the statewide restaurant ban. However data are available from California's OSHPD Hospital Outcomes Project. We have considered these data linear because although a decline was observed in 1997, the linear up-trend resumed in 1998 and thereafter in these HCUP data. We found the same to be true of the USA overall data from 1993 to 1997. We calculated the percent slope from 1993 to 1997 using the OSHPD linear formula reported in Table II. During that period, California's AMI admissions through the ER increased 3.14% annually while the USA overall only increased 2.42% annually. Since California's increase was greater than the USA we concluded that California's statewide restaurant ban did not illustrate a Helena effect.

According to our equation, California's expected AMI number for 1995 is 42159, close to the actual data-point 42183. If California's actual 1995 AMI data had been lower than 40748, we would have been 95% confident at least a 2.1% decline relative to the 1994 data had occurred. Therefore, we concluded that there was no significant AMI decline after the restaurant ban.

Table II: California OSHPD data, 1993-1997, USA HCUP data,1993-1997, Standard Deviation, Percent Slope, Confidence Interval, and Percent Confidence Interval and Linear Equation.

	1993	1994	1995	1996	1997	SD	% slope	C.I.	% C.I.
CA	37850	41927	42183	43400	43703	1138	3.14	1411	3.4
1318(year)-2587251= California AMIs									
USA	404371	424815	438454	455371	441497	9891	2.42	12265	2.8
10481(year)- 20476294= USA AMIs									

TABLE II

By October, 1993, according to the California Smoke-free Cities Bulletin (9), 4,376,160 Californians, (approximately 13%) lived in areas requiring smoke-free restaurants. In 1993, Californians suffered 37850 AMIs. The statewide restaurant ban took effect January, 1995. Within those 14 months, the percentage of Californians covered by a restaurant ban increased from 13% to 100%. Despite a net change of 87% of all Californians becoming covered by a restaurant ban in the relatively short period of time of 14 months, Californians had 42183 AMI admissions (11% more) in 1995, the year immediately following the ban, so again it is clear that no Helena effect was observed.

The average of the 1993 and 1994 California AMI admission data from OSHPD is 39889 AMIs/year. The average of the 2001 and 2002 HCUP admission data is 46095 AMIs/year, 15% more. The difference, 6206 AMIs from the 1993-1994 data, is greater than the total of the standard deviations of the OSHPD and HCUP datasets, which is 1494 AMIs. Within the six-year period separating these data, we again confirmed with 95% confidence that no longer term decline in AMI admissions occurred after the year 2001 despite the imposition of both bar and restaurant bans which covered the remaining 87% of Californians not covered during 1993. This

data indicates that not only did the short term Helena effect not exist for California, but the usually expected overall longer-term improvement in AMI rates after smoking bans also did not occur.

Figure 2: Comparison of all California admission data from 1993 to 2002 and USA data from 1993 to 2003

