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Cardiovascular Effect of Bans on Smoking in Public Places

A Systematic Review and Meta-Analysis

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Objectives A systematic review and a meta-analysis were performed to determine the association between public smoking bans and risk for hospital admission for acute myocardial infarction (AMI).

Background Secondhand smoke (SHS) is associated with a 30% increase in risk of AMI, which might be reduced by prohibiting smoking in work and public places.

Methods PubMed, EMBASE, and Google Scholar databases plus bibliographies of relevant studies and reviews were searched for peer-reviewed original articles published from January 1, 2004, through April 30, 2009, using the search terms "smoking ban" and "heart" or "myocardial infarct." Investigators supplied additional data. All published peer-reviewed original studies identified were included. Incidence rates of AMI per 100,000 person-years before and after implementation of the smoking bans and incidence rate ratios (IRRs) with 95% confidence intervals (CIs) were calculated. Random effects meta-analyses estimated the overall effect of the smoking bans. Funnel plot and meta-regression assessed heterogeneity among studies.

Results Using 11 reports from 10 study locations, AMI risk decreased by 17% overall (IRR: 0.83, 95% CI: 0.75 to 0.92), with the greatest effect among younger individuals and nonsmokers. The IRR incrementally decreased 26% for each year of observation after ban implementation.

Conclusions Smoking bans in public places and workplaces are significantly associated with a reduction in AMI incidence, particularly if enforced over several years. (J Am Coll Cardiol 2009;54:1249–55) © 2009 by the American College of Cardiology Foundation

Secondhand smoke (SHS) increases the risk of acute myocardial infarction (AMI) by 25% to 31% (1–5). In countries where smoking prevalence is high, for example, Britain 50% (6), Europe 62% (7), and Greece 156% (8), versus 22% in the U.S. (2,9), AMI in nonsmokers is particularly increased. The dose-response relationship between SHS and AMI is nonlinear, increasing rapidly even at low concentrations (10–12). Bans on smoking in public places and workplaces have been instituted in several countries, 32 U.S. states, and many cities and counties in the U.S. We performed a systematic literature review and meta-analysis to estimate the overall effect of public (workplace and public place) smoking bans on the risk of AMI in the general population.

Methods

We searched PubMed, EMBASE, and Google Scholar from January 1, 2004, through April 30, 2009, using the search terms "smoking ban" and "heart" or "myocardial infarct" and reviewed pertinent bibliographies. One unpublished abstract and 1 nonpeer-reviewed report were excluded, leaving 11 peer-reviewed published studies concerning 10 geographic locations. Duplicate data abstracting was performed by 2 authors (D.G.M. and J.S.N.). Only AMI cases were included (some investigators supplied additional data), except where the case definition was acute coronary syndrome (ACS), which required an elevated serum troponin.

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To avoid duplicate cases (Piedmont and Latium [Rome] were separately reported), only the regions of Fruili Venezia Giulia (Trieste) and Campania (Naples) were analyzed from the Italian study of 4 regions. Results were converted to incidence rates (new cases/100,000 person-years) using the most recent official census and including all age groups.

Meta-analysis used the random-effects model in the *metan* statistical package in STATA version 10 (Stata Corp., College Station, Texas) (13) because heterogeneity was significant in the fixed effects model ($p < 0.001$). Unlike previously pub-

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Abbreviations and Acronyms

ACS = acute coronary syndrome
AMI = acute myocardial infarction
CI = confidence interval
ICD = International Classification of Diseases
IRR = incidence rate ratio
SHS = secondhand smoke

lished meta-analyses, which used average yearly incidence rates (14,15), we weighted studies by person-years, thus considering both population size and duration of observation, and assumed that the incidence of AMI satisfied a Poisson process (16). Because the funnel plot showed systematic heterogeneity among the study results, we performed a meta-regression analysis using the *metareg* package of STATA 10 to examine whether the estimate of incidence rate ratio (IRR) depends on such factors as post-ban duration, population size, or region (U.S. or non-U.S.).

