European Journal of Public Health, Vol. 25, No. 2, 195–199

doi:10.1093/eurpub/cku067 Advance Access published on 3 June 2014

Reduction of ST-elevation myocardial infarction in Canton Ticino (Switzerland) after smoking bans in enclosed public places—No Smoke Pub Study

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Background: Second-hand smoke increases the risk of acute myocardial infarction. Canton Ticino (CT) first introduced a smoking ban in public places in 2007. This offered the opportunity to assess the long-term impact of a smoking ban on the incidence of ST-elevation myocardial infarctions (STEMI) compared with a population where the law was not yet implemented. **Methods:** We assessed the incidence of STEMI hospitalizations per 100 000 inhabitants both during 3 years before and after the ban application in CT and in Canton Basel City (CBC), where this law was not yet applied. Data were obtained from the codified hospital registry (ICD-10 codes). **Results:** In CT, the mean incidence of STEMI admissions during the 3 pre-ban years (123.7) was significantly higher than the incidence of admissions in each of the 3 post-ban years (92.9, 101.6 and 89.6 respectively; P <.024). Analysing population subsets, a post-ban reduction was observed among ≥65-year-old people of both sexes in each of the 3 post-ban years and in the <65-year age group during the first post-ban year ($P = 0.02$). Conversely, the mean incidence of STEMI hospitalizations in CBC (92.4) didn't change significantly in each of the 3 post-ban years (83.9, 83.3 and 79.5, P = NS) during the same period. However, a significant long-term reduction in STEMI admissions was observed in CBC among the male group with ≥65 years ($P < 0.01$). **Conclusion:** Our work suggests a significant impact of the smoke-free policy on the number of annual STEMI. Specific population subsets (i.e. ≥65-year-old females) were particularly affected by the smoking ban, showing a significant reduction in STEMI hospitalizations.

Introduction

Second-hand smoke (SHS) increases the risk of coronary artery disease (CAD) and acute myocardial infarction (AMI).[1–3] Both platelet activation and acute haemodynamic response to smoke exposure may increase the risk of AMI in relation to SHS. Such acute effects are probably transient and disappear within a short time after cessation of exposure.[4] Epidemiological studies suggest a decrease in the risk of AMI within months after the cessation of exposure to active and passive smoking.[5,6] For these reasons, public health efforts aimed at reducing tobacco consumption may have a significant impact in the worldwide prevention of AMI.[1] Canton Ticino (CT) is one of the 26 Cantons of the Swiss Federation, representing a well-defined political area with its own public health care system. CT was the first Swiss canton to introduce a smoking ban in April 2007, which prohibited tobacco consumption in all public places, including public administrative buildings and offices, cafés, bars, restaurants and discos. Because Switzerland has a federal political system, smoking bans were enforced later in other cantons, presenting a unique opportunity to compare the epidemiology of AMI in two cantons with similar health care systems but different legislation concerning the smoking ban. Therefore, the aim of our study was twofold: (i) to compare the incidence of hospitalization due to ST-elevation myocardial infarction (STEMI) in CT before and after the smoking ban enforcement and (ii) to compare the contemporary incidence of STEMI in CT where the smoking ban had not yet been implemented.

Methods

Location and demographic data

This retrospective observational study was conducted in two Swiss Cantons, Ticino and Basel City. The Ethics Committee of both Cantons approved the study protocol and the Swiss Federal Statistical Office provided demographic data on the two populations during the observational period (April 2004 to March 2010).

CT is located in southern Switzerland and represents a well-defined geographical and political area with its own health care system and with a population of ∼330 000 individuals, during the observational period. In CT, there are four public hospitals and one single institution (Cardiocentro Ticino, CCT) that perform coronary interventions. CT was the first Swiss Canton to enforce a smoking ban, on 12 April 2007, which prohibited smoking in all public places. Since 1 May 2009, in CT cigarette advertising too has been prohibited from all public places (posters, public advertising). No public legislation has been approved in order to prevent cigarette selling to young people. Such policy will probably be implemented on 1 June 2013.