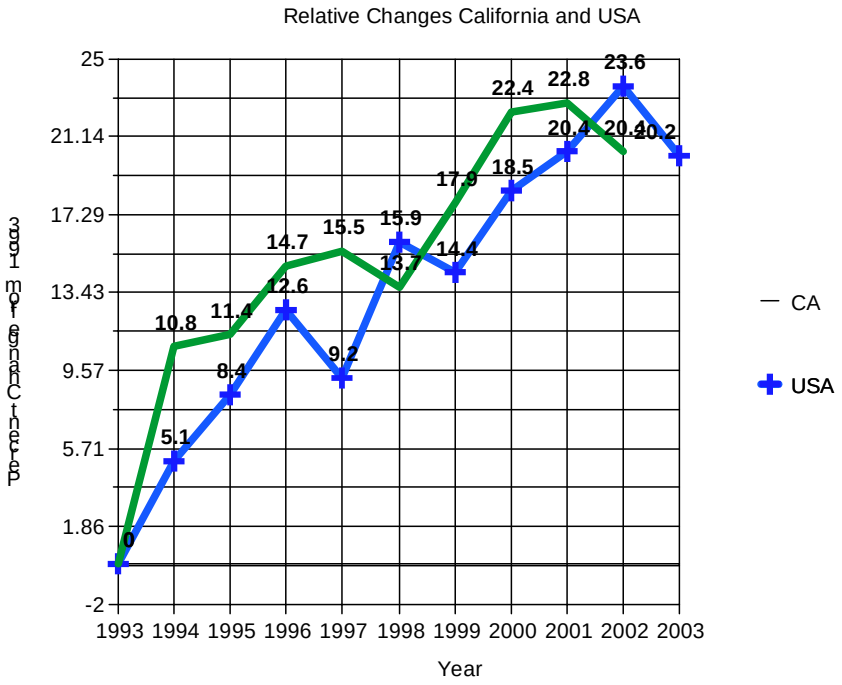

Figure 2

A “smearing” hypothesis was discussed by Sargent et al (1) to explain the lack of observance of a Helena effect in states with phased in bans. Essentially, the hypothesis proposed that states have many localities with bans prior to the implementation of statewide bans. Since these local bans phase in slowly, the Helena effect is gradual and spread over the entire span of time between when the first local bans and eventual state bans.

We have already ruled out that the smearing hypothesis was operating in California because 87% of the state’s residents went smoke-free in a short 14 month period. A Helena effect would have resulted in California’s having 87% of a 20 to 40% decline in AMI admissions between 1993 and 1995.

We tested this hypothesis further. The largest metropolitan areas of New York all imposed local restaurant bans prior to the statewide total ban in 2003. According to the Corning Hotel and Restaurant Administration Quarterly (10), The City of New York and the counties of Erie, Monroe, Suffolk and Westchester all had local restaurant bans enacted between 1995 and 1999.

These covered a significant portion of the state's residents. Nevertheless, New York had a larger increase in AMI admissions relative to the USA or control states between 1997 and 2002, the year before its statewide ban.

According to the CDC's State Tobacco Activities Tracking and Evaluation (STATE) System, (11) Florida had preempted local bans prior to the enactment of its statewide ban in July 2003. Smoking was allowed in 50% of all restaurant space, and 100% of all bar space throughout the whole state, prior to July 2003. The restaurants and bar-restaurants of the entire state abruptly went smoke-free in July 2003. If the Helena effect had occurred there, the second half of 2003 should have had a 30 to 40% decline in AMI admissions relative to the first half of 2003, or a 15 to 20% decline relative to the entire year of 2002. We ruled out that the "smearing" hypothesis operated in Florida because we were 95% confident we could have detected anything greater than a 3.3% decline in admissions for all of 2003.

California's active adult smoking trend also should have contributed to a relative decline in AMI admissions between 1993 and 2002. According to the Behavioral Risk Factor Surveillance System, in 1993, 18.5% of adult Californians smoked and 22.6% of all US adults smoked. By 2002, California's adult smoking rate fell to 16.4%, while the nationwide rate increased slightly to 23.0% (12).

This relative change means secondhand smoke exposure in California residences should also have declined 10% compared to the country as a whole. In addition to the protection the statewide bar and restaurant bans should have offered, smoking inside residences in California declined faster than the USA even among those residences occupied by an active smoker. (13) Nonsmoking Californians should have been protected from AMIs by not only by the bar and restaurant bans, but also by overall reduced exposure at home. Reduced residential exposure in addition to the elimination of bar and restaurant exposure should have given California an additional advantage over the USA, yet AMI admission rates increased faster than the USA during the entire period from 1993 to 2002.

Conclusion: Examination of statewide data encompassing a database on the order of a 1,000 times larger than that used in previous studies such as Helena's does not support any conclusion of a significant drop in AMI hospital admissions in either the short or medium term aftermath of governmentally imposed smoking bans.

Strengths of this study: Our study is the first to have used the statistical power of large quantities of AMI data authenticated by government statisticians. The size of these databases enabled us to establish confidence intervals well below 5%, which is eight times the certainty of the 40% decline reported in (1). Such data allow for full and free examination and validation or correction by other researchers. Our basic data, standards for judging AMIs, and all other such information were compiled by others without any stake or bias in the outcome. Our study was also conducted without dependence on any funding source that might have caused us to bias our methodology so as to produce results pleasing to granting organizations, corporations, or foundations. Previous studies and media releases have not shared these strengths. More such studies of large smoke-free jurisdictions should be conducted as data become available and similar unbiased studies should be made of areas where smoking bans are modified or reversed.

