SCIENTIFIC REPORT

Impact of the indoor smoking ban on hospital admissions due to acute myocardial infarction

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Executive summary

Background: Passive smoking is a human health risk and is responsible for certain types of cancer, respiratory diseases and cardiovascular illnesses. Among these, of particular importance is the increase in acute myocardial infarction (AMI). Recent research has shown a decline in hospital admissions for AMI following introduction of a ban on smoking in indoor spaces. In March 2006, Uruguay became the first smoke-free country in the Americas. The present study assesses the health impact of that measure on hospital admissions for AMI; it represents the second study of this kind to be conducted for any entire country, and the first in a developing country.

Methods: We compared the number of hospital admissions for AMI in the 24 months preceding and following 1 March 2006. All patients with an exit diagnosis of Code 121 of the International Classification of Diseases, Revision 10 (ICD-10) were considered as AMI cases. We reviewed a random sample of 10% of patients admitted in each hospital to verify whether the AMI diagnosis was correct, reviewing all clinical case histories if improper diagnoses exceeded 2%. We performed an interrupted time series analysis, adjusting for sex and age, comparing admissions in the same months of each year. The protocol was approved by the Ethics Committee of the Faculty of Medicine, Universidad de la Republica, Uruguay, and the Roswell Park Cancer Institute in the USA.

Results. The study covered all AMI admissions in 37 hospitals, accounting for 79.3% of AMI admissions in Uruguay. During the period studied, 7947 patients were admitted, revealing a decline of 17.1% following the ban on smoking in indoor public spaces; the reduction among patients admitted to private institutions (22.0%) was greater than that for public institutions (6.3%). The reduction was greatest among young people: 38.5% among persons under 45 years, 14.8% between 45 and 64 years, and 16.8% in the over-65 age group. The reduction for men was 17.9% and for women 15.5%. The final statistical analysis is currently being performed at the Roswell Park Cancer Institute.

Conclusions. The ban on smoking in indoor public spaces led to a reduction of 17.1% in admissions for AMI after two years, with the greatest reduction occurring among younger persons admitted to private institutions.

Background

Passive smoking is a human health risk, causing cardiovascular disease, respiratory illnesses and certain types of cancer. Observational epidemiological studies have shown that exposure to secondhand tobacco smoke increases the risk of myocardial infarction (AMI) among non-smokers by around 30%.[1] The physio- pathological mechanisms associated with exposure to tobacco smoke and cardiovascular damage include both long-term effects (arteriosclerosis) and short-term ones, involving greater plaque activation, endothelial dysfunction, oxidative stress, inflammation, alteration of the lipid profile, alterations in the sympathetic nervous system, and reduced heart rate variability and exercise tolerance.[2] Secondhand smoke is a complex mixture of gases and particles originating at the burning tip of the cigarette and from the main current of exhaled smoke. The particles emitted in the combustion have a size ranging from fine to ultrafine (0.02 to 2 μ) and when inhaled can reach the depths of the lungs, with adverse effects on health[3]. Various studies have shown that the concentration of particulates greater than 2.5 μ ($PM_{2,5}$) is greater in places where smoking is allowed than in places where there is no smoking.[4]

Research in the United States, Italy, Ireland and Canada has shown a 19% reduction in admissions for AMI shortly after a ban on smoking in indoor spaces was introduced (table 1).[5]

Table 1. Meta-analysis of studies assessing the impact of smoking bans on the incidence of acute myocardial infarction.

Study	***OR (IC 95%)***	***Weighting (%)***
Helena, USA	0.60 (0.21 to 0.99)	1.76
Pueblo, USA	0.73 (0.63 to 0.85)	10.13
Piamonte, Italy	0.89 (0.81 to 0.98)	12.14
Bowling Green, USA	0.61 (0.55 to 0.67)	14.24
New York, USA	0.80 (0.80 to 0.80)	17.20
Ireland	0.89 (0.81 to 0.97)	12.56
Saskatoon, Canada	0.87 (0.84 to 0.90)	16.35
Rome, Italy	0.89 (0.85 to 0.93)	15.61

All	0.81 (0.76 to 0.86)	100.0

A recent study in Scotland showed that such a reduction occurs among smokers and non-smokers alike.[6]

On 1 March 2006, Uruguay became the first smoke-free country in the Americas when it introduced a ban on smoking in indoor public spaces. Prior to that measure it was socially acceptable to smoke in the workplace, in recreational and sporting facilities and at social gatherings and in other indoor spaces.

