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Heterogeneous trend in smoking prevalence by sex and age group following the implementation of a national smoke-free law

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Competing interests

"All authors declare that the answer to the questions on your competing interest form [\[http://bmj.com/cgi/content/full/317/7154/291/DC1\]](http://bmj.com/cgi/content/full/317/7154/291/DC1) are all No and therefore have nothing to declare."

Contributors

E Regidor developed the general idea and wrote the draft. E Ronda, JL Gutierrez-Fisac, and C Pascual contributed to collect the data. S de Mateo, L de la Fuente and J Sánchez-Payá contributed to the analysis. All of the authors provided references, commented on the draft of the paper, and approved the final version.

Summary

Objective: Given the limited evidence available about the effects of clean indoor air laws on smoking behaviour in the general population, this study assessed the impact of national smoke-free workplace, bar and restaurant legislation, implemented on 1 January 2006, on smoking prevalence in Spain.

Methods: Population-based trend analysis using estimates for 27 periods from the beginning of 2000 to the end of 2008 – three periods per year. To calculate the period percent change in smoking prevalence, the permutation test for joinpoint regression to detect significant changes was used.

Results: In men and women aged 15-24 the prevalence of smoking declined between the first period in 2000 and the third period in 2008, whereas in women aged 45-64 it increased by 1.7% per period. A declining trend was detected up to the first period in 2006 in men and women aged 25-44 and in men aged 45-64, but between the beginning of 2006 and the end of 2008 the prevalence of smoking increased by 1.2%, 0.7% and 2.0% per period in men aged 25-44, in women aged 25-44, and in men aged 45-64, respectively.

Conclusions: Three years after a national smoke-free law was implemented, the trend in smoking prevalence in some population groups was unchanged, but in others the declining trend of previous years was reversed. The similarity of these findings to those observed in other countries suggests that clean indoor air laws, although effective in reducing exposure to second-hand smoke, may not achieve the secondary objective of reducing the prevalence of smoking in the population.

Introduction

A large body of evidence has shown that tobacco control policies, especially when they are implemented as part of a comprehensive program, can significantly reduce smoking rates. [1-2] Raising the price of tobacco by increasing taxes, and clean indoor air laws, by prohibiting smoking in public places, have been indicated as the policies with the greatest impact on smoking rates. [3]

Legislation to ban smoking in all indoor public places has been or is currently being introduced in several countries due to the evidence showing the harmful effects of environmental tobacco smoke on non-smokers.[4-5] These types of laws have proved effective in reducing both the amount of and exposure to environmental tobacco smoke. [1, 6-19] Although their main objective is the protection of those involuntarily exposed to tobacco smoke, other indirect effects of these legislative measures that have repeatedly been described are reductions in smoking prevalence, larger numbers of people who quit smoking, and reduced tobacco consumption in smokers .[1,3,11]

A reduction in smoking behaviours has been observed in workers subject to restrictions in the workplace. In fact, most investigations that have evaluated the effect of these restrictions have focused on quantifying the effects of smoke-free workplaces on smoking behaviour in employees, whether imposed by public laws or private firms. [11-12] However, compared to the large amount of evidence showing the effects of price on cigarette consumption at the population level, both on prevalence rates and the number of cigarettes consumed by those who continue to smoke, [2-3, 13-14] there is little evidence about the effects of clean indoor air laws on smoking behaviour in the general population. Moreover, according to a recent review of the effect of mandated smoking

restrictions, [12] the few studies that have assessed smoking behaviour in the general population, before and after implementation of new laws restricting smoking in public and workplaces, were analytically weak and produced mixed results.

On 1 January 2006 Spain introduced a comprehensive smoke-free law covering workplaces, bars and restaurants. [15] Under this law smoking has been completely banned in all indoor workplaces. Smoking is also banned in bars and restaurants larger than 100 square metres, but completely isolated smoking areas can be created, whereas the law authorizes the owners of bars and restaurants smaller than 100 square metres to decide whether or not to allow smoking. The question addressed in this study is whether this law has been successful in reducing the prevalence of smoking in the Spanish population. We present data on trends in the prevalence of smoking during the period before and after implementation of the law.