While we recognize some local bans were present in states prior to statewide bans, it should be noted that generally fewer than 1/4 of these populations were covered locally prior to the statewide enactment of bans. Whether the ban comes from a state statute or a local ordinance should not affect any of the clinical dynamics of the purported Helena effect among those residents of local jurisdictions without bans when a statewide ban is enacted.

Our states study utilized data from large populations, with the great bulk isolated from populations without bans. Most of the residents of California, Oregon, and Florida (except Jacksonville) are geographically isolated from other states which do not have bans because their large metropolitan areas are far from their borders. Few of their AMI patients would be admitted into an ER located in another state. Further, within New York, New York City's metropolitan area is the only highly populated locality within reasonable distance of another state and given the abundance of hospital facilities within NYC such out of state transit is probably fairly uncommon. For these same reasons, few of these residents live within a distance where they could migrate to a jurisdiction without a ban to smoke while drinking or dining and later suffer an AMI resulting in admission into an ER located in a state with a ban.

Weaknesses of this study: We relied on numerous other workers who authenticated the diagnoses of AMI and compiled the databases we used. During the time period studied, criteria used to implement a diagnosis of AMI have changed as have reporting methods. This is particularly true of these California data prior to 1997. However, the USA data for the same time period would have been authenticated using the same diagnostic criteria. It is due to such concerns that we did not combine these pre-1997 data with the post-1997 data for California.

Even so, we found the pre-1997 and post-1997 data for California and the USA "fit" with each other. The slopes and Y-intercepts matched the respective data sets quite well. We were particularly concerned with the California 1997 HCUP data point. It is significantly different than the 1997 data point reported by OSHPD. The regression analysis derived from the HCUP data and the analysis derived from the OSHPD data both produced expected AMIs indicating that the true 1997 data point is between 44795 and 40231. However, this wide variation makes it impossible to accurately assess the short-term impact of the California bar ban in 1998. Nonetheless, we were able to conclude the bar ban caused no long term decline in AMI admissions. Substituting a higher value for the 1997 data point in California's HCUP regression eliminates most of the excess rise in AMI admissions after 1997, but still does not allow a conclusion that a long term decline occurred from California's statewide bans.

What is already known on this topic: Some studies, usually using concentrated "smoke chamber" conditions, have concluded secondhand smoke causes immediate cardiovascular-related effects. (14) (15) Others have concluded that the effects of normal exposure levels are longer term (16), and still others have concluded no effect exists. (17) (18) Most conclude that any immediate effects occurring are reversible over a relatively short period of time and that longer term effects are reversible over longer periods.

What this paper adds: Within our confidence limits to detect declines in ER admissions for AMIs, we have detected no such declines after enactment of smoking bans in large jurisdictions.

We were however able to acquire and analyze large amounts of data, sufficient to conclude abrupt, statistically significant drops in AMI admissions are not common when larger scale population samples are examined.

Relation to other studies: Only one similar study has been published. (1) Our findings are in direct conflict with the findings of that study. We believe our findings are more reliable because we have the statistical power necessary to properly determine if the Helena effect is common.

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Competing interests: The authors are both active smokers, involved with and supporters of groups fighting smoking bans and are personally opposed to smoking bans. David Kuneman worked as a research chemist for Seven-Up roughly 20 years ago at a time when it was formally owned by Philip Morris. Neither author receives any funding for their work in this area other than a very modest income for Mr. McFadden resulting from sales of his writings.

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David W. Kuneman, Director of Research, The Smokers Club, INC. 1015 O'Day Ave, St. Louis, MO. 63119 314-968-8241
Michael J. McFadden, Mid-Atlantic Director, The Smokers Club, INC. 4424 Ludlow St., Philadelphia, PA 19104 215-266-5083