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# BMJ Open

## Does Smokefree legislation work for teens too- evidence from ESPAD Ireland surveys.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-032630
Article Type:	Research
Date Submitted by the Author:	28-Jun-2019
Complete List of Authors:	Li, Shasha; TobaccoFree Research Institute Ireland Keogan, Sheila; TobaccoFree Research Institute Ireland, Clancy, Luke; TobaccoFree Research Institute Ireland, Research
Keywords:	Price,, Secondhand smoke, Advertising and Promotion,, Denormalisation, EPIDEMIOLOGY

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Manuscript Word Count: 2748

Does Smokefree legislation work for teens too- evidence from ESPAD Ireland

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Keywords: Price, Secondhand smoke, Advertising and Promotion, Denormalisation

Word Count: 2673

Abstract

Objectives:

This study aims to assess the role of Tobacco Control Legislation in reducing youth smoking in Ireland and to consider if it contributed to the gender equalisation in prevalence that occurred between 2003 and 2015. Smoke-free workplace legislation was introduced in 2004 in Ireland. Its impact on youth smoking is unclear but in the context of the large reduction in youth smoking prevalence observed it may be related but other legislative interventions also need consideration.

Setting:

Data are from the European School Survey Project on Alcohol and Other Drugs (ESPAD) Ireland, which took place every four years from 1995 to 2015. Total sample size of 12,394 boys and girls aged 15-16 attending school in Ireland. A logistic regression model on grouped data was used. Dependent variable is whether a student was a smoker in last-30 day. Independent variables are time, gender and policy indicators, workplace ban on smoking, Point-of-Sale (POS) display ban, the introduction of graphic images on packs and the average real price of cigarettes.

Results:

Smoking prevalence among youths in Ireland dropped from 41% in 1995 to 13% in 2015. We estimate that in girls real price effect reduced prevalence by 5.8% (95%CI 2.96-6), workplace ban 7.3 % (95% CI 2.94-11.68), graphic images 8.8% (95% CI 2.60-15.01) but POS did not have a significant effect.

In boys the real price effect estimate was 8.4% (95% CI 5.16 - 11.66), workplace ban 4.9 (95% CI 0.77-9.08), POS – 7.02% and graphic images had an insignificant effect.

Conclusion

Increased TC legislation introduced in Ireland helped to explain the out-of-trend reduction in youth smoking prevalence. The differential effects of the workplace ban, POS displays, real price changes and graphic images on packs help to explain the sharper decline in girls than boys and support their efficacy in adolescents.

### Article summary

#### Strengths and limitations of this study:

The ESPAD survey provides the best available adolescent data on smoking prevalence in Ireland from 1995 to 2015.

Nevertheless, the sample size is not ideally large and the interval between surveys is long at four years.

The data for 1999 and 2003 were obtained by recalculating the number of male and female smokers based on prevalence and total sample size.

Most of the important Tobacco Control Legislation in Ireland occurred during period 1995 to 2015 and their contribution to the reduction in prevalence in adolescent smoking is examined.

### Introduction

Ireland is one of the pioneer countries in tobacco control. Smoking in workplaces in Ireland was banned on 29 March 2004, making Ireland the first country in the world to institute a comprehensive ban on smoking in workplaces. From that date onwards, under the Public Health (Tobacco) Acts 2002, it has been illegal to smoke in all enclosed workplaces, including bars, restaurants, clubs, offices, public buildings, and schools, the ban is strictly enforced. (1) While the 2004 smoke-free workplaces legislation has reduced adult smoking prevalence (2) (3) and has helped to avoid at least 3,500 tobacco-related deaths in the first three years (4), its impact on adolescents is less clear. A particularly large reduction was observed in adolescent smoking prevalence between 2003 and 2015 (5). Although the smoke free legislation was not particularly targeting adolescents, this study sets out to assess if it was effective in reducing adolescent smoking in Ireland. Also, to see if it could help to explain the large fall in 30-day smoking prevalence, particularly in girls, occurring in recent years.