Methods

Source of data

The estimates of tobacco consumption were obtained from the General Media Survey conducted by the Association for Research in the Communications Media. Although the main objective of this survey is to identify the use of the communications media – the press, radio and television – in the Spanish population, the questionnaire also includes questions to explore the use of other products and lifestyles related with leisure time.

The General Media Survey is carried out by personal interview in a representative sample of the non-institutionalised Spanish population aged 15 years or older. Subjects are selected by a random multi-stage stratified procedure, in which the municipalities within each province are grouped into strata depending on population size. First, one municipality is randomly selected within each stratum of each province, then households within each municipality are randomly selected and, finally, one person in each household is selected to answer the survey. Each year three samples of the Spanish population are obtained: January-March, April-June and September-November. The mean sample size in each period is 14,200 subjects – about 44,200 subjects are interviewed per year. In the present study we analysed the 27 surveys carried out between the beginning (January-March) of 2000 and the end (September-November) of 2008. The response rate ranged between 70% and 75%.

The questionnaire includes questions about the use of blond-tobacco cigarettes, black-tobacco cigarettes, cigars and low-nicotine cigarettes. Respondents are asked whether or not they consume each product and, if so, whether they consume the product at least once a week or less frequently. Since regular smokers may be more sensitive to implementation of a comprehensive smoke-free law, respondents who consumed any of these products at least once a week were considered smokers.

Our study was restricted to persons aged 15 to 64 years because one of the places where the law bans smoking is the workplace, and after age 64 most of the population is retired. Likewise, since previous studies have indicated that the magnitude of the effect of clean indoor air laws varies depending on age, [3] separate estimates were made for three age groups: 15-24 years, 25-44 years and 45-64 years, with respective mean sample sizes of 1,800, 4,800 and 3,200 persons interviewed in each survey. The analysis was made separately in men and women since

Spain is in the last stage of phase III in the smoking epidemic, in which middle-aged women (45 - 64 years) have not yet reversed the rising trend in tobacco consumption. [16]

Statistical analysis

We first estimated the prevalence of smoking in each age-sex group and for each of the 27 periods analysed. The graphic representation of the trend was made by the moving arithmetic average of the prevalence based on three estimates: the one corresponding to each period, the previous period and the subsequent period. The Chi-square statistic was used to test the statistical significance of the difference between the prevalence obtained in the survey before the law was implemented (end of 2005) and the prevalence obtained in the most recent available survey (end of 2008). To take into account the complex sampling design, the estimate of prevalence and of the standard error of the prevalence in each age-sex group and for each of the 27 periods was made using the SAS procedure PROC SURVEYFREQ. [17]

We then used the permutation test for joinpoint regression to detect significant changes in the smoking prevalence trend. [18-19] This procedure chooses line segments that change slope at joinpoints denoting a statistically significant change in trend. The overall statistical significance level was $\alpha = 0.05$ with a maximum of three joinpoints and four line segments allowed. We fit the models on the log scale, using a weighted least square criterion, where the weight was the standard error of the observed prevalence. In this way the slope of each continuous linear phase is interpreted as the period percent change in the prevalence.

Finally, because the empirical evidence shows that laws restricting smoking in workplaces reduce smoking prevalence in workers, these analyses were also made in the subgroup of employed persons. For this purpose, we selected respondents who, in reply to the question about employment status, said they were working; those who were unemployed, retired, students or home-makers were excluded from this analysis.

Results

Figure 1 depicts the evolution in smoking prevalence in general population – by the moving average – from 2000 to 2008. Table 1 shows a summary form of the trend in smoking prevalence before and after the implementation of the law. From the start of 2000 to the end of 2005, smoking prevalence decreased in all the groups analysed except for women aged 45-64, in whom it increased from 15% to 19%. At the start of 2006 smoking prevalence also declined with respect to the previous period in all groups. However, the prevalence in the final period of 2008 increased with respect to that of the last period of 2005 in all groups, although the difference between the two periods was significant only in women aged 45-64. The largest increases in smoking prevalence were seen in men and women aged 45-64, in whom it rose from 34.8% to 37.8% and from 19.0% to 23.7%, respectively.