Canton Basel City (CBC) is located in northern Switzerland and had a population of ∼192 000 individuals during the observational

period. CBC has only one public hospital that performs coronary interventions and cares for patients with AMI. Similar to CT, the national border delimited CBC but in contrast to CT, there is no major geographical barrier towards the nearby Cantons. In CBC, the smoking ban law was not enforced until April 2010. However, since 1 January 2005, cigarette advertising has been prohibited in CBC from all public places (posters, public advertising). Moreover, cigarette selling to young people (<16 years) has been prohibited since 1 August 2007 and forbidden for minors (<18 years) since 1 January 2009, as well as cigarette distribution from vending machines.

Study population

In CT, the period of interest included the 3 years before (from April 2004 to March 2007) and the 3 years after the smoking ban (from April 2007 to March 2010). Each year was computed from the 12th of April to the 11th of the following April and did not correspond to the calendar year. In CBC, data were available only for 2 years before the smoking ban in CT (from April 2005 to March 2007) and for the 3 years after the smoking ban (from April 2007 to March 2010). We retrospectively collected data of all patients discharged for STEMI (survivors and non-survivors) in CT and CBC during the observed period. Records were acquired from the codified hospital discharge registry (ICD-10 codes: I21.0, I21.1, I21.2 and I21.3) in the form of anonymized data concerning date of hospitalization, age and sex. For our analysis, we considered only the resident patients of CT and CBC.

Statistical methods

We tested the hypothesis that the enforcement of the smoking ban in CT was associated with changes in the annual number of admissions for STEMI during a 3-year period when the law was in effect. We compared the number of admissions during the 3 years when the law was in effect (2007–08, 2008–09 and 2009–10) with the average number of admissions during the same period in the years before (2004–05, 2005–06 and 2006–07). Incidence of admissions due to STEMI was calculated both in absolute numbers and per 100 000 inhabitants. Subgroups by age (<65 and ≥65 years) and gender were also considered. All calculations were performed on incidence of STEMI per 100 000 inhabitants for both CT and CBC, to correct the potential migrant effect played by the varying population over time. All comparisons were conducted on the assumption of a Poisson distribution of the number of admissions. Incidence per 100 000 inhabitants during the 3 years before and after the ban in CT was compared between the two Cantons. Comparability of patients hospitalized for STEMI in the two Cantons according to sex and age was verified using χ^2 and Student's t-tests for independent samples. The significance level was set to $\alpha = 0.05$, two-sided. Descriptive statistics of continuous variables are shown as mean ± standard deviation. Statistical analysis was performed with SPSS version 19 and SAS version 8.

Results

Canton Ticino

We identified a total of 1733 residents (70% men, mean age 67.4 ± 14 years) in CT discharged with the ICD-10 diagnosis of STEMI during the entire observational period (April 2004–March 2010). Absolute number of STEMI hospitalizations and patients' characteristics are outlined in table 1. The mean number of annual STEMI admissions during the 3 years before the smoking ban (323) was significantly higher than the number of admissions in each of the 3 years after the smoking ban (247, 274 and 244 respectively; $P = 0.002$, $P = 0.024$ and $P = 0.001$). The overall annual incidence of hospitalizations because of STEMI was 122.8, 134.9 and 114.2 per 100 000 inhabitants during the 3 years before the implementation of the smoking ban in public places. During the 3 years following the enforcement of the new legislation, the incidence of hospitalization due to STEMI significantly decreased to 92.9, 101.6 and 89.6 ($P = 0.02$, $P = 0.024$ and $P = 0.001$) respectively. This corresponds to an estimated STEMI reduction of 23.5% (95% CI: −6.5% to −37.4%), 15.1% (95% CI: −2.4% to −26.10%) and 24.1% (95%°CI: −7.5% to −38.2%) during the first, second and third year after the introduction of the ban, respectively, compared with the mean pre-ban 3-year period (Supplement figure 1).

Moreover, analysing population subsets, a significant reduction of annual STEMI incidence was observed after the enforcement of the smoking ban among ≥65-year-old people of both sexes within each year after the ban. In particular, among ≥65-year-old women, the number of STEMI decreased by 26.6, 22.8 and 32.9% during the first, second and third year after the introduction of the ban. Similarly, ≥65-year-old men showed 21.4, 23.9 and 36.8% reduction during the same years.

