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Short-term effects of Italian smoking regulation on rates of hospital admission for acute myocardial infarction

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Aims We used the hospital discharge records of Piedmont region (northern Italy) to evaluate whether a national law banning smoking in public resulted in a short-term reduction in hospital admissions for acute myocardial infarction (AMI).

Methods and results Rates of admission for AMI before the ban (October–December 2004) and during the ban (February–June 2005) were analysed. Each period was compared with the corresponding period 12 months before. Among persons aged under 60, the number of admissions for AMI decreased significantly after the introduction of the ban: from 922 cases in February–June 2004 to 832 cases in February–June 2005 (sex- and age-adjusted rate ratio, 0.89; 95% confidence interval, 0.81–0.98). No decrease was seen before the ban. No effect was found among persons aged at least 60. We estimated that the observed reduction in active smoking after the introduction of the ban could account for a 0.7% decrease in admissions for AMI during the study period, suggesting that most of the observed effect (11%) might be due to the reduction of passive smoking.

Conclusion Our study, based on a population of about 4 million inhabitants, suggests that smoke-free policies may result in a short-term reduction in admissions for AMI.

Introduction

On 10 January 2005, the Italian Government banned smoking in all indoor public places, including cafés, bars, restaurants, and discos.[1] Similar bans on smoking in all indoor public places have been introduced within the past 2 years in other European countries, including Ireland, Malta, Norway, and Sweden.[2] In Italy, surveys revealed a decrease in the level of passive smoking as a direct effect of the ban.[3] There is evidence that this smoke-free policy might have resulted in a significant decline in cigarette consumption, especially among young persons and women, and achieved a decrease in the prevalence of active smokers.[4]

Smoking is a well-known cause of several diseases, including lung cancer and cardiovascular and respiratory diseases.[5] It is the leading cause of disease burden in industrialized countries and an emerging risk factor in developing countries.[6] In industrialized countries, 40% of cardiovascular diseases occurring among men and 13% of that occurring among women in the age group 30–69 years has been estimated to be attributable to smoking.[7]

The excess of risk for ischaemic heart disease for all ages associated with active smoking of 20 cigarettes per day is about 100%, whereas persons exposed to passive smoking have an excess risk of 30%.[8] Growing evidence indicates that both active and passive smoking increase cardiac risk through both chronic (atherosclerosis) and acute (platelet activation, endothelial dysfunction) pathways.[8–10] Laboratory findings indicate that even brief exposure to smoke can cause platelet aggregation and other haemodynamic changes responsible for the development of ischaemic heart disease.[8,10–12] Such acute effects are probably transient and disappear within a short time (hours to days) after cessation of the exposure.[13–16] Consistent with the laboratory findings, epidemiological studies found that there is a decrease in risk of ischaemic heart disease within some months after the cessation of exposure to active and passive smoking.[14,16,17]

With the general aim of evaluating the effect of the smoking ban on morbidity, we used the Hospital Discharge Registry of Piedmont, Italy, to study whether the ban resulted in a short-term reduction in hospital admissions for acute myocardial infarction (AMI).

Methods

Study population

Piedmont is an Italian region with a population of around 4 300 000 individuals. Records of hospital admissions in Piedmont between

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January 2001 and June 2005 with a primary discharge diagnosis code of AMI (ICD-9-CM code: 410[18]) and hospital deaths due to AMI were obtained from the regional Hospital Discharge Registry in the form of individual anonymous records, which included age, date of admission, and sex. Only patients residing in Piedmont were included in the study. Data of Piedmont residents admitted to hospitals in other Italian regions or abroad were not considered, as that information was not complete for the year 2005. Population figures by sex, 5-year age group, and calendar year were obtained from the National Statistical Office.[19]

Statistical analysis

We calculated age-standardized incidence rates of admissions for AMI using the European standard population.[20] Two periods of interest were defined: October–December 2004 (before the ban) and February–June 2005 (during the ban). Each period was compared with the corresponding period 12 months earlier in order to take into account seasonal changes in admissions for AMI. This implies that incidence rates in February–June 2005 were compared with the corresponding incidence rates in February–June 2004, whereas incidence rates for the period October–December 2004 were compared with the corresponding period October–December 2003. January 2005 was not analysed, as it was considered a transition period, in which the ban was increasingly affecting people's smoking habits and passive smoking.

