EDITOR'S CHOICE

Reduction in hospital admissions for acute coronary syndrome after the successful implementation of 100% smoke-free legislation in Argentina: a comparison with partial smoking restrictions

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ABSTRACT

Background Several studies have shown a decrease in acute coronary syndrome (ACS) admissions after the implementation of 100% smoke-free legislation. However, no studies have been conducted in developing countries.

Methods We conducted a time series analysis of ACS hospital admissions in Santa Fe province and Buenos Aires city, Argentina. In 2006, Santa Fe implemented a 100% smoke-free law and Buenos Aires implemented a partial law with designated smoking areas and exceptions. Age-standardised ACS admissions rates were compared before and after the implementation of the laws in each district. Smoking prevalence, compliance with legislation and exposure to secondhand smoke (SHS) was also assessed in both districts.

Results In Santa Fe an immediate decrease in ACS admissions was observed after implementation (−2.5 admissions per 100 000, p=0.03; 13% reduction), compared with no change in Buenos Aires city (rate ratio Santa Fe vs Buenos Aires: 0.74, 95% CI 0.63 to 0.86, p≤0.001). In Santa Fe, the immediate effect was followed by a persistent decrease in admissions due to ACS (−0.26 admissions per 100 000 per month). Smoking prevalence did not change significantly in either district during the same period. In both districts, there was a reduction in self-reported SHS exposure, with a trend towards lower exposure in Santa Fe province. No other comprehensive tobacco control interventions were implemented during the study period.

Conclusions A 100% smoke-free law was more effective than a partial restriction law in reducing ACS admissions. An immediate effect was followed by a sustained decrease in ACS admissions. Smoke-free initiatives can be also effective in decreasing acute coronary events in developing countries.

INTRODUCTION

Exposure to secondhand smoke (SHS) is a well recognised risk factor for acute coronary syndrome (ACS) (unstable angina and myocardial infarction). The 2006 Surgeon's General Report concluded that exposure to SHS has immediate adverse effects on the cardiovascular system.[1] Recent meta-analyses indicate a 25—30% increase in the risk of coronary heart disease in people exposed to SHS.[1]

The WHO Framework Convention to Tobacco Control (FCTC)[2] committed countries to implementing 100% smoke-free legislation. The elimination or significant reduction of SHS exposure can rapidly decrease cardiovascular risks (such as ACS),

as shown by several studies evaluating the impact of smoke-free legislation[3—8] and reviewed recently in a meta-analysis[9] and in a report from the Institute of Medicine.[10] Theses studies show that the risk of ACS decreased after the implementation of smoke-free laws. However, studies evaluating the cardiovascular disease impact of smoke-free legislation have only been reported in developed countries. No evidence is available regarding the impact of these interventions in developing countries. Moreover, 100% smoke-free legislation has not been compared with partial smoking restriction policies when estimating the impact on the incidence of ACS. Previous studies have shown that partial smoking restrictions do not adequately protect non-smokers from SHS exposure.[1]

Although Argentina signed the WHO FCTC in 2005, it has not been ratified yet by the congress. As a federal country, different Argentine provinces and cities have enacted local smoke-free legislation during the past 5 years. Several Argentine provinces have enacted and effectively enforced comprehensive 100% smoke-free legislation in public places. Santa Fe was the first province to enact completely 100% smoke-free legislation in June 2005, which was fully implemented by the end of August 2006 with high levels of compliance (personal communication from the National Tobacco Control Program). In 2005, the city of Buenos Aires passed a partial smoking restriction law that entered into force in October 2006, which was influenced by a strong lobby from the tobacco industry.[11] The law allows for designated smoking areas in bars and restaurants and air purifiers are required to provide ventilation.

The objective of this study was to examine the association between the 2006 implementation of a complete ban in Santa Fe province on ACS hospital admissions, compared to the partial ban implemented in Buenos Aires city.