Considering <65-year-old people, the mean incidence of annual STEMI admissions during the 3 pre-ban years significantly decreased among men in the first year after the ban enforcement (109.0 vs. 85.3, $P = 0.01$). Also among <65-year-old female patients, a decrease close to significance was observed in the first year after the ban enforcement (19.5 vs. 12.8, $P = 0.066$ NS). No significant decrease was observed in the second and third year among men or women. figure 1.

Table 1 Canton Ticino: admissions for STEMI during the 3 years period before and the 3 years period after the ban

All population		Before the official ban				After the official ban			*P*-value[a] vs. mean before ban		
		2004–05	2005–06	2006–07	Mean before Ban	2007–08	2008–09	2009–10	2007–08	2008–09	2009–10
N		316	352	300	323	247	274	244			
Incidence 100 000 inhabitants		122.8	134.9	114.2	123.7	92.9	101.6	89.6	$P = 0.002$	$P = 0.024$	$P = 0.001$
Age	**Sex**	**Incidence per 100 000 inhabitants[b]**									
<65 years	Male	106.1	122.1	102.2	109.0	85.3	102.5	101.6	$P = 0.010$	$P = 0.270$	$P = 0.270$
	Female	22.8	15.8	19.7	19.5	12.8	21.5	14.6	$P = 0.066$	$P = 0.072$	$P = 0.105$
	Both sexes	63.7	68.0	60.2	63.9	48.4	61.4	57.5	$P = 0.023$	$P = 0.389$	$P = 0.214$
≥65 years	Male	418.2	555.9	418.3	464.1	340.3	318.4	256.4	$P = 0.000$	$P = 0.000$	$P = 0.000$
	Female	242.0	207.7	187.3	212.3	149.9	154.3	131.4	$P = 0.000$	$P = 0.000$	$P = 0.000$
	Both sexes	322.6	358.1	287.7	322.8	225.2	218.2	179.2	$P = 0.000$	$P = 0.000$	$P = 0.000$

a: Assuming Poisson distribution of data.
b: Incidence per 100 000 inhabitants for the total admissions and per 100 000 inhabitants by age class and sex for the subgroups.

Demographic data concerning the population of CT during the observation period are outlined in Supplementary table S1. The population slightly increased (from 319 931 to 335 720 inhabitants) during the period of interest as well as the proportion of people aged ≥65 years (from 18.6 to 20.2%). Such population aging over time potentially accounted for a slight increase in the 'expected' incidence of STEMI over time in CT. However, because the 'observed' incidence of STEMI decreased, we could indirectly exclude a significant effect of population aging over time.

Canton Basel City

A total of 672 residents discharged with a diagnosis of STEMI from the University Hospital in CBC (mean age 68.4 ± 14.4 years, 64.7% men) were included in the present study. Absolute number of STEMI hospitalizations and patient's characteristics are outlined in table 2. In this Canton, where the smoking ban had not yet been implemented, no significant change was observed in the number of annual STEMI, comparing the years before and after the implementation of the smoking ban in CT. In particular, from April 2007, when the smoking ban was enforced in CT, the annual incidence of STEMI per 100 000 inhabitants for the 3-year period was 83.9, 83.3 and 79.5, reflecting a non-significant reduction compared to the mean value of the pre-ban years (92.4) ($P = 0.219$, $P = 0.189$, $P = 0.114$ NS) (Supplementary figure S2). However, when analysing subgroups by gender and age, ≥65-year-old males showed a significant decrease in the incidence of STEMI admissions in each of the 3 years after the smoking ban (223.6, 234.4 and 199.8; $P < 0.01$, $P < 0.01$ and $P < 0.01$) compared with the mean value of the pre-ban years (362.4) (figure 2).

Demographic data concerning the population of CBC during the observation period are outlined in Supplementary table S1. The population slightly increased (from 186 753 to 187 898 inhabitants) during the period of interest, while the proportion of people aged ≥65 years remained unchanged (from 20.7 to 20.2%).

