

# Smoking Ban Significantly Reduces Acute Coronary Syndrome Admissions

Pell JP, Haw S, Cobbe S, et al. Smoke-free legislation and hospitalizations for acute coronary syndrome. *N Engl J Med* 2008;359:482–91.

## Study Overview

**Objective.** To prospectively compare the number of admissions for acute coronary syndrome (ACS) before and after implementation of legislation banning smoking in enclosed public places.

**Design.** Quasi-experimental observational study with prospective data collection.

**Setting and participants.** Data were prospectively collected on all patients admitted with ACS to 9 hospitals across Scotland 10 months before implementation of the indoor smoking ban (June 2005–March 2006) and 10 months after the ban (June 2006–March 2007). The hospitals accounted for 63% and 64% of ACS admissions in Scotland before and after the ban, respectively. Study research nurses obtained daily lists of patients who had troponin levels measured for acute chest pain admissions. After obtaining informed consent, nurses conducted structured interviews regarding smoking habits and exposure to secondhand smoke. 87% of patients gave consent in both study periods. Cotinine, a nicotine metabolite measure in serum, was measured in all patients with ACS to verify smoking status and assess exposure to environmental smoke in nonsmokers. To account for lifestyle or treatment changes, historical trends for ACS admissions in Scotland were obtained from the Scottish Morbidity Record 01 for 1995 to 2005. As a geographic control, admissions for ACS in England, which did not enact an indoor air smoking ban, were obtained for the same two 10-month periods.

**Main outcome measures.** Percentage change in the number of admissions for ACS (defined as detectable levels of cardiac troponin after an emergency admission for chest pain) before and after implementation of the smoking ban, overall and according to smoking status.

**Main results.** The number of ACS admissions decreased from 3235 before the smoking ban to 2684 after the smoking ban, a 17% reduction (95% confidence interval [CI], 16%–18%). During the same time period, a 4% decrease in ACS ad-

missions was seen in England. In the preceding 10 years in Scotland, the mean annual decrease in ACS admissions was 3% (maximum decrease, 9%). The number of patients in Scotland who died of ACS but were not hospitalized decreased by 6% over the study time period. ACS admissions decreased by 14% (95% CI, 12%–16%) in current smokers, 19% (95% CI, 17%–21%) in former smokers, and 21% (95% CI, 18%–24%) in never smokers. Overall, 67% of the decrease in admissions for ACS occurred among nonsmokers. The reductions in ACS admissions were greater in women as compared with men and in older patients as compared with younger patients regardless of smoking status. The proportion of former smokers who reported no exposure to secondhand smoke increased from 57% to 78% ( $P < 0.001$ ), with similarly significant changes seen among never smokers. These findings were supported by reductions in the geometric means of cotinine among former smokers (from 0.68 ng/mL to 0.56 ng/mL;  $P < 0.001$ ) and never smokers (from 0.71 ng/mL to 0.57 ng/mL;  $P < 0.001$ ). Smokers admitted for ACS showed no change in geometric mean cotinine level ( $P = 0.72$ ).

**Conclusion.** Admissions for ACS across a large part of Scotland decreased significantly after implementation of smoke-free indoor air laws. Most of the reduction was seen among nonsmokers, and the overall reduction could not be explained by temporal, geographic, or seasonal trends. Exposure to secondhand smoke among nonsmokers declined after the legislation by both self-reported and biochemically verified measures.

## Commentary

A growing body of literature strongly supports an association between indoor air smoking bans and quick reductions in ACS admissions. The first study that examined this relationship was performed in Helena, MT, and showed a 40% reduction in ACS admissions after introduction of a smoking ban as compared with a nonsignificant increase in a community without a smoking ban [1]. Although initial reactions to this finding were decidedly mixed given its single location and magnitude of reduction, further epidemiologic studies

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have supported these findings. A 39% reduction in ACS admissions was seen in Bowling Green, OH, after enactment of smoke-free legislation [2], while a 27% reduction was seen in Pueblo, CO, after a comparable smoking ban was enacted [3]. Similar results were seen across diverse communities in New York, Canada, and Italy, with a large study from Rome (population, 2.7 million) showing a 7.9% reduction in ACS events in patients aged 65 to 74 years and an 11.2% reduction in patients aged younger than 65 years after enactment of smoke-free legislation [4]. The epidemiologic literature is supported by biologic studies, which have linked plaque rupture and acute thrombosis to secondhand smoke inhalation by way of reversible endothelial damage, platelet activation, and decreased nitric oxide-mediated vasodilation seen in animals and humans exposed to secondhand smoke for as little as 30 minutes [5,6].