METHODS
Study setting

We conducted a time series analysis to describe the effect of smoke-free laws on hospital admissions for ACS in Buenos Aires and Santa Fe, Argentina. As described above, Santa Fe province implemented a 100% smoke-free law in all enclosed public places, which was implemented in August 2006 and has been well enforced.[12] Buenos Aires city implemented a partial smoking restriction law in October 2006.[13]

Data sources

Hospital admissions

In Argentina, all admissions to public hospitals are compiled by the National Department of Health Information and Statistics, Ministry of Health.[14] The population of adults aged 18 and over covered by public sector hospitals is nearly 660 000 in Santa Fe and 700 000 in Buenos Aires (approximately 30% of the adult population, see below). For this analysis, monthly admissions for ACS (International Classification of Diseases (ICD) 10 code I20—I25) from January 2004 to December 2008 were obtained for all public hospitals located in Buenos Aires and Santa Fe province. Only patients residing in these districts were included in the analysis.

Population

In order to estimate admission rates, population projections by age and sex for years 2004—2008 were obtained from the National Institute of Statistics.[15] The proportion of the population covered by public sector hospitals was obtained from the National Risk Factor Surveys conducted in 2005 and 2009,[16] implemented by the Ministry of Health, and the Permanent Household Survey,[17] implemented by the National Statistical Institute. Each year's coverage estimate was applied to the total population sizes to obtain the denominators for the admission rates.

Estimation of ACS rates

Hospitalisation rates were calculated by dividing the number of monthly admissions for ICD codes I20—I25 by the population denominators for each district described above. Rates were age-standardised and sex-standardised through direct standardisation using the 2000 Argentine standard population.

Laws and implementation

Data concerning dates and the extent of the implementation of the laws were obtained from the National Tobacco Control Program. This programme compiles information on the implementation of tobacco control policies across the country, such as enforcement, dates to entry into force, implementation decrees, as well as details about mass media campaigns through ongoing communication with provincial tobacco control representatives.[18]

Smoking prevalence, SHS exposure and compliance with legislation

Smoking prevalence and SHS exposure were measured before and after implementation of the smoke-free laws, using data from the National Risk Factor Survey for 2005 (pre-law) and 2009 (post-law). The National Risk Factor Survey is a nationally representative, household survey conducted every 4—5 years. Probabilistic sampling is used to enrol 50 000 subjects aged 18 and over. We obtained estimates of smoking prevalence and SHS exposure among subjects from Buenos Aires (n=2000) and Santa Fe (n=2000).[19] Smoking prevalence was defined as currently smoking daily or non-daily, and having smoked more than 100 cigarettes in the lifetime. SHS exposure was measured in two ways: in 2005 respondents were asked about noticing people smoking in indoor places in the last week. In 2009, respondents were asked about noticing smoking in different indoor places (worksite, home, bars and restaurants, educational facilities, public buildings and others) visited in the last 30 days.

Statistical analyses

For hospital admissions, a descriptive analysis was initially conducted of the annual and monthly ACS admissions one year before and after implementation of each district's laws.

To estimate the effect of the laws on admission rates, we applied a multiple linear regression analysis using standard methods for interrupted time series analysis.[20] The dependent variable was the monthly age-standardised admission rate due to ACS in each province. Monthly age-adjusted rates from both provinces from 2004 to 2008 resulted in 120 data points. We introduced a linear time trend variable for each district to account for secular trends. A month indicator variable was introduced to adjust for seasonality in ACS admissions. Two dichotomous variables were included to account for the month of the implementation of each district's law in order to estimate the instantaneous change in the rates. Interactions between the implementation of the laws and district trends were also included to estimate the change following the implementation of the laws.

Rate ratios and their 95% CIs were estimated to compare admission rates between Santa Fe and Buenos Aires, before and after the implementation of the laws, after adjusting for seasonality and secular trends.

Smoking prevalence and self-reported SHS exposure was estimated from the 2005 to 2009 national risk factor surveys using complex sampling survey analysis and compared using χ^2 tests. These surveys are nationally representative and allow for population-based estimates for each province. In the 2009 survey, smoke-free law compliance questions were added that asked respondents if they have noticed smoking in different indoor places visited in the past 30 days (outside designated areas for the case of provinces with partial restrictions). Smoking prevalence was age-standardised and sex-standardised. Sample sizes by province were approximately 2000 for both surveys. R statistical software was used for all analyses.[21]

RESULTS

During the study period (2004—2008), 8425 public hospital ACS admissions occurred in Buenos Aires city and 6320 in Santa Fe province. In Santa Fe, there were 1612 ACS admissions in the year prior to the law and 1277 admissions in the year after, corresponding to a 20.8% reduction in the number of admissions. In Buenos Aires, there were 1699 ACS admissions in the year before the law and 1608 admissions in the year following the law, resulting in a 5.3% decrease (figures 1 and 2) in ACS admissions.