Using a Poisson regression model, we also compared the incidence of STEMI in CT and CBC, before the introduction of the smoking ban in CT and afterwards. The STEMI incidence was significantly lower in CBC both before (−23.6%, $P = 0.009$, 95% CI: −37.6 to −6.4%), and after (−23.0%, $P = 0.041$, 95% CI: −40.0 to −1.0%).

Discussion

The present study provides demonstration for a significant and long-lasting reduction in the incidence of STEMI admissions among the overall population of CT after the enforcement of a smoking ban in public places. We observed a 21.1% mean reduction in the incidence of STEMI hospitalizations, which is in line with the results of prior reports showing a comparable reduction of acute coronary events after the introduction of similar smoke-free legislations.[7–13] In particular, as we can appreciate from the longer observation period of our study, the decrease in acute coronary events seems not to be a merely transient phenomenon. Benefits were present on

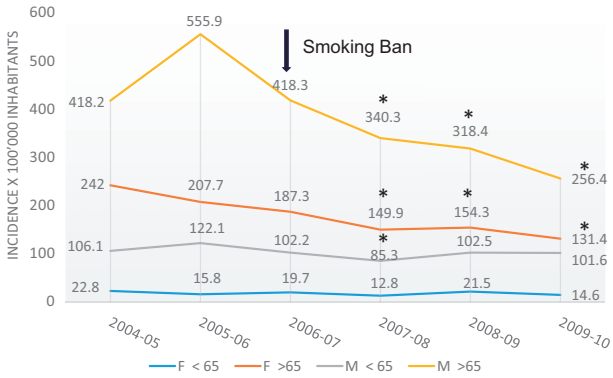

Figure 1 Incidence of STEMI hospitalization per 100 000 inhabitants in Canton Ticino, by age class and sex
*Significant changes comparing mean incidence before ban with each subsequent year, assuming Poisson distribution

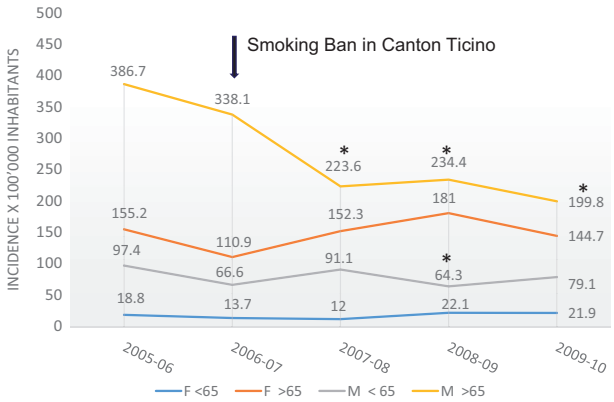

Figure 2 Incidence of STEMI hospitalization per 100 000 inhabitants in Canton Basel City, by age class and sex
*Significant changes comparing mean incidence before ban in CT with each subsequent year, assuming Poisson distribution

Table 2 Canton Basel City. Admissions for STEMI during the 2 years period before and the 3 years period after the ban in CT

All population		Before the official ban in Ticino				After the official ban in Ticino			*P*-value[a] vs. mean before ban		
		2004–05	2005–06	2006–07	Mean before Ban	2007–08	2008–09	2009–10	2007–08	2008–09	2009–10
N			163	124	144	130	130	125			
Incidence 100 000 inhabitants			104.8	80.0	92.4	83.9	83.3	79.5	$P = 0.219$	$P = 0.189$	$P = 0.114$
Age	**Sex**	**Incidence per 100 000 inhabitants[b]**									
<65 years	Male	97.4	66.6	82.0	91.1	64.3	79.1	$P = 0.853$	$p = 0.023$	$P = 0.398$	
	Female	18.8	13.7	16.2	12.0	22.1	21.9	$P = 0.193$	$P = 0.942$	$P = 0.942$	
	Both sexes	57.7	39.8	48.7	51.1	43.0	48.5	$P = 0.663$	$P = 0.231$	$P = 0.498$	
≥65 years	Male	386.7	338.1	362.4	223.6	234.4	199.8	$P = 0.000$	$P = 0.000$	$P = 0.000$	
	Female	155.2	110.9	133.1	152.3	181.0	144.7	$P = 0.952$	$P = 0.999$	$P = 0.894$	
	Both sexes	243.2	197.8	220.5	179.8	201.7	156.1	$P = 0.003$	$P = 0.10$	$P = 0.000$	