Although early studies provided strong initial evidence of an association between smoke-free legislation and a decreased incidence of ACS, they had significant limitations. They were all retrospective, limited to 1 community (small or large), and relied on clinic diagnostic labels as opposed to quantifiable metrics. Only 1 previous study examined differences among smokers and nonsmokers and, although a 71% reduction in ACS admissions among nonsmokers was reported, this study was limited by self-reporting bias and small sample size [7].

The purpose of the study by Pell et al was to discern in a prospective fashion whether smoke-free legislation reduces ACS admissions and to verify these findings through the use of laboratory-based definitions for ACS, measurements for smoking status (ie, cotinine level), and standardized follow-up across a large area of Scotland. The study found that the number of admissions for ACS decreased by 17% and that, notably, 67% of the decrease was found in nonsmokers. Cotinine measurements supported self-reported decreases in exposure to secondhand smoke. Smokers admitted for ACS had no change in geometric mean cotinine values.

This study had several strengths. Unlike previous studies, it was prospective and biochemically verified ACS and exposure to secondhand smoke to complement self-reported status and clinical labels. Of note, only 52% of patients in this study received a clinical diagnosis of acute myocardial infarction in the Scottish Morbidity Record; the remaining received more vague or uninformative codes for heart disease. Thus, this study probably gave a more accurate measure of ACS admissions than previous retrospective chart reviews. Furthermore, this study was a multicenter study conducted across 9 hospitals, accounting for 64% of ACS admissions in Scotland over that time period. Geographic, temporal, and seasonal controls were included, although they do not seem to explain the differences found. Finally, study research nurses collected detailed household, work-

place, and recreational exposure histories that added weight to the findings above.

A few limitations to this study deserve mention. Although it was a prospective study, it relied on a quasi-experimental design that cannot completely exclude confounding. It is also possible, although unlikely, that the other remaining 36% of hospitals in Scotland not included in this study would have produced different results. Finally, the case definition for ACS was based on troponin measurements in patients who had chest pain, but other non-ACS conditions can raise troponin in the setting of chest pain, including pericarditis, congestive heart failure, and pulmonary embolism. No electrocardiographic findings or cardiac catheterization data were used to confirm ACS admission and exclude these other causes. Thus, misclassification bias could have occurred in a proportion of patients, especially given the discrepancy between clinical diagnoses seen in the Scottish Morbidity Record. However, it is doubtful that misclassification bias could have accounted for the total reduction seen in this study.

### Applications for Clinical Practice

The introduction of smoke-free legislation across Scotland was associated with a statistically significant 17% reduction in ACS admissions starting immediately after implementation of the ban. Nonsmokers comprised two thirds of the reduction, and these findings were confirmed biochemically. The introduction of indoor smoking bans is strongly associated with decreased ACS admissions for both smokers and nonsmokers. The magnitude of this reduction on a population level is greater than that of most medications used to prevent ACS. This large reduction combined with its reproducibility across disparate locales should spur health professionals and lawmakers to advocate strongly for clean indoor air laws, especially considering that they have no adverse economic impact on bars and restaurants [8].

—Review by Asaf Bitton, MD

### References

1. Sargent RP, Shepard RM, Glantz SA. Reduced incidence of admissions for myocardial infarction associated with public smoking ban: before and after study. *BMJ* 2004;328:977-980.
2. Khuder SA, Milz S, Jordan T, et al. The impact of a smoking ban on hospital admissions for coronary heart disease. *Prev Med* 2007;45:3-8.
3. Bartecchi C, Alsever RN, Nevin-Woods C, et al. Reduction in the incidence of acute myocardial infarction associated with a citywide smoking ordinance. *Circulation* 2006;114:1490-6.
4. Cesaroni G, Forastiere F, Agabiti N, et al. Effect of Italian smoking ban on population rates of acute coronary events. *Circulation* 2008;117:1183-8.
5. Barnoya J, Glantz SA. Cardiovascular effects of secondhand smoke: nearly as large as smoking. *Circulation* 2005;111:2684-98.

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6. Heiss C, Amabile N, Lee AC, et al. Brief secondhand smoke exposure depresses endothelial progenitor cells activity and endothelial function: sustained vascular injury and blunted nitric oxide production. *J Am Coll Cardiol* 2008;51:1760-71.
7. Seo DC, Torabi MR. Reduced admissions for acute myocardial infarction associated with a public smoking ban: matched controlled study. *J Drug Educ* 2007;37:217-26.
8. Alamar B, Glantz SA. Effect of smoke-free laws on bar value and profits. *Am J Public Health* 2007;97:1400-2.

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