Prevalence fell from 44.9 % in 1995 to 13.1 % in 2015 in girls and from 36.7 % to 13.1% in boys. Other policies that would potentially help to reduce adolescent smoking prevalence introduced in Ireland since 1995 were, 1. a ban on packs of 10 cigarettes at the end of May 2007, 2. the point-of-sale (POS) advertising display ban of tobacco products introduced in 2009 and 3. the inclusion of graphic images on both sides of tobacco packs in 2011 (see Appendix 1). The existing international evidence suggested that these interventions could be expected to advance tobacco control and help to reduce smoking in young people. (6–8) In particular, Ireland was the first country in EU to implement a ban on point-of-sale display, which came into effect on 1 July 2009. The legislation prohibited advertising of tobacco products in retail premises and mandated the tobacco products must be stored out of view of customers. It also prohibited vending machines except in licensed premises and registered clubs (in accordance with Regulations), and that all persons selling tobacco products by retail had to register with the Office of Tobacco Control (OTC). One of the motivations behind these legislative changes was to reduce awareness of smoking, especially among young

people. Therefore, it is also of interest to assess if these laws contributed to the reduction in adolescent smoking prevalence.

## Methods

### Data

This study used data from the European School Survey Project on Alcohol and Other Drugs (ESPAD) in Ireland. The main purpose of the survey was to collect comparable data on substance use among 15- and 16-year-old students across Europe, in order to monitor trends within and between countries, including Ireland (8). ESPAD surveys were conducted every four years between 1995 and 2015, resulting in six waves of data from 26 countries, and 35 countries participating in 2015. The sampling procedures, data collection and questionnaires used in Ireland were consistent with the international ESPAD study protocol (9). School students born in specific calendar years were eligible and selected using stratified random sampling. Data were collected anonymously through paper-and-pencil, self-completion questionnaire administered in the classroom. After standardised cleaning procedures, the datasets (2007, 2011 and 2015 waves) were obtained from the ESPAD official database. Full accounts of the methodology of the study in each survey year can be found in the respective reports of the ESPAD project. (9–11)

Original raw datasets from the 1999 and 2003 waves were unavailable. However, smoking prevalence and sample size of both genders are available from officially published reports. (12,13) The number of smokers and non-smokers of both genders in the two surveys are reconstructed as shown in Table 1. The final data were aggregated every four years from 1995 to 2015, with an average of 2,067 observations per survey year. The observed prevalence estimates as the average of 0-1 smoker variable that indicates whether an individual in the sample smokes.

**Table 1 Reconstructed number of smokers form 6 ESPAD surveys from 1995 to 2015**

	Male smokers	Female smokers	Total smokers	Total survey sample
1995	328	421	749	1832
1999	355	491	846	2277
2003	343	442	785	2407
2007	194	325	519	2216
2011	207	254	461	2205
2015	98	92	190	1467

The prevalence for each survey is shown in Figure 1.

Other tobacco control policies which may have confounded the impact of workplace ban on adolescent smoking are included in the model. In particular, indicator variables for the introduction of POS ban and graphic images on packages were included. Increasing price on cigarettes is found to be one of the most effective measures in reducing smoking, particularly

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3 among adolescents as they usually have less disposable money and cigarettes are therefore  
4 less affordable than they are for adults. (14,15) Ireland has increased the cost of cigarettes  
5 every year since 1995, from 3.5 EUR in 1995 to 10.5 EUR in 2015. The real price changes,  
6 retail price corrected for consumer price index with 1995 as base year, are shown in the  
7 Supplementary File 1. Average real price therefore is included in the model to capture price  
8 effect.  
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### 11 12 13 14 15 Patient and Public Involvement

16  
17 No patients were involved. The principals of the schools involved were fully informed and  
18 cooperated in explaining the studies and administering the surveys. The results of each survey  
19 were disseminated through the media and Dept of Health.  
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### 22 23 24 25 Statistical analysis

26  
27 For statistical analysis, a logistic regression model on grouped data was used. All analyses  
28 were conducted separately for boys and girls. We have included real price and policy  
29 indicators. Seven models are assessed. First, we look at the impact of real price on adolescent  
30 prevalence (Model 0). Then we assess the impact of workplace ban on adolescent smoking by  
31 adding a workplace ban indicator, together with price (Model 1).  
32  
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34 Then we repeat the first step by replacing the workplace ban by the POS ban indicator  
35 (Model 2) and graphic images indicator (Model 3). Pairwise combinations of the policy  
36 indicators are also considered (Model 4 – 6). Lastly, all policy indicators and price are  
37 included (Model 7). Various criteria are used to determine the best model. In particular,  
38 models with smaller Akaike information criterion (AIC) values and Bayesian information  
39 criterion (BIC) values are preferred. Likelihood ratio tests are used for comparing two nested  
40 models. A significant test suggests that the full model is an improvement on the reduced  
41 model. All analyses were performed with the Stata 13 (StataCorp. 2013. Stata Statistical  
42 Software: Release 13. College Station, TX: StataCorp LP.)  
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### 53 Results

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57 The regression results of the seven models are presented in Supplementary File 2. For boys,  
58 all of the variables in each model are strongly significant except for graphic images. Average  
59  
60



real price increase and introducing the workplace ban reduced smoking prevalence. Model 4 provides the best fit to the data as shown in Table 2.