a: Assuming Poisson distribution of data.
b: Incidence per 100 000 inhabitants for the total admissions and per 100 000 inhabitants by age class and sex for the subgroups.

the whole population even 3 years after the introduction of the smoking ban. Multiple mechanisms related to nicotine consumption—such as platelet activation, endothelial dysfunction, arterial stiffness, oxidative stress, decreased antioxidant defence, vascular inflammation and reduction of the parasympathetic tone—provide biological plausibility for the observed reduction of STEMI after the enforcement of the smoke-free legislation.[4]

However, the analysis of age- and sex-standardized data allowed us to better understand the internal dynamics of such change in STEMI hospitalizations, keeping in mind the intrinsic limitations of sub-analysis associated with relatively small sample size. During the post-ban period, a significant and long-lasting reduction of STEMI admissions was observed only among ≥65-year-old people of both sexes. On the other hand, younger people (i.e. <65 years) showed a reduction (statistically significant in men, with a trend toward significance in women) in STEMI admissions only in the first year, with no significant decrease in the second and third year after the ban enforcement. According to the recent work of Giovino et al.,[14] the mean current smoking prevalence in ≥65-year-old people calculated over 16 different countries of the world is about 16.8%, much lower than in younger people. Data from the University of Zurich[15] concerning the smoking habit of the Swiss population from 2001 till 2010 suggest a decreasing prevalence of active smokers with increasing age. Therefore, passive smoking plays the most important role in such class of age, characterized by a greater time of exposure to free-smoking attempts too. Thus, it is not surprising that the persisting decrease of passive smoking caused by the free-smoke legislation is associated with a long-term reduction in the number of STEMI admissions among people aged ≥65 years of age.

Another point is represented by the comparison of data between CT and CBC where the smoking ban had not yet been introduced. CT was the first Canton of Switzerland to introduce the smoking ban in public places, followed by Canton Graubünden, where an overall 22% reduction in the rate of acute myocardial infarction was observed within the first and second years after enactment of the public smoking ban.[16,17] Bonetti et al[16] observed a reduction of STEMI (17%) similar to our results one year after the introduction of a smoking ban in Canton Graubünden.[16] In CBC, no significant change was appreciated among the whole population in the number of annual STEMI, comparing the years before and after the implementation of the smoking ban in CT. However, analysing age- and sex-standardized values, ≥65-year-old male patients showed a significant long-term decrease in the number of STEMI admissions in each of the 3 years after the smoking ban. This result seems to suggest that the significant STEMI reduction among ≥65-year-old males (appreciated in CT as well as in CBC where the ban was not yet implemented) may be mostly explained by ban-independent reasons such as smoking habit changes of male smokers. Several studies performed in different countries[18–20] demonstrated a higher proportion of former smokers among males aged ≥65 years probably due to a higher health awareness and to a greater perception of vulnerability, especially after having been attempted by smoking-related health problems. The improvement of primary and secondary cardiovascular prevention during the observational period and a more aggressive attitude towards both prevention and treatment of the greatest subset (≥65-year-old males) of STEMI population[21–23] may represent further explanations.