Results of the Systematic Review

Abstractor agreement was 100%. Results are summarized in Table 1. All studies reported decreases in incidence (at least in a subgroup), with the largest decreases observed in the U.S. Table 2 lists important study parameters based on the Newcastle-Ottawa scale (17). No study had all parameters, although the Scotland study had nearly all. All studies excluded transients and matched observation periods by season.

Helena, Montana. This community of 47,154 persons passed a ban on public smoking (all but 2 businesses complied) in June 2002, which was judicially suspended in December 2002 (18). Investigators screened cases of AMI by International Classification of Diseases (ICD) 9th Edition codes (410xx) and confirmed cases by chart review (criteria not published). Incidence decreased from 170 to 102 cases/100,000 person-years, then returned to baseline, a 40% temporary decline. In the surrounding area, incidence increased from 118 to 172 cases/100,000 person-years, an increase of 46%. This was the first study of a public smoking ban and the only study to include data from after a ban was suspended.

Pueblo, Colorado. Pueblo (population 103,648) banned smoking in bars, restaurants, bowling alleys, and business establishments, whereas Colorado Springs (population 370,448), 45 miles distant in El Paso County, did not (19). Cases included a primary diagnosis of AMI by ICD-9 code 410xx (with no confirmation by biomarkers) for 18 months before and the initial 18 months during ban enforcement. During the ban, AMI incidence in the city of Pueblo decreased by 27% (257 to 187 cases/100,000 person-years, IRR: 0.73, 95% confidence interval [CI]: 0.64 to 0.82). The surrounding Pueblo County (noncity population 44,103) decreased 15% (135 to 115 cases/100,000 person-years, IRR: 0.85, 95% CI: 0.56 to 1.14). Adjacent El Paso County (population 550,478) experienced a 4% decrease (157 to 150 cases/100,000 person-years, IRR: 0.96, 95% CI: 0.87 to 1.04). An additional 18 months of observation noted a further 19% reduction in Pueblo City (152 cases/100,000 person-years) for an overall 3-year reduction of 41% (IRR: 0.59, 95% CI: 0.49 to 0.70) with no reduction in either Pueblo County (IRR: 1.03, 95% CI: 0.68 to 1.39) or adjacent El Paso County (IRR: 0.95, 95% CI: 0.87 to 1.03) (20). This study used well-separated communities and shared the longest observation period.

New York State. Many communities in New York State (population 18,976,457) had banned public smoking, and the state had increased taxation on tobacco before the July 2003 implementation of a statewide ban on work and public smoking (bars, restaurants, and hospitality venues) (21). A statewide database (252 hospitals) was searched for the primary diagnosis of AMI cases (ICD-9 codes 410.0 to 410.99 with no biomarker confirmation) for 1995 through 2004. The AMI incidence decreased 8%, from 483 (46,332 cases) to 445 cases/100,000 person-years (45,412 cases). Compliance with the ban was 93%. Had there been no local laws, the comprehensive state law would have been associated with a 19% decline in admissions. From 2002 to 2004, New York City smoking prevalence decreased from 21.5%

Table 1 Summary Results of Smoking Bans

Ban Location	Population Exposed to Ban	Post-Ban Observation Period (Yrs)	Pre-Ban Rate*	Post-Ban Rate*	Incidence Rate Change in Ban Area	Incidence Rate Change in Non-Ban Area
U.S.						
Helena	68,140	0.5	170	102	−40%	+46%
Pueblo	698,229	3.0	257	152	−41%	−5%
New York	18,976,457	1.0	483	445	−8%	None
Indiana	239,332	1.5	14	7	−50%	−20%
Ohio	29,636	3.0	277	223	−20%	−5%
Canada						
Saskatoon	202,340	1.0	176	152	−13%	None
Europe						
Piedmont	~4,300,000	0.5	200	204	+2%†	None
Rome	2,663,182	1.0	252	253	0%‡	None
Italy	7,033,451	0.2	159	149	−6%	None
Scotland§	~3,000,000	0.8	129	107	−17%	−4%

*Cases per 100,000 person-years. †The acute myocardial infarction incidence decreased 9.8% in those age <65 years and increased 6.2% in those age >65 years. ‡The acute myocardial infarction incidence decreased 11% in those age <65 years and decreased 8% in those age 75 to 84 years, particularly among men. §The end point was acute coronary syndrome.