**Table 2 Logistic regression results and reduction in smoking prevalence from best fit models**

VARIABLES	Regression results		Reduction in prevalence	
	Boy	Girl	Boy	Girl
Real price	0.63***	0.75***	-0.0841***	-0.0587***
Workplace ban	0.76*	0.70**	-0.0493*	-0.0731**
POS ban	1.48*		0.0702*	
Graphic images		0.65**		-0.0880**
Constant	2.83**	2.13**		
Observations	6,080	6,324		
AIC	6657	7606		
BIC	6684	7633		

Coefficients are odds ratios in regression results

\*\*\* p<0.001, \*\* p<0.01, \* p<0.05

First, Model 4 has the smallest AIC among the seven models. Secondly, the Likelihood ratio tests on Model 4 and Model 0 -2 are all significant (all p values <0.02), which implies that Model 3 is an improvement on the reduced models. In addition, likelihood ratio test on Model 4 and Model 7 is insignificant (p value=0.81), which shows that Model 7 is not an improvement on Model 4. It is confirmed by the insignificant coefficient of graphic images in Model 7.

Table 2 shows how much the boys' prevalence was marginally affected by various variables in the best fit model, i.e. Model 4. Controlling for price and POS ban, introducing the workplace ban reduced the prevalence by 4.93% (95% CI 0.77%-9.08%), which is a considerable reduction given the prevalence before the ban was 33%. The effect of real price increase is also large and significant, with a unit increase in the real price could reduce the prevalence by 8.41% (95% CI 5.16% - 11.66%). However, POS ban was associated with increased prevalence by 7.02% (95% CI 1.65% -12.40%).

For girls, Model 5 provides the best fit as shown in Table 2. First, the likelihood ratio tests on Model 5 and Model 0, 1 and 3 are all significant ( $p$  value $<0.01$ ), suggesting that Model 5 is an improvement on the reduced models. In addition, likelihood ratio test on model 5 and 7 is insignificant ( $p$  value=0.2036). Model 7 is not an improvement on Model 5, confirmed by the insignificant coefficient of POS ban. Secondly, Model 5 has smallest AIC.

From Table 2, we can see that introducing the workplace ban reduced girls' prevalence by 7.31% (95% CI 2.94%-11.68%), which is larger than the effect on boys, but without statistically significant difference. In addition, the marginal effect of real price is 5.87% (95% CI 2.96% - 8.79%), which is smaller than the price effect on boys. Introduction of graphic images is associated with 8.80% (95% CI 2.60% - 15.01%) reduction in girls' prevalence, in contrast to the insignificant impact on boys. Figure 2 shows the best fit between the models (Supplementary File2) and actual prevalence for boys (model 4) and girls (model 5).

## Discussion

Although there is a general decline in adolescent smoking in ESPAD countries, there is no evidence of convergence in the different countries or geographic regions<sup>1</sup>. In Ireland, there was a steep drop in adolescent smoking prevalence between 2003 and 2007 when the decline was similar in girls and boys but slightly greater in girls. The results show that the workplace ban introduced in 2004 helps to explain the steep drop when controlling for price effect, consistent with evidence found in other studies. (16,17) In particular, although the overall average real price increased in the 2003-2007 period compared to the previous period, the annual real price decreased for the two years 2004 to 2006. This reinforces the strong impact of the workplace ban on reducing smoking prevalence between the 2003 and 2007 period. In addition, the workplace ban rendered an estimated additional 5% reduction in actual smoking prevalence beyond price effect, which is a considerable effect given that the prevalence was 37% among females and 28% among males in 2003. The study also confirms that real cigarette prices are strong determinants of youth smoking. (16,17) Furthermore, the other components of MPOWER did not change significantly between 2003 and 2007. In particular, mass media campaigns stayed moderately funded for the whole period of 1995 to 2015. Health warnings were moderate between 2003 and 2007, and cessation treatment and youth access were stable in the period. Therefore, between 2003 and 2007, the only significant and positive change in tobacco control policies was the introduction of workplace ban. The mechanisms that explain the link between the workplace ban and adolescent smoking prevalence are uncertain and our data do not allow a further interrogation. However, some studies from other countries have provided some explanations. For example, one study shows that stronger public places restrictions had a significantly protective effect on smoking prevalence.(18) Another suggested that a workplace ban affects adolescents who are at work (through part-time jobs).(19) It showed that adolescents who worked in smoke-free workplaces were only 68% (95% CI, 51%-90%) as likely to be smokers as adolescents who worked in a workplace with no smoking restrictions. It is also possible that the discourse around smoking which occurred pre-implementation helped to denormalise smoking in general even though the law was primarily about the workplace. (20) The decrease in prevalence from 2007 to 2011 was much steeper in girls than boys. During this period, the annual real price decreased from 2010 to 2011 although the average real price for the period 2007 to 2011 increased slightly (Supplementary File 1). The model suggests that price has a greater marginal effect on boys than girls (8.4 % V 5.8 %). The decrease in the annual real