In Santa Fe, the estimated mean admission rate in the 12 months preceding the legislation was 19 admissions per 100 000 inhabitants per month, with a stable trend (non-significant reduction of 0.03 admissions per 100 000 per month, p=0.46). In Buenos Aires, the mean admission rate was 21 admissions per 100 000 inhabitants in the year prior to the law, also with a stable trend (non-significant reduction of 0.05 admissions per 100 000 per month, p=0.14). As a result, there were no significant differences in ACS admission rates in the two locations prior to the implementation of the laws (RR 0.90, 95% CI 0.54 to 1.41, p=0.68) (figure 3, table 1).

The implementation of the law resulted in an immediate change in Santa Fe (−2.5 admissions per 100 000, 95% CI −4.74 to −0.26, p=0.03), and a persistent change after the implementation of the law (post-law trend: 0.26 fewer admissions per 100 000 inhabitants per month, 95% CI−0.39 to −0.13, p<0.001).

In Buenos Aires city, the implementation of the law was not associated with either an immediate effect (increase of 1.74 admissions per 100 000 inhabitants, 95% CI−1.43 to 4.92, p=0.28) or a change in the trend (0.01 admissions per 100 000 inhabitants per month, 95% CI−0.12 to 0.14, p=0.89). The

Figure 1 Monthly acute coronary syndrome (ACS) admissions in public hospitals one year before and after the law in Santa Fe.
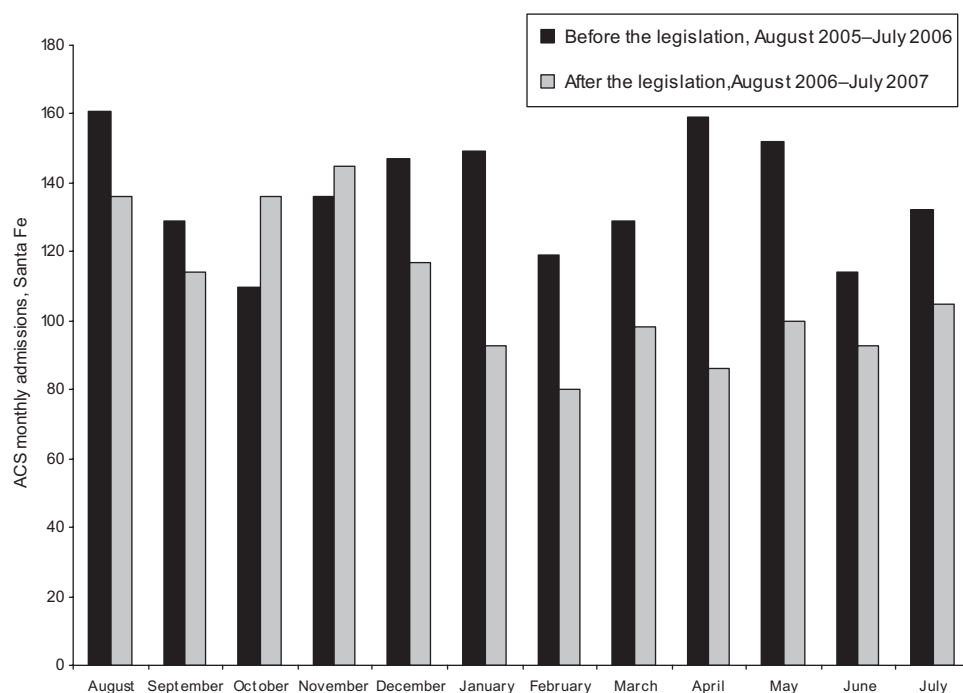
mean rate during the first year after implementation was 16 admissions per 100 000 per month in Santa Fe, compared with 22 admissions per 100 000 per month in Buenos Aires (rate ratio 0.74, 95% CI 0.63 to 0.86, p≤0.001) (figures 1 and 2). There were no significant changes in total admissions over the years analysed (data not shown).