At the Center for Research on the Smoking Epidemic (*Centro de Investigación para la Epidemia de Tabaquismo,* CIET) we explored three aspects of the impact of this legislation: 1) compliance with the measure, 2) degree of air pollution, and 3) prevalence of smoking.

Compliance with the smoking ban was verified through visits to 66 bars, tea rooms, restaurants, pubs, discotheques, "food courts" in shopping centers, departure lobbies and casinos: in 63 of those places there were no smokers to be seen, indicating a compliance rate of 95.5%.

Our analysis of air pollution showed a reduction in the concentration of $PM_{2,5}$ in indoor spaces, which dropped from 210 µg/m³ before the ban to 18 µg/m³ after the ban.[7] That study was conducted as part of a similar measurement undertaken simultaneously in 32 countries, as a result of which Uruguay ranked second among countries with the least pollution from this type of particles.

In a recent nationwide survey of 5375 randomly selected households in towns with more than 2500 inhabitant, we found that the prevalence of smoking among adults was 24.8%, lower than the 32.7% found previously in the National Survey of Risk Factors conducted by the Ministry of Public Health.[8],[9]

The present study was designed to measure the impact of an indoor smoking ban on hospitalizations for AMI. At the time it was designed a number of studies covering certain cities or regions had been published, but there was no study for any country as a whole; a study conducted in Scotland was published subsequently, covering 64% of AMI admissions in that country.

Methods

Uruguay's population of approximately 3.3 million (of whom 2.27 million are over 20 years of age) is covered by the National Integrated Health System (SNIS), and any AMI case will be treated in one of the SNIS hospitals. To test the hypothesis, we conducted an observational study comparing AMI admissions, analyzing retroactively the clinical histories of patients in the 24 months before the new law came into effect (from 1 March

2004 to 28 February 2006) and in the 24 months immediately after that date (1 March 2006 to 29 February 2008).

Inclusion criteria. We included consecutive patients 20 years of age or over admitted in all SNIS hospitals with an AMI diagnosis (Code 121), established a time of admission.

Exclusion criteria. We excluded patients who did not have an AMI diagnosis, who were under 20 years of age, who were nonresidents of the country, who developed AMI after a non-primary coronary angioplasty or after a coronary bypass, or who had a different primary diagnosis upon admission, with AMI is only a secondary diagnosis (for example, if they were admitted for cancer surgery and the AMI resulted as a complication).

Data source. Uruguay has no centralized registry of hospital admissions, and the availability of information varies: in some hospitals it is handled by the Medical Records Department and is available in electronic databases, while in other hospitals the records are kept in the intensive care unit, and in still others the only record is on paper. Consequently, we had to tailor our data search to the specific circumstances of each institution.

Data collection. In each hospital we arranged for a physician, a registered nurse or a health worker to collect information on a form that included the following variables: institution, patient number, date of admission, patient ID card, age, sex, place of health coverage, department or country of residence, primary or secondary AMI diagnosis, place of transfer.

Processing of the data. We entered the data from each hospital into a database prepared for the study. We checked the consistency of the data, contrasting each of the data sheets with the consolidated database. Using the personal ID number, we checked for possible duplication of patients admitted to more than one hospital for the same AMI. If we found duplications, we retained the first admission and deleted the duplicate records.

Quality control. We reviewed 10% of the clinical histories in each hospital to verify the AMI diagnosis. For this purpose we generated a random list from among all cases in the hospital and sent this to the corresponding institution with the lead time requested by the local researcher. The principal researcher visited the hospital on the agreed date to verify the AMI diagnosis in the clinical histories provided by local researcher. After verifying the registration number and admission date in the clinical history, the researchers looked for the elements needed to diagnose AMI in accordance with the Universal Definition of Myocardial Infarction.[10]

A. Rise and/or fall of cardiac biomarkers (preferably troponin) with at least one value above the 99th percentile of the upper reference limit for the hospital together with evidence of ischemia with at least one of the following:

- Symptoms of ischemia.
- ECG changes indicative of new ischemia (new ST-T changes or new LBBB).

- Development of pathological Q-waves in the ECG.
- Imaging evidence of new loss of viable myocardium or new regional wall motion abnormality.