price, which is not taken into account in the change of average real price in the model and the finding that the workplace ban seemed to have a greater effect in girls than boys (7.3% V 4.9%) may partially explain the difference in the rate of decline of prevalence. The impact of the POS ban on reducing youth smoking prevalence was not significant, which is consistent with the finding of the study by McNeill A. et al. (2011), (21). They failed to find significant short-term changes in prevalence among youths or adults due to POS ban. However, their study showed that the proportion of youths believing more than a fifth of children their age smoked decreased from 62% to 46%,  $p < 0.001$ ). Post-legislation, 38% of teenagers thought it would make it easier for children not to smoke. Compliance was very high and the law was well supported. Recall of displays among teenagers reduced significantly post-legislation and there were encouraging signs that the law helped de-normalise smoking. While it was postulated at the time that it might take a longer time for the POS ban to effectively reduce smoking prevalence among youths, we have not seen it in this study based on a longer time series. Others however have seen more positive results in young people. (5–7) Context may be significant in this regard as our population were under age for legal purchase of cigarettes in Ireland and access in those circumstances occurs through other routes where POS displays may not be relevant. It does not however explain why the POS display ban was associated with a negative effect in boys in this analysis. It seems likely that this was a price effect because the real price actually declined in two of the relevant years (Supplementary File 1) but also there was a marked switch to cheaper roll your own cigarettes in both adults and teens. (22,23) In ESPAD countries with different initial status from Ireland generally, gender convergence is marked in smoking prevalence. In 1995, on average in ESPAD countries boys showed higher smoking prevalence than girls. In 2015, these differences were no longer apparent or became smaller. However, in 1995 Irish female adolescents had a much higher smoking prevalence than male adolescents (45% VS 37%), price and workplace ban effects were marked in both genders but somewhat different. As discussed above price effect was stronger in boys than girls while there is no conclusive evidence on this in the literature. (17,24) The impact of the POS ban differed between the two groups. In particular, POS ban did not significantly affect girls' smoking prevalence, while it is significantly and positively (7 %) related to boys' smoking prevalence. The introduction of graphic images on packs seemed to have a much greater impact on girls with an 8.8% marginal effect whereas it had no significant effect on boys. These differential effects on POS and graphic images with the lesser differentials for price and the workplace ban may explain why we observed that by the end of the period, the gender gap was closed, with female prevalence less than male prevalence by 2015, consistent with most ESPAD countries. One of the potential issues of the above analysis is that the sample size is not ideally large and the interval between each survey is long, as there were only six surveys between 1995 and 2015. However, this is so far the best adolescent survey data in Ireland that provides adolescent smoking prevalence. Other surveys on smoking either didn't have enough adolescent samples (e.g. Survey on Lifestyle and Attitude to Nutrition and Healthy Ireland surveys), or were too recent to establish a baseline before the policies were introduced (e.g. Monthly phone interview surveys from National Tobacco Control Office from 2002), or had fewer data points (e.g. Health Behaviour in School-aged Children study had 5 between 1998 and 2014). Another limitation is that the data of 1999 and 2003 were obtained by recalculating the number of male and female smokers based on prevalence and total sample size, a process which may have introduced very small inaccuracies. However, the results are clear cut and the margin of error compared

to total sample is negligible. Therefore, the process should not have significant impact on the results.

## Conclusions

In Ireland there were no school-specific policies introduced between 1995 and 2015. However, adolescent smoking prevalence dropped significantly in boys and girls. This study found that the workplace ban introduced in 2004, to protect workers and customers from second-hand smoking, has significantly helped to explain the out-of-trend reduction in adolescent smoking prevalence. While removal of point of sale tobacco promotion may have reduced awareness of smoking among young people, there was no evidence of a beneficial effect on prevalence. Graphic images appear to have made a significant impact on girls' smoking prevalence but not on boys. In addition, we confirmed that price increase was consistently effective in both boys and girls. While some of the results are surprising in general, they support the beneficial role of the introduction of comprehensive tobacco control measures in reducing smoking prevalence in young people.