Table 1. Prevalence of smoking in Spain before and after implementation of a smoke-free law in January 2006 .

Sex and age group	Smoking prevalence (%) and 95% confidence interval			
	Before smoke-free law		After smoke-free law	
	January/March 2000	September/November 2005*	January/March 2006	September/November 2008*
Men				
15-24	36.0 (33.3, 38.7)	31.6 (28.8, 34.7)	29.1 (26.4, 31.8)	32.5 (29.0, 36.0)
25-44	49.8 (47.9, 51.8)	43.1 (41.3, 44.9)	40.9 (39.1, 42.8)	43.8 (41.6, 45.9)
45-64	37.0 (34.7, 39.3)	34.8 (32.7, 36.9)	29.8 (27.8, 31.9)	37.8 (35.37, 40.3)
Women				
15-24	35.3 (32.6, 38.1)	29.8 (27.0, 32.6)	28.7 (25.9, 31.5)	31.3 (27.8, 34.9)
25-44	40.8 (38.8, 42.7)	33.2 (31.4, 34.9)	30.9 (29.1, 32.6)	34.1 (32.1, 36.3)
45-64	15.0 (13.3, 16.6)	19.0 (17.2, 20.7)	17.8 (16.1, 19.4)	23.7 (21.6, 25.9)

* The difference between estimates at the end 2005 and the end 2008 were not statistically significant, except in the subgroup of women aged 45-64

The results of the statistical analysis with joinpoint regression are shown in figure 2 and table 2.

In men and women aged 15-24 and in women aged 45-64 no significant inflection points were detected between the first period of 2000 and the final period of 2008. In men and women aged 15-24 smoking prevalence declined significantly, whereas in women aged 45-64 years there was a significant increase of 1.70% ($p < 0.001$).

Table 2. Period percentage change (PPC) in smoking prevalence in Spain by sex and age group

Sex and age group	Trend 1		Trend 2		Trend 3	
	Duration	PPC	Duration	PPC	Duration	PPC
Men						
15-24	From start 2000 to end 2008	-0.70*				
25-44	From start 2000 to end 2006	-1.15*	From end 2006 to end 2008	1.23		
45-64	From start 2000 to end 2003	-0.21	From end 2003 to start 2006	-2.44*	From start 2006 to end 2008	2.03*
Women						
15-24	From start 2000 to end 2008	-1.18*				
25-44	From start 2000 to end 2004	-0.96*	From end 2004 to start 2006	-3.45	From start 2006 to end 2008	0.70
45-64	From start 2000 to end 2008	1.70*				

* PPC is significantly different from zero

Joinpoint regression analyses detected one significant inflection point in men aged 25-44 and two significant inflection points in men and women aged 45-64. In men aged 25-44 smoking prevalence declined by 1.15% per period ($p<0.001$) between the start of 2000 and the end of 2006, and increased by 1.23 ($p=0.09$) per period between the end of 2006 and the end 2008. In men aged 45-64 years the prevalence of smoking declined by 0.21% per period ($p=0.46$) between the start of 2000 and the end of 2003, and by 2.44% per period ($p=0.007$) between the end of 2003 and the start of 2006, but increased by 2.03% ($p<0.001$) per period between the

beginning of 2006 and the end of 2008. Finally, in women aged 25-44 smoking prevalence declined by 0.96% per period ($p<0.001$) between the start of 2000 and the end of 2004, and by 3.45% ($p=0.07$) per period between the end of 2004 and start of 2006, but increased by 0.70% ($p=0.12$) per period between the beginning of 2006 and the end of 2008.

The results of the analyses made only in persons who worked showed a similar trend to that observed in the general population (tables 3 and 4).