We also analysed the rates of admission for AMI in the period February–June between 2001 and 2003 to evaluate whether a long-term trend was present.

As the attributable risk of myocardial infarction due to smoking is generally found higher at younger ages,[21] and the smoking habits and passive smoking of the younger people might have been more strongly affected by the new regulation,[4,22] we considered people aged under 60 and those aged at least 60 separately. All comparisons were conducted on the assumption of a Poisson distribution of the number of admissions.

We estimated the expected effect on AMI of the decrease in active smoking after the ban was introduced. Calculations were based on the following data: (i) observed reduction in smoking prevalence from 30 to 29.3% among men and from 22.5 to 22.1% among women,[4,23] (ii) observed reduction in the mean number of cigarette smoked per day from 16.7 to 16.3 among men and from 13.7 to 12.4[4,23] among women, (iii) relative risks of 3–4 for ischaemic heart disease associated with consumption of 20 cigarettes per day among persons under 60,[24] (iv) a linear dose–response relationship between cigarettes smoked (in the range between 5 and 20 cigarettes per day) and the logarithm of the relative risk for AMI (beta = 0.04 per cigarette/day),[24] and (v) an exponential decline in the relative risk for AMI over time after smoking cessation or reduction, as described by Lightwood and Glantz[17] and Hurley,[25] according to which, a relative risk of, say, 3 for an active smoker decreases to a relative risk of 2.6 5 months after smoking cessation (*Figure 1*).

Results

The observed number of admissions for AMI and the age-standardized rates observed during the ban (February–June 2005) and during the corresponding periods between 2001 and 2004 are reported in *Table 1*. Among men under 60, the rates increased over time until 2004 and decreased thereafter. Similarly, although the rates were stable over time among women under 60, the highest and the lowest rates were observed in 2004 and in 2005, respectively. Among men and women aged at least 60, the rates of admission for AMI increased over time, including in 2005.

The rate ratio (RR) for all ages for the ban period (February–June 2005) compared with the period February–June 2004 was 1.01 [95% confidence interval (95% CI): 0.97–1.06]. Age-specific RRs for both sexes are reported in *Table 2*. Among people under 60, the RR of AMI for the ban period (February–June 2005) compared with the period February–June 2004 was 0.89 (95% CI: 0.81–0.98). The rates of admissions decreased for both men (RR: 0.91; 95% CI: 0.82–1.01) and women (RR: 0.75; 95% CI: 0.58–0.96). Notably, no decrease was seen before the ban (comparison of October–December 2004 with October–December 2003). When we analysed people aged 60 or more, no decrease in the admissions for AMI was

$$\text{Decrease}(\%) = \left[1 - \frac{(1-\text{Prev}_{\text{pre}})(I_{\text{b}}) + (\text{Prev}_{\text{pre}} - \text{Prev}_{\text{ban}})(\text{RR}_{\text{ex}})(I_{\text{b}}) + (\text{Prev}_{\text{ban}})(\text{RR}_{\text{ban}})(I_{\text{b}})}{(1-\text{Prev}_{\text{pre}})(I_{\text{b}}) + (\text{Prev}_{\text{pre}})(\text{RR}_{\text{pre}})(I_{\text{b}})}\right] * 100$$

Where

I_b, the rate of admission for myocardial infarction among non-smokers (background incidence);

Prev_{ban}, the prevalence of active smokers during the ban;

RR_{ban}, the relative risk of myocardial infarction associated with average number of cigarettes smoked per day during the ban, assuming a linear dose-response relation and a RR of 4 associated with smoking 20 cigarettes per day;[24]