Smoking prevalence in 2005 was 27.4% (95% CI 24.4% to 30.6%) in Buenos Aires and 27.3% (95% CI 24.3% to 30.5%) in Santa Fe (p=0.95). In 2009, there was a slight but non-significant decrease in prevalence in both districts. In Buenos Aires the smoking prevalence was 26.1% (95% CI 22.8% to 29.7%) and in Santa Fe it was 26.6% (95% CI 25.5% to 27.8% (p=0.84). In 2009, more smokers attempted to quit in the year prior to the survey in Santa Fe than in Buenos Aires (53.2%, 95% CI 42.5% to 63.6% vs 44.4%, 95% CI 34.3% to 55.0%, p=0.045). No changes were observed in the proportion of daily smokers or cigarettes consumed per day in both provinces, both in 2005 and 2009 (data not shown).
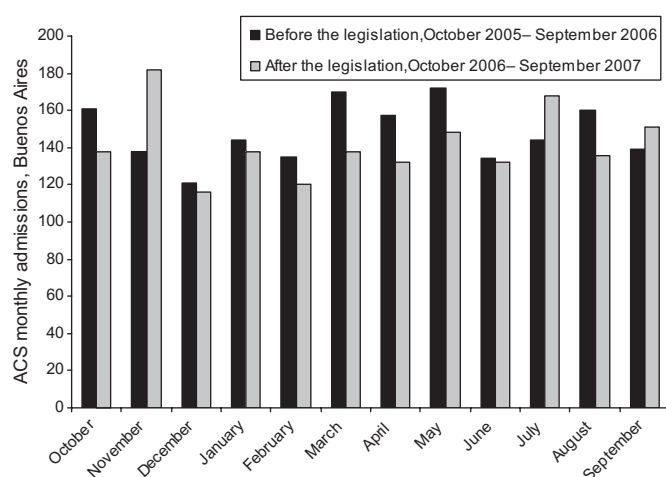
In 2005, self-reported exposure to SHS among adults aged 18 or more was 52.9% (95% CI 49.6% to 56.1%) in Buenos Aires and 51.6% in Santa Fe (95% CI 48.3% to 54.9%), p=0.59. After the law, in 2009, self-reported SHS exposure was 31.7% (95% CI 26.2 to 36.6) in Buenos Aires and 31.7% (95% CI 28.4 to 35.1%) in Santa Fe, p=0.88.

In 2009, SHS exposure in specific public places tended to be lower in Santa Fe compared with Buenos Aires, although none of the differences was statistically significant. The following estimates of SHS exposure are reported among those who visited each place. SHS exposure at worksites was 22.4% (95% CI 19.2% to 25.9%) in Santa Fe versus 24.9% (95% CI 21.2% to 29.1%) in Buenos Aires, p=0.33. SHS exposure at education facilities was 19.2% (95% CI 16.3% to 22.4%) in Santa Fe versus 24.7% (95% CI 19.5% to 30.8%) in Buenos Aires, p=0.07. In bars and restaurants, exposure was similar: 33.5% (95% CI 29.3% to 37.9%) in Santa Fe versus 34.1% (95% CI 29.8% to 39.8%) in Buenos Aires, p=0.83.

DISCUSSION

This study shows that in the province of Santa Fe there was a significant reduction in the number of hospital admissions for ACS following the implementation and enforcement of 100% smoke-free legislation. The reduction in admissions in Santa Fe occurred soon after full implementation and enforcement and was followed by a decreasing trend after the legislation. Implementation of the law did not appear to impact smoking prevalence. In both districts, there was a reduction in self-reported SHS exposure.

Conversely, in Buenos Aires city, no significant impact on ACS admissions was observed after the introduction of the new legislation.