Conversely, STEMI reduction among ≥65-year-old females seems to represent a direct result of the smoking ban enforcement, as demonstrated by the absence of effect in CBC. In other words, although a similar post-ban mean STEMI reduction (25.6% among women and 22.3% among men, in CT), only among ≥65-year-old females, STEMI decrease seems to reflect a ban introduction-related effect. Our result totally agrees with several studies[24,25] demonstrating a greater impact of second-hand smoke and consequently of smoke-free policies among women. Such result may be probably explained by several reasons. As suggested by Oeberg et al.,[25,26] the number of non-smoker women exceeds by the 60% that of non-smoker males, identifying a greater population susceptible, by definition, to second-hand smoke exposure and smoke-free interventions as well. Pell et al.[24] also demonstrated a lower post-ban exposure to second-hand smoke among non-smoker women, showing lower cotinine concentrations after smoking ban enforcement. Moreover women, who probably share a greater relative risk associated with smoking, show a sharper dose-response as well.[24,27] Through its pro-thrombotic effects, smoking may contribute to thrombus formation on eroded plaques and such event has been demonstrated to be particularly common in women's acute coronary syndromes.[24,28]

Finally, comparing the annual STEMI incidences between CT and CBC, the latter showed significantly lower values both before and after the ban enforcement. This finding remains unexplained. It seems very unlikely that relevant differences in primary and secondary prevention or in acute treatment of STEMI may be responsible for such differences.

A particular clarification should be mentioned for patient selection. In contrast to previous studies reporting the incidence of acute coronary syndrome or non-specified myocardial infarction,[7–13,17–18] we specifically considered only the diagnosis of STEMI whose identification is based on an indisputable persistent ST-segment elevation at the ECG. Conversely, the diagnosis of NSTEMI is based on ECG changes and cardiac biomarker elevations (i.e., the serum troponin level above a normal threshold). This makes uncertain the reported ICD-10 code diagnosis of NSTEMI during observational studies, especially when this diagnosis is based on different thresholds of cardiac biomarkers, as occurred during the observational period in our study. In fact, in the 3 years after the introduction of the smoking ban, we observed a notable increase in NSTEMI hospitalizations (mean +110%). However, during the observational period, the troponin T threshold was reduced on two occasions and, in 2007, troponin T was replaced by troponin I. This course of non-ST-elevation myocardial infarction mirrors the data published by Yeh et al.[29] In particular, the increased incidence of NSTEMI closely reflects the increase in troponin testing and demonstrates how changing a biomarker or its threshold affects the rate of NSTEMI diagnosis.[29]

Study limitations

Our study presented several limitations. First, the current study was conceived on an ICD code-based design that did not allow the assessment for further patient information (besides age, sex and date of admission) such as smoking habits, cardiovascular risk factors, socio-economic status and other prevention and treatment strategies. Moreover, the limited sample size prevented a multivariate analysis taking into account other potential confounders or causes of the observed decline in STEMI events. For this reason, we could not control data for air pollution, infection disease epidemics or holidays, which are well-known factors associated with the development of acute cardiovascular events. Furthermore, the statistical approach (based on the assumption of a Poisson distribution of the number of admissions) does not consider the secular trend of decreasing hospitalizations over time. However, the limited number of STEMI observations and the short span of time preceding and following the smoking ban prevented a more complex statistical approach to account for the analysis of secular trend. Finally, out-of-hospital deaths due to presumptive STEMI were not considered in this study.

Conclusions

Our work represents one of the few studies that investigate the long-term change in the annual number of STEMI admissions after the enforcement of a smoking ban in public places. We demonstrated a long-term post-ban reduction in the incidence of STEMI admissions among the overall population of CT.

Supplementary data

Supplementary data are available at *EURPUB* online.

Funding

This study was sponsored by a grant from the Swiss Heart Foundation and a grant from Advisory Board of scientific research EOC (ABREOC).

Conflicts of interest: None declared.

Key points

- Our work represents one of the few studies that investigate the long-term change in the annual number of admissions due to ST-segment elevation myocardial infarction after the enforcement of a smoking ban in public places.
- A major point of the study is represented by the comparison of data between two cantons of Switzerland, Canton Ticino and Canton Basel City where the smoking ban had not yet been introduced.
- Our study corroborates the results of previous studies showing a reduction of acute coronary syndromes after the introduction of smoking ban in public places and underlines the public health implications of smoking bans.
- The results of the current study seem to confirm that smoke-free policies may offer a simple and inexpensive intervention for the prevention of cardiovascular diseases and should be included in prevention programs worldwide.

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