RR_{ex}, the relative risk of myocardial infarction asociated with ex-smokers 5 months after smoking cessation, assuming an exponential decline in the RR after smoking cessation;[17,25]

Prev_{pre}, the prevalence of active smokers before the ban;

RR_{pre}, the relative risk of myocardial infarction associated with average number of cigarettes smoked per day before the ban, assuming a linear dose-response relation and a RR of 4 associated with smoking 20 cigarettes per day;[24]

Figure 1 Estimate of decrease (%) in the rate of admission for AMI attributable to the effect of the ban on the smoking habits of active smokers.

Table 1 Numbers of admissions for AMI and age-standardized rates (cases/1000 person-years) by year and age group (Piedmont, Italy, 2001–2005)

Age (years)	Sex	February–June 2001		February–June 2002		February–June 2003		February–June 2004		February–June 2005	
		Number of cases	Rate[a]	Number of cases	Rate[a]	Number of cases	Rate[a]	Number of cases	Rate[a]	Number of cases	Rate[a]
<60	Male	674	1.21	691	1.25	737	1.31	779	1.35	724	1.24
	Female	122	0.22	125	0.22	110	0.19	143	0.24	108	0.19
≥60	Male	1456	6.86	1429	6.63	1563	7.16	1559	6.97	1645	7.21
	Female	962	2.90	985	2.85	1063	3.02	1100	3.11	1178	3.19

[a]Age-standardized according to the European Standard Population.[20]

Table 2 RRs and 95% CI for AMI, by sex, age group and period (Piedmont, Italy)

Age	Sex	Before ban (October–December 2004 vs. October–December 2003) RR (95% CI)[a]	During ban (February–June 2005 vs. February–June 2004) RR (95% CI)[a]
<60 years	Men	1.08 (0.95–1.23)	0.91 (0.82–1.01)
	Women	0.88 (0.64–1.20)	0.75 (0.58–0.96)
	Both sexes	1.06 (0.93–1.19)	0.89 (0.81–0.98)
≥60 years	Men	1.05 (0.96–1.14)	1.03 (0.96–1.11)
	Women	1.02 (0.92–1.13)	1.05 (0.97–1.14)
	Both sexes	1.05 (0.98–1.12)	1.05 (1.00–1.11)
Comparison	Men	$P = 0.73$	$P = 0.04$
(<60 years vs. ≥60 years[b])	Women	$P = 0.37$	$P = 0.01$
	Both sexes	$P = 0.89$	$P = 0.003$

[a]RR adjusted for age (5-year age groups).
[b]χ^2 test for homogeneity.[32]

observed, neither in the period before the ban nor during the ban.

Table 2 also shows the results of the test for homogeneity between estimated RRs among persons under 60 and among those aged 60 or more. The RRs were homogeneous before the ban, whereas they diverged during the ban ($P = 0.003$; $P = 0.04$ for men and $P = 0.01$ for women), suggesting that the ban modified admission rates for AMI only among people under 60.

Using the formula shown in *Figure 1*, we estimated that the observed reduction in active smoking after the introduction of the ban could account for a 0.7% reduction (0.6% among men, 0.9% among women) in admissions for AMI during the study period.

Discussion

We found a significant drop in admissions for AMI among both men and women under 60. No such decrease was evident in the months before the ban. Moreover, rates of AMI, if anything, increased between 2001 and 2004, suggesting that the reduction that we observed is not attributable to long-term trends. Indeed, as there was evidence that AMI was increasing over time, it is possible that our estimate of an 11% decrease after the introduction of the ban underestimates the real effect of the ban.