### **Figure 1 Trend of Irish adolescent smoking prevalence by gender (%) 1995-2015 ESPAD surveys**

### **Figure 2 Prevalence of smoking from ESPAD surveys from 1995-2015 and fitted lines of predicted prevalence from best fit models for boys and girls**

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**Funding:** This work was supported by a grant made under an RFT for research services by the DOH Ireland for the ESPAD survey 2015; RCDHT Grant 178 supports SL.

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication

**Ethical Approval:** Ethical approval was awarded for the ESPAD study by TU Dublin, Research Ethics Committee: Ethical Clearance Ref 18 -126

**Contributors** LC conceived the study. LC and SL designed the study. SL, SK and LC were involved in analysis of the data. SL drafted the first version of the manuscript. LC and SK had input into all redrafts. All authors read and approved the final version.

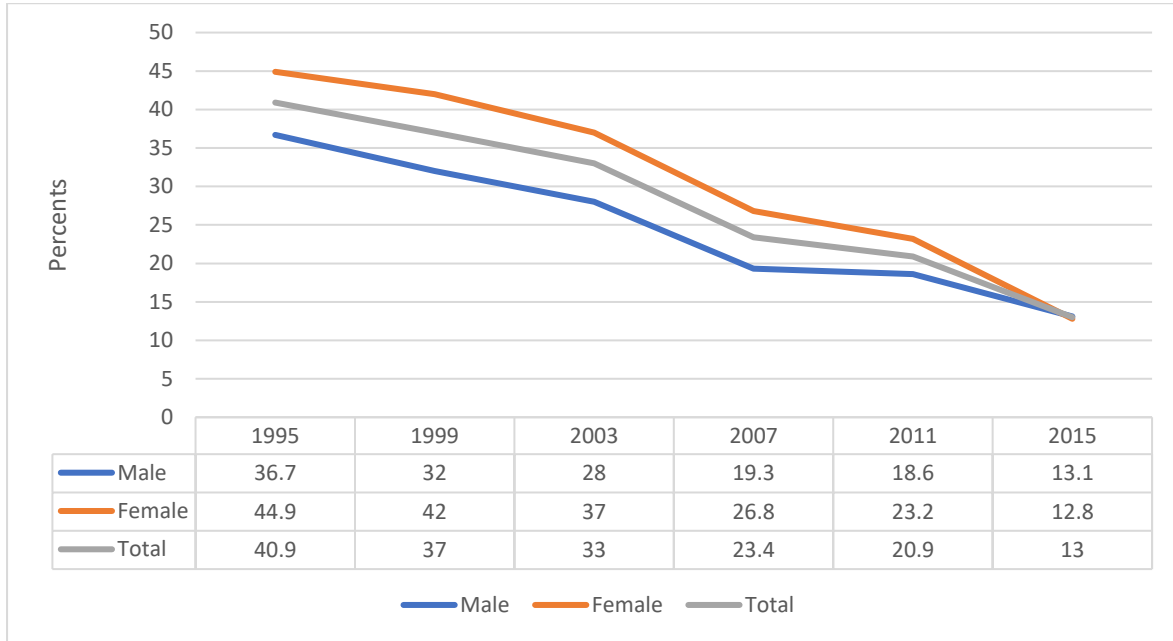
LC, SK and SL declare no competing interests.

**Acknowledgements:** We wish to thank Focas Research Institute, Dublin Institute of Technology for facilities and the ESPAD international researchers supported by EMCDDA contract CC.14.SDI.032 who compiled a common ESPAD Trend database (1995–2015).