Table 3. Prevalence of smoking in employed persons in Spain before and after implementation of a smoke-free law in January 2006

Sex and age group	Smoking prevalence (%) and 95% confidence interval			
	Before smoke-free law		After smoke-free law	
	January/March 2000	September/November 2005*	January/March 2006	September/November 2008*
Men				
15-24	47.0 (43.0, 52.67)	44.6 (40.0, 49.1)	39.2 (34.5, 43.9)	49.2 (43.0, 55.3)
25-44	50.7 (48.5, 52.9)	42.6 (40.7, 44.5)	39.5 (37.6, 41.4)	43.0 (40.6, 45.4)
45-64	38.9 (35.7, 41.3)	33.8 (31.4, 36.3)	29.4 (27.0, 31.8)	38.2 (35.2, 41.2)
Women				
15-24	46.4 (40.8, 52.0)	40.9 (35.5, 46.3)	34.6 (29.4, 39.9)	43.4 (36.6, 50.1)
25-44	41.6 (36.6, 50.1)	32.7 (30.6, 34.8)	30.1 (28.1, 32.3)	33.1 (30.6, 35.7)
45-64	21.6 (17.8, 25.4)	26.0 (22.9, 29.0)	24.0 (21.0, 27.0)	30.6 (27.6, 33.5)

* Difference between estimates at the end of 2005 and the end of 2008 were not statistically significant

Table 4. Period percentage change (PPC) in smoking prevalence in employed persons in Spain, by sex and age group

Sex and age group	Trend 1		Trend 2		Trend 3	
	Duration	PPC	Duration	PPC	Duration	PPC
Men						
15-24	From start 2000 to end 2008	-0.57*				
25-44	From start 2000 to end 2006	-1.25*	From end 2006 to end 2008	1,32		
45-64	From start 2000 to end 2003	-0,28	From end 2003 to start 2006	-2.54*	From start 2006 to end 2008	2.32*
Women						
15-24	From start 2000 to end 2008	-1.22*				
25-44	From start 2000 to end 2004	-0.75*	From end 2004 to start 2006	-2.78*	From start 2006 to end 2008	0.68
45-64	From start 2000 to end 2008	1.01*				

* PPC is significantly different from zero

Discussion

Main findings

In men and women aged 25-44 and in women aged 45-64, the trend in smoking prevalence during the three years after the law was passed did not change significantly with respect to the

previously observed trend, whereas in men aged 25-44 and 45-64 and in women aged 25-44 a significant inflection point was detected after the implementation of the law, and a rising trend was observed, which reversed the declining trend of the previous years.

Comparisons with other studies and possible explanations

It is possible that the clean indoor air law passed in Spain has not been successful in reducing the prevalence of smoking because, although it bans all smoking in workplaces, the limitation is only partial in bars and restaurants. In fact, studies that have evaluated the effects of this law have shown that after it was passed, exposure to environmental tobacco smoke was considerably reduced in workplaces, but the reduction was smaller in bars and restaurants. [10, 20] Nevertheless, success in applying the law in workplaces does not guarantee a reduction in smoking prevalence, since the trend in workers observed in our study was similar to that of the general population.

According to some authors, policies to control smoking in Spain were among the most permissive in the European Union before this law was passed, [21] and this may have limited their impact on smoking prevalence. However, since 1988 several regulations have been passed in Spain restricting tobacco sales and advertising and limiting the places where smoking is allowed. [22-23] Likewise, between 1988 and 2008 the price of tobacco has risen by 400% -- as compared to the 120% increase in the general price index.[24] Moreover, during those 20 years the prevalence of smoking in men declined from 57% to 32%, [25-26] while the rising trend in women aged 25-44 was reversed at the beginning of the present decade, which is consistent with a country in the final part of stage three of the smoking epidemic. [16] In addition, during the time

covered by the present study, the mean annual increase in the price of tobacco was similar in the periods before and after implementation of the law. Specifically, between 2000 and 2008 the price of tobacco increased by 50% as compared to a 30% increase in the general price index.[24]

Few studies have evaluated the effect of clean indoor air laws on the prevalence of smoking in the general population, and in some that have done so, the post-law prevalence was estimated within a year after implementation of the law so the likelihood of observing any potential effect or lack of effect was limited. For example, a study in the Region of Madrid (Spain) found that smoking prevalence in the 6 months after the law's implementation was similar to the prevalence in the 6 months before. [10] Likewise, two studies in Italy and Scotland found that the prevalence of smoking in the Italian and Scottish populations was unchanged in the year following the introduction of a comprehensive smoke-free law in January 2005 and in March 2006, respectively. [27-28] The authors of the Italian study also estimated the overall prevalence of smoking in the two years following the introduction of the measure and showed that, with respect to the previous two years, the prevalence decreased significantly in men and in the population aged 15-44, but not in women or in the population older than 45 years.