Several pieces of evidence suggest that the ban introduced in Italy at the beginning of 2005 actually reduced exposure to active and passive smoking. First, the new smoking legislation is almost universally observed in Italy, with fewer than 100 (1.5%) violations in about 6000 checks by the police.[4] Secondly, a survey carried out in randomly selected pubs and discos before and after the smoking ban found reductions of 90–95% in nicotine vapour phase concentration.[3] Thirdly, official data revealed a decline in legal cigarette sales of 8.9% in 2005.[4] Finally, surveys conducted before and after the ban showed a 7.6% reduction in consumption of cigarettes, owing to both a decrease in smoking prevalence and a reduction in the mean number of cigarette smoked per day.[4,23] The latter figure should, nevertheless, be interpreted cautiously, as the prevalence of current smokers and the mean number of cigarettes smoked were already decreasing during the first few years of 2000. This detracts somewhat from an interpretation of a direct effect of the ban on the smoking habits of active smokers.

Although the ban was national and therefore no control group was available, we compared younger with older people and analysed data for the 3 months before the ban was introduced. These analyses support the hypothesis that the ban resulted in a decrease in admissions for myocardial infarction. First, we found that the decrease in admission rates was limited to persons under 60, consistent with a greater effect of the ban on the habits of younger persons[4] and with a lower attributable risk of myocardial infarction for smoking among older persons.[24] Secondly, the age-specific RRs were similar before the ban and began to differ significantly only after the ban was introduced. Finally, we found no decrease in admissions for AMI before the ban.

As this was an ecological study, it is possible that unmeasured confounders were responsible for the observed effects. Nevertheless, it is hard to conceive of a factor that could change the rates of admission of persons of each sex only among those under 60 and only after January 2005. For example, an important potential confounder such as temperature affects mainly the elders.[26]

Although a fraction of patients with AMI die before they reach hospital,[27] it is unlikely, however, that the proportion of deaths outside hospital increased during 2005 in such a way as to bias our observed incidence rates downwards.

Recommendations from the European Society of Cardiology and the American College of Cardiology released in 2000 changed the diagnostic criteria for AMI,[28] probably resulting in an increase in the annual number of patients in whom AMI is diagnosed.[29] Although that change might explain our finding of an increasing trend in rates of admission for AMI between 2001 and 2004, it cannot be responsible for the decline observed in 2005.

The effect of a smoking ban on AMI was investigated before in a small population in the USA in 2004.[30] A drop in hospital admissions for AMI in a community in Montana was observed after the introduction of a local law banning smoking in public and in the workplace. The ban was abrogated after 6 months, and this was followed by an increase in admissions for AMI. Fitchtenberg and Glantz[31] compared the observed and the expected trends in incidence after a tax on cigarettes was introduced in 1988 within the framework of the California Tobacco Control Program.[31] Consistent with our findings, they found that mortality for heart diseases started to decrease in the first year after the introduction of the programme.[31]

The direct effect of a smoking ban is to decrease passive smoking. However, some of the reduction in admissions for AMI observed in our study can also be due to changes in the smoking habits of the active smokers. Consistent with our estimate of a 0.7% decrease in AMI, simulations of the effect of a 1% absolute reduction in prevalence of active smokers in Australia and the USA predicted a decrease of less than 1% in rates during the first year.[17,25] Overall, these estimates indicate that changes in the habit of active smokers can explain only a limited proportion of the effects of the Italian ban and that, out of the 11% observed reduction in the admissions for AMI, up to 10% might be due to the reduction in passive smoking. However, as the decrease in the relative risk of AMI has been estimated to reach a plateau only 5–7 years after smoking cessation,[17] the possible effects mediated by changes in active smoking are expected to increase over the next years.

Conclusions

Since January 2005, when the Italian Government banned smoking in all indoor public places, hospital admissions for AMI decreased among men and women under 60 residing in the Piedmont region, northern Italy. Despite the limitations inherent to ecological studies, our findings suggest that smoking regulations may have important short-term effects on health. The long-term effects of the Italian ban on respiratory and cardiovascular diseases and cancer will have to be evaluated in the years to come.

Conflict of interest: none declared.

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