**Data sharing:** The data were from the European School Survey

Project on Alcohol and Other Drugs (ESPAD) and various official reports available from <http://www.espad.org/reports-documents>. With the 2003 data collection as a starting point, it was decided that all country datasets should be merged into a common database. After that also data from 2007 and 2011 are available in separate databases. Initially, these databases were stored and maintained by the Databank Manager Thoroddur Bjarnson. During the 2015 wave of ESPAD, the international database was compiled and standardised by CAN (Stockholm). Even though, since 2007, countries are obliged to deliver their national datasets to the database, there are—as stated in the database rules—no obligations to let other researchers use the national data without permission. In order to obtain a copy of a database, an application form has to be filled in and posted to the coordinators for further distribution to the ESPAD Application Committee. The composition of the committee as well as restrictions around the database and its use are described and explained in the ESPAD database rules (database rules for ESPAD researchers and database rules for non-ESPAD researchers). When an application is approved, a contract is signed before a copy of the database is delivered. Approved applications are presented in a list, which also displays the deadline of the projects. ESPAD researchers are allowed to apply for the most recent database once the International ESPAD Report has been released. Non-ESPAD researchers are also allowed to work with ESPAD data. Access for non-ESPAD researchers is allowed after an embargo period determined by an assembly: ESPAD 2003 Database: accessible now. ESPAD 2007 Database: was accessible since 1 July 2013. ESPAD 2011 Database: was accessible since 1 July 2015. ESPAD 2015 Database: at present, it is only accessible to ESPAD researchers. [http://www.espad.org/sites/espad.org/themes/cs\\_espad/logo.png](http://www.espad.org/sites/espad.org/themes/cs_espad/logo.png):

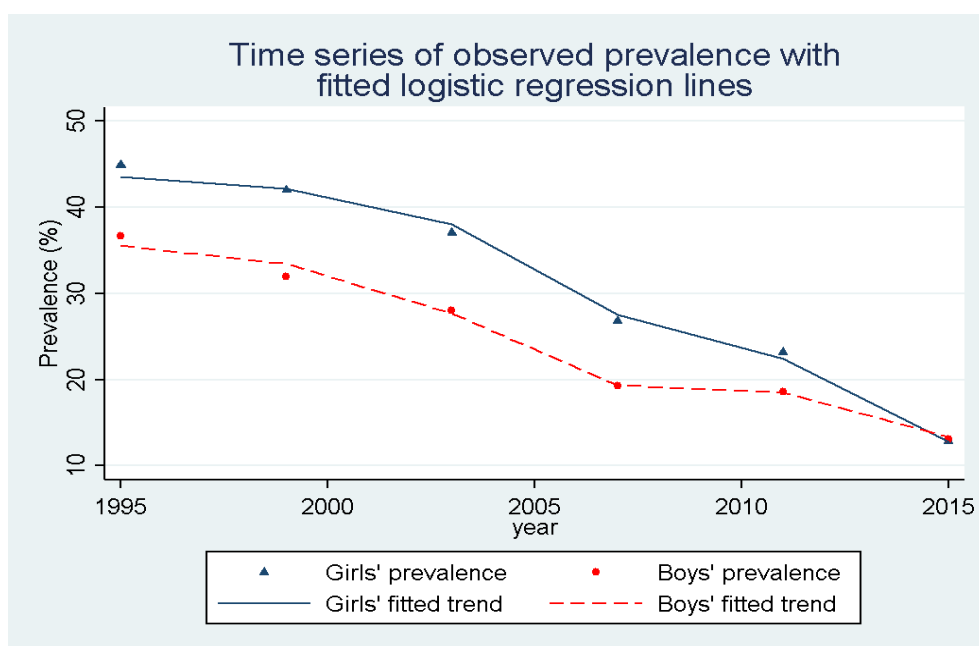
**Figure 1 Trend of Irish adolescent smoking prevalence by gender (%) 1995-2015 ESPAD surveys**