In the province of Santa Fe, a strong 100% smoke-free legislation was passed in June 2005, but the implementation process was gradual. The communication campaign to educate bar and restaurant owners and the general population and the complete enforcement of the law were implemented in August 2006, in conjunction with the local ordinance in Rosario (the main city

Figure 2 Monthly acute coronary syndrome (ACS) admissions in public hospitals one year before and after the law in Buenos Aires.

Figure 3 Monthly acute coronary syndrome (ACS) admissions rates 2004–2008 in Santa Fe and Buenos Aires.
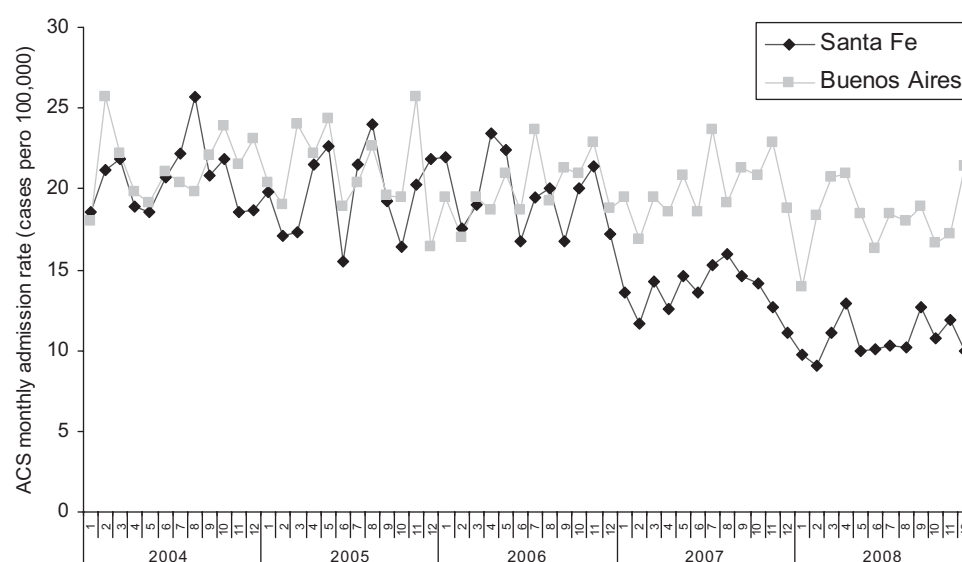
in Santa Fe province) entering into force. The rest of the province also started full implementation and enforcement in August 2006. In this province, the law also included other elements, such as a local ban on tobacco advertisement, promotion and sponsorship throughout the province. These additional activities were not comprehensive since other tobacco control interventions are under national laws.

In the city of Buenos Aires, a partial restriction law was implemented, which allowed designated smoking areas in bars and restaurants and other exceptions. The law also included a less comprehensive tobacco restriction on advertisement, promotion and sponsorship compared to legislation in Santa Fe.

The changes observed in admission rates could not be attributed to a decrease in prevalence, since smoking prevalence remained very similar before and after the implementation of the law. The more plausible explanation for the observed reduction in ACS admissions is the reduction in SHS exposure. Although self-reported SHS decreased in both districts to a similar extent, and this fact could undermine the hypothesis that the decrease in ACS is due to a decrease in SHS exposure, it

has been shown that accommodation and partial laws do not adequately protect non-smokers from SHS exposure, and exposure measured though objective methods could have been higher in Buenos Aires.[1] Despite the lack of a significant difference in self-reported SHS exposure, we found an impact on ACS admissions only in Sante Fe province. Future studies will incorporate more objective measures to assess the degree of exposure to SHS and compliance with the legislation.

In Santa Fe province, the Ministry of Health was directly in charge of law enforcement. Public places where people smoked were closed and had to pay fines.[22] A telephone line was set to receive complaints about violations to the law.

It is also unlikely that the other components of the law account for the reduction in hospital admissions. In Santa Fe other interventions were implemented, such as a local and total ban on tobacco advertisement (which was not the case in Buenos Aires). However, smoking prevalence declined only slightly in both districts and it is not clear how effective a local ban on advertising would be when advertising is allowed in national media (such as newspapers and magazines).