The results of our study are more similar to the findings of the tobacco use surveillance systems in Finland and Ireland based on continuous surveys aimed at the whole population. In Finland, after implementation in March 1995 of the reformed Tobacco Control Act making workplaces totally smoke free, the prevalence of smoking in the population aged 15-64 years dropped from 26% in 1991-93 to 23% in 1994-96, but rose to 25% in 1997-98. [29] And according to estimates of the Irish Office of Tobacco Control, after the introduction on 29 March 2004 of a comprehensive smoke-free law covering all indoor workplaces, bars and restaurants, the prevalence of smoking in the population declined in the following 12 months from 25.4% to

23.3%, but subsequently increased by the end of the third year to levels similar to those in Ireland before the intervention. [30] After the third year the trends in smoking prevalence by age were heterogeneous: whereas there was a downward trend in persons under age 45, there was a rising trend in the population aged 45 or over.

With the exceptions previously mentioned, the studies to date that have evaluated the impact of the implementation of smoke-free policies on smoking behaviours have been made in the working population after the passage of clean indoor air restrictions that ban the use of tobacco. A systematic review published in 2002 concluded that totally smoke-free workplaces are associated with reductions in the prevalence of smoking of 3.8%. [11] It is possible that this effect is diluted in studies made in the general population, since not everyone is employed and some employed persons work in the open air. In this regard, a study in Finland on smoking habits among employees showed that, with respect to the previous year, the prevalence of smoking decreased significantly one year after the passage of the reformed Tobacco Control Act in March 1995. [31] In the discussion of the results, the authors of this study mentioned that, surprisingly, in the same period there was no significant decline in smoking rates in the general population.

However, we can not rule out the possibility that clean air laws do not really have any effect on the prevalence of smoking, not even among employed people. The findings of the studies conducted are not conclusive. For example, one characteristic of the review studies mentioned is the short interval between the implementation of smoke-free workplace policies and the follow-up survey (a median of 9 months), which limits the conclusions that can be drawn from these investigations.

Likewise, another review published three years before 2002, which included most of the studies in the preceding review, drew different conclusions. [32] According to these authors, design limitations or information biases in some cases, and failure to consider the secular trend in cessation in others, limited the validity of the reduced prevalence of smoking observed in most studies after the implementation of smoking bans in the workplace. On the other hand, the US Task Force on Community Preventive Services concluded in 2001 that the evidence of an effect of banning smoking in indoor public places on the prevalence of tobacco use is inconsistent. [2]

Finally the most recent review of the effect of mandated smoking restrictions on smoking behaviour concludes that studies of workers subject to restriction in the workplace indicate that new restrictions reduce the number of cigarettes smoked daily, but that whether or not this reduction is sufficient to make smokers less addicted, and therefore more likely to quit in the future, is unknown. [12]

The results of our study suggest that implementation of smoking bans in the workplace does not achieve a reduction in smoking prevalence in workers, since the results were similar to those of the general population: the trend in smoking prevalence in some population groups was unchanged, but in others the declining trend of previous years was reversed. Even though 60% of the population in Spain works in closed areas where the mandated smoking restriction would exert its effect, [10] it is not possible to rule out the possibility that the trend observed in the working population as a whole can be attributed to the 40% who work in open spaces.

In the working population aged 15-24 years there was a huge increase in the prevalence of smoking between the first and last period after implementation of the law. Because the sample size was only one-third as large as the total sample size in that age group, this finding must be

attributed to the random nature of the estimates. In fact, the period percent change in smoking prevalence from the beginning of 2000 to the end of 2008 was -0.57 in men and -1.22 in women.