view only

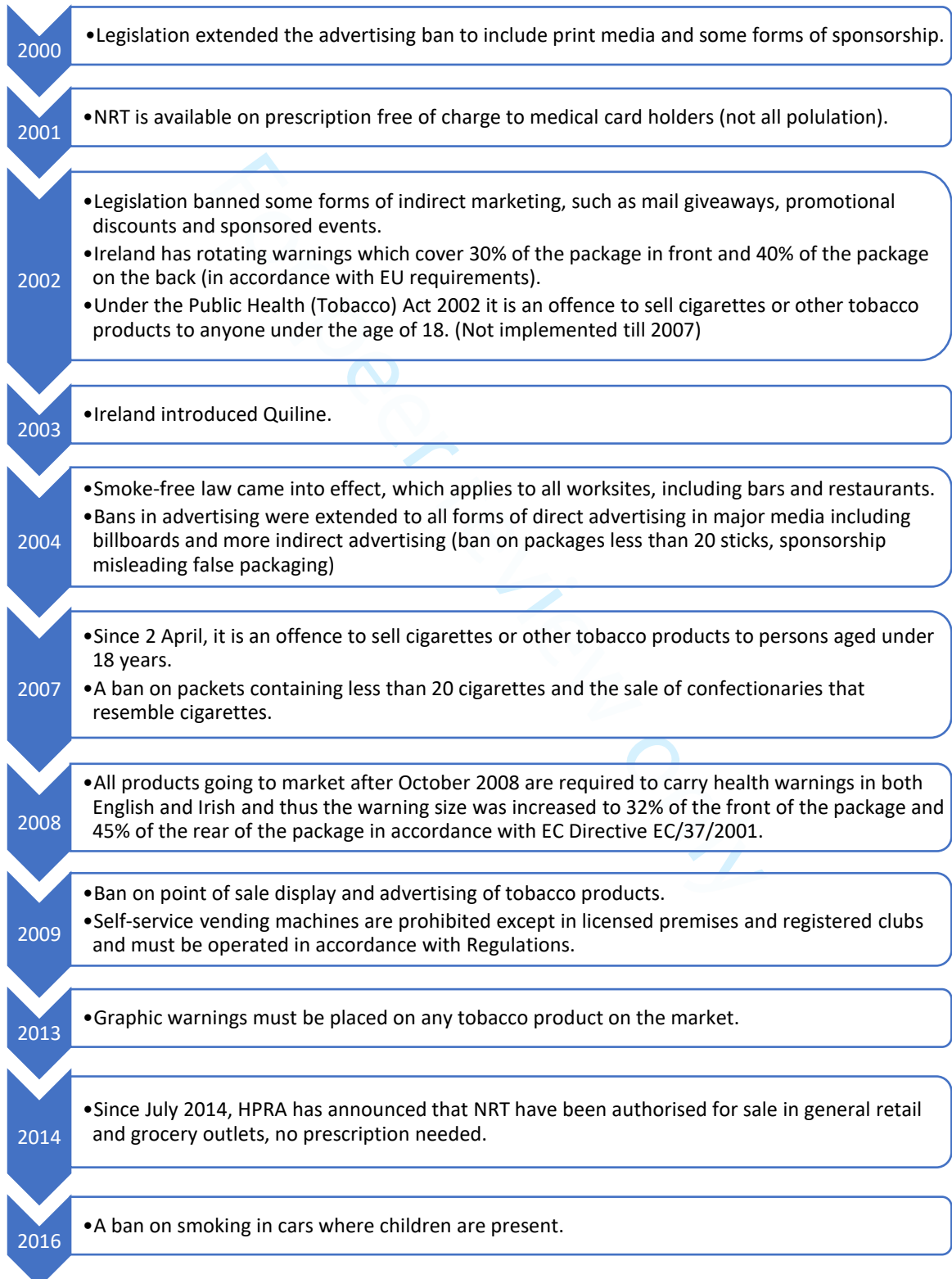


Figure 2. Prevalence of smoking from ESPAD surveys from 1995-2015 and fitted lines of predicted prevalence from best fit models for boys and girls



## Appendix 1

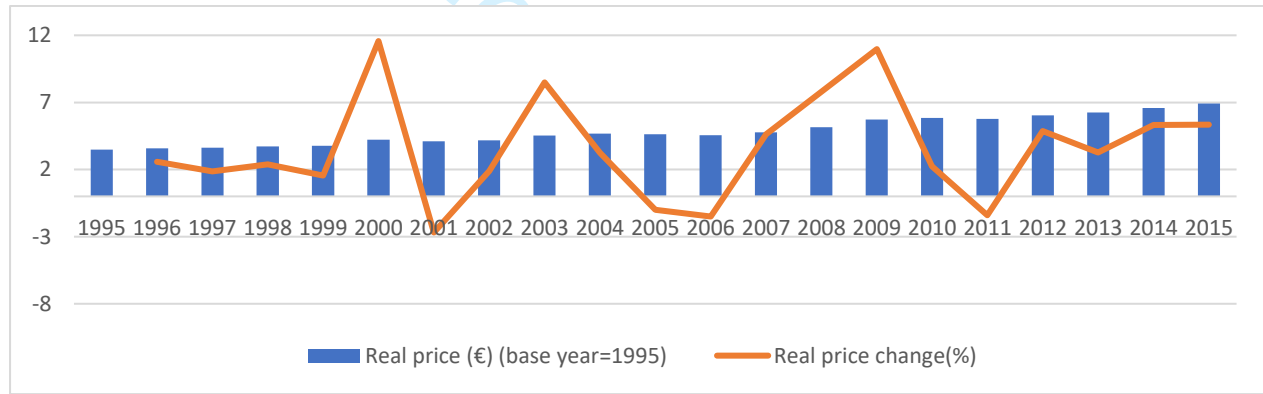
### Timeline of Tobacco Control Policies/ Interventions in Ireland, 2000 -2016