B. Pathological findings of AMI:

- Fresh thrombus verified by angiography.
- Fresh thrombus verified by autopsy.

We also looked for the presence of elements indicating secondary AMI. When more than 2% of cases had no primary AMI diagnosis using the established criteria, we verified the diagnosis of all patients in the hospital.

Cross-checking with external databases. The *Fondo Nacional de Recursos* has records on all patients subjected to angiography and/or revascularization procedures, making it possible to determine whether the patient had a recent AMI. Based on the patient's ID number we checked whether the patients subjected to angiography and/or myocardial revascularization following an AMI between 1 March 2004 and 29 February 2008 were recorded in the study database. When we found a case not included in the study we asked the local researcher to examine the clinical history.

Statistical analysis. We conducted an interrupted time series analysis, comparing admissions in the same months of each year, and adjusting for age and sex. We also adjusted for the season of the year, because the data show a spike in admissions for AMI during the winter months.[11] The age adjustment was done using the 2004 population census. The difference between the standardized admission rate before and after the legislation will be evaluated using the Mantel-Haenszel chi-square test. Based on previous studies, we would expect a drop of around 15%. According to the estimated incidence, there was a power of 99% for detecting a difference of at least 90 events per 100,000 inhabitants, with a standard deviation of 30 events per 100,000 before and after the law. Given the size of the sample and the foregoing assumption, we will have an 80% power for detecting a difference as small as six events per 100,000 inhabitants.

Confidentiality of patient records. The data for each patient included the ID number, which was needed to eliminate patients admitted to hospital more than once. After duplications were detected and eliminated, each patient was assigned a random identifier number, eliminating the ID number from the database to avoid access to patients' personal information. There was no direct contact between researchers and patients. All the data are stored at the Roswell Park Cancer Institute and in CIET in computers protected with security keys, and the data will be destroyed a year after they are collected. Summaries of publications resulting from the study will contain only aggregated data, with no item to identify patient or the name of the hospital.

Results

We included all patients admitted for AMI in 37 hospitals, representing 79.3% of all AMI admissions in Uruguay.

In the four years of the study, 7947 patients were admitted with a primary AMI diagnosis; of those, 5311 (66.8%) were admitted to private and 2638 (33.2%) to public institutions.

There were 4198 admissions (52.8%) in hospitals of the Department of Montevideo and 3751 admissions (47.2%) in hospitals in the rest of the country.

The average age of patients was 66.6 years (SD 18.9); 5158 patients were male (64.9%) and 2791 were female (35.1%).

Of the 7947 patients admitted, 4345 were admitted prior to 1 March 2006 and 3604 were admitted after that date, representing a decline of 17.1% in admissions.

Note: the final result, with its corresponding statistical significance, will emerge from the analysis now underway at Roswell Park, which includes adjustment by sex, age and temperature.

The observed decline for patients admitted to private hospitals was 22.0%, while for public hospitals it was 6.3% (table 1).

Table 1. Admissions before and after the smoking ban, by type of hospital

	Hospitals	
Admissions	**Private**	**Public**
Before	2,983	1,362
After	2,328	1,276
Reduction	22.0%	6.3%

The reduction in AMI admissions was greater among younger people, as can be seen from table 2.

Table 2. Admissions before and after the smoking ban, by age bracket

Age (years)	***Admitted before***	***Admitted after***	***Reduction***
<35	23	12	47.8%
35-39	36	23	36.1%
40-44	146	91	37.7%
45-49	270	221	18.1%

50-59	798	689	13.7%
60-69	1.110	910	18.0%
70-79	1.218	1.005	17.5%
80+	690	584	15.4%
Total	4.345	3.604	17.1%

The observed reduction for men was 17.9%, while that for women was 15.5%.

Conclusions

The ban on smoking in indoor public spaces led to a reduction of 17.1% in admissions for AMI after two years, with the greatest reduction among young people and those admitted to private institutions.

This indicates that the smoking ban in indoor public spaces has had an important health impact, related to the observed reduction in air pollution and the previously observed decline in smoking.

The observed differences between admissions to private hospitals and public hospitals may reflect a lower rate of compliance with the workplace smoking ban, a lower "quitting rate" or a smaller decline in tobacco use among population groups who rely on the public hospitals. The question could be a subject for future research in order to adopt measures to reduce this social divide.

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