Limitations

One of the limitations of this analysis, shared with ecological analysis, is the lack of information on variables at the individual level for each ACS admission, such as smoking status and SHS exposure. Information from the hospital admissions database does not include smoking status. As a result, it is not possible to estimate the extent to which the reduction in ACS admissions occurred among smokers quitting or cutting down or reduced SHS exposure among non-smokers. Most of the previous studies had the same limitation. One exception is the study published by Pell *et al*, which shows that the number of admissions for ACS in Scotland decreased after the implementation of smoke-free legislation among smokers and non-smokers.[8]

Another limitation is the data source for the admissions. They only represent public hospitals, covering one-third of the overall population. However, over the years of this study, there have not been significant changes in health services usage, public hospital coverage and total number of admissions per centre and province. Total number of admissions remained stable during the studied period (in Buenos Aires city, total number of admissions were 169 274 in 2004 vs 163 054 in 2008, and in Santa Fe Province 154 183 in 2004 vs 144 860 in 2008), and public hospitals

Table 1 Interrupted time series regression model. Dependent variable: monthly acute coronary syndromes admission rates (2004–2008)

Variable	Coefficient	p value	95% CI
Sante Fe			
Pre-intervention trend (admissions per 100 000 per month)	−0.03	0.463	−0.11 to 0.05
Post-intervention trend (admissions per 100 000 per month)	−0.26	<0.001	−0.39 to −0.13
Immediate change after intervention (admissions per 100 000)	−2.50	0.029	−4.74 to −0.27
Buenos Aires			
Pre-intervention trend (admissions per 100 000 per month)	−0.06	0.138	−0.14 to 0.02
Post-intervention trend (admissions per 100 000 per month)	0.01	0.893	−0.12 to 0.14
Immediate change after intervention (admissions per 100 000)	1.74	0.279	−1.43 to 4.92
Difference in baseline rate between Santa Fe and Buenos Aires (admissions per 100 000)	−1.52	0.227	−4.02 to 0.97
Baseline rate for Buenos Aires (admissions per 100 000)	20.80	<0.001	19.06 to 22.55

Note: Month indicator effects are not shown.

What this paper adds

This study provides evidence of benefit of 100% smoke free laws in developing countries that was still lacking. Moreover, it also adds data on comparative effectiveness on clinical outcomes between partial restriction laws and 100% smoke free laws.

provided coverage for 30% of Buenos Aires city adult population and 30.5% in Santa Fe Province.[23]

In spite of these limitations, using communities as their own control provides some advantages in terms of analysis and interpretation. If no other policies are introduced in the period, a cause and effect relation can be inferred. Although we did not match the intervention community with a control community, Buenos Aires city also serves as a control. Moreover, the data from Buenos Aires suggest the ineffectiveness of the implementation of partial smoke-free legislation.

Previous literature has clearly shown that anything less than 100% smoke-free legislation does not protect against SHS exposure and adverse health outcomes.[24] The most effective approach for controlling the tobacco epidemic in Argentina is to ratify the FCTC and implement the recommended interventions, including 100% smoke-free environments. Under the current legislative scenario, provincial laws should be 100% smoke-free and should be duly enforced to have a positive impact on public health. However, passage of a strong national law and FCTC ratification would have a greater impact on public health. For example, if a 100% smoke-free law was implemented at the national level, about 4000 admissions for ACSs could be avoided in the next subsequent year, based on the results observed in this study. This may be an underestimation of the impact, since usually about half of all myocardial infarctions lead to sudden death and do not reach coronary care facilities. The impact could be even higher with the implementation of a comprehensive package of interventions.[25 26]

In conclusion, this study provides the first evidence of an association between implementation of a 100% smoke-free law and ACS hospital admissions in a developing country. It also clearly shows that partial smoke-free laws are not effective in reducing admissions. These results reinforce the strong message supporting 100% smoke-free environments, without exception, as the only way to completely protect people from SHS exposure. Provincial efforts in Argentina should be supported by the ratification of the FCTC and passing a strong national law consistent with the treaty. If nationwide cost-effective tobacco control measures are not implemented soon, the tobacco epidemic will continue to grow.

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