Strengths and limitations of study

Based on 27 estimates from the beginning of 2000 to the end of the third year after the smoke-free law was enacted, this study has shown the trends in the prevalence of tobacco use in different population groups in Spain. The results of this study, together with Irish Office of Tobacco Control system for monitoring trends in tobacco use, [30] constitute the most relevant information about evolving trends in smoking prevalence in the general population after the implementation of clean indoor air laws.

The definition of tobacco in our study is the same as that used in other places to monitor smoking prevalence. [29] The estimates obtained are a valid approximation of the prevalence of daily smokers. According to the 2006 National Health Survey, [26] the prevalence of daily smokers in that year in the Spanish population aged 16 and over was 32.2% in men and 22.1% in women, while the estimates obtained for the same year in our data source were 32.7% in men and 21.5% in women.

It might be suggested that smoking prevalence could also be monitored taking into consideration all subjects who smoke, and not just regular smokers. However, when the analyses were made considering all smokers, the results were similar (see table and figure in web site). This is probably because around 95% of smokers, both before and after implementation of the law, were regular smokers.

The trend in smoking prevalence in workers was also investigated in this study. However, adequate evaluation of the impact of implementation of the smoke-free law on the working population would have required us to distinguish between workers in closed areas and those who work in open spaces, which was not possible. Nor were we able to compare people who were already working in smoke-free environments with workers affected by the law.

As has been pointed out, the findings of studies conducted in the working population show that the effect of smoking restrictions and bans on reducing the amount of tobacco consumed is consistent. Moreover, in Ireland a reduction in the prevalence of smokers of more than 20 cigarettes smoked daily was observed after the introduction of the comprehensive smoke-free law. [30] Unfortunately, the data source used in our study does not collect information on the number of cigarettes consumed by smokers, so we cannot evaluate the possible effect of this in the general population. However, some indirect evidence suggests that this effect may also be observed in Spain in the general population. According to data from the Commissioner for the Tobacco Market, [33] the number annual of cigarettes sold per person aged 15 years and older declined by about 5% each year between 2005 and 2008, whereas there was little change in the annual number of cigarettes sold per person between 2000 and 2005.

Implication of findings

In summary, three years after the enactment of the clean indoor air law in Spain, the trend in the prevalence of smoking in the different population groups analysed was unchanged or was

reversed in comparison with the declining trend observed in previous years. The similarity of our findings to the trend observed in Ireland – the country with the longest series of estimates of smoking prevalence after implementation of a clean indoor air law, suggests that these types of laws, although they reduce exposure to environmental tobacco smoke and the number of cigarettes smoked daily, may not achieve the other objective pursued: reduction of the prevalence of smoking in the population.

What is already known on this subject

The few studies that have assessed smoking behaviour in the general population before and after the implementation of new laws restricting smoking in public and workplaces were analytically weak and produced mixed results.

What this study adds

Three years after the introduction of a comprehensive smoke-free law in Spain, the trend in smoking prevalence in some population groups was unchanged, but in others the declining trend of previous years before the implementation of the law was reversed.

The similarity of these findings to the trend observed in Ireland – the country with the longest series of estimates of smoking prevalence after implementation of a clean indoor air law- , suggests that clean indoor air laws, although effective in reducing exposure to second-hand smoke, may not achieve the secondary objective of reducing the prevalence of smoking in the population.

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FIGURE LEGENDS:

Figure 1. Trend in smoking prevalence (%) by sex and age group in Spain, 2000-2008 (moving average).

Note: The vertical line between 2005 and 2006 represents the time when the law was implemented.

Figure 2 Observed smoking prevalence (%) and best joinpoint model estimates by sex and age group. Spain, 2000-2008.

(● observed data; joinpoint estimated data).

Note: The vertical line between 2005 and 2006 represents the time when the law was implemented.

Men 15-24 years

Women 15-24 years

Men 25-44 years

Women 25-44 years

Men 45-64 years

Women 45-64 years

Men 15-24 years

Women 15-24 years

Men 25-44 years

Women 25-44 years

Men 45-64 years

Women 45-64 years