Supplementary File 1

Table 1 Real price (€) per package of 20 cigarettes in Ireland, 1995-2015

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Retail price	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5
CPI (year 1995=100)	100	102	103	106	107	113	119	124	129	134	140	145	150	155	160	165	170	175	180	185	190
Real price (base year=1995)	3.5	3.6	3.6	3.7	3.8	4.2	4.1	4.2	4.5	4.7	4.6	4.6	4.8	5.2	5.7	5.8	5.8	6.0	6.2	6.3	6.4
Real price change (%)	-	2.6	1.9	2.4	1.6	11.6	-2.4	11.9	8.5	3.2	-1.1	-1.5	4.6	7.7	11.1	1.7	-1.4	4.9	3.3	5.3	5.3



## Supplementary File 2

Irish ESPAD 1995 to 2015:

Logistic regression of male prevalence on factors from various models 1-7

VARIABLES	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Real price	0.65*** (0.02)	0.75*** (0.05)	0.54*** (0.04)	0.64*** (0.03)	0.63*** (0.06)	0.78** (0.06)	0.53*** (0.04)	0.64*** (0.07)
Workplace ban		0.72** (0.08)			0.76* (0.09)	0.70** (0.09)		0.75* (0.10)
POS ban			1.57** (0.23)		1.48* (0.23)		1.59** (0.24)	1.47* (0.23)
Graphic images				1.09 (0.16)		0.90 (0.15)	1.12 (0.17)	0.96 (0.16)
Constant	2.39*** (0.36)	1.43 (0.34)	4.83*** (1.34)	2.55*** (0.48)	2.83** (1.01)	1.24 (0.39)	5.36*** (1.64)	2.66* (1.17)
Observations	6,080	6,080	6,080	6,080	6,080	6,080	6,080	6,080
AIC	6668	6662	6661	6669	6657	6663	6662	6659
BIC	6681	6682	6681	6689	6684	6690	6689	6693

Coefficients are odds ratios

SE in parentheses

\*\*\* p&lt;0.001, \*\* p&lt;0.01, \* p&lt;0.05

## Irish ESPAD 1995 to 2015

## Logistic regression of female prevalence on factors from various models 1-7

VARIABLES	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Real price	0.59*** (0.02)	0.65*** (0.04)	0.52*** (0.03)	0.61*** (0.02)	0.58*** (0.05)	0.75*** (0.06)	0.54*** (0.04)	0.68*** (0.07)
Workplace ban		0.79* (0.08)			0.83 (0.09)	0.70** (0.08)		0.73** (0.09)
POS ban			1.36* (0.18)		1.27 (0.18)		1.35* (0.18)	1.20 (0.17)
Graphic images				0.80 (0.12)		0.65** (0.10)	0.81 (0.12)	0.67* (0.11)
Constant	5.24*** (0.74)	3.58*** (0.77)	8.46*** (2.12)	4.48*** (0.78)	5.65*** (1.92)	2.13** (0.61)	7.22*** (1.97)	3.11** (1.29)
Observations	6,324	6,324	6,324	6,324	6,324	6,324	6,324	6,324
AIC	7615	7612	7612	7615	7611	7606	7611	7606
BIC	7629	7632	7632	7635	7638	7633	7639	7640

Coefficients are odds ratios

SE in parentheses

\*\*\* p&lt;0.001, \*\* p&lt;0.01, \* p&lt;0.05

# Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

## Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

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			Page Number
<b>Title and abstract</b>			
Title	<a href="#">#1a</a>	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	<a href="#">#1b</a>	Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background / rationale	<a href="#">#2</a>	Explain the scientific background and rationale for the investigation being reported	3
Objectives	<a href="#">#3</a>	State specific objectives, including any prespecified hypotheses	3
<b>Methods</b>			
Study design	<a href="#">#4</a>	Present key elements of study design early in the paper	4
Setting	<a href="#">#5</a>	Describe the setting, locations, and relevant dates, including periods of	4

		recruitment, exposure, follow-up, and data collection	
1			
2	Eligibility criteria	<a href="#">#6a</a> Give the eligibility criteria, and the sources and methods of selection of	4
3		participants.	
4			
5			
6		<a href="#">#7</a> Clearly define all outcomes, exposures, predictors, potential	5
7		confounders, and effect modifiers. Give diagnostic criteria, if applicable	
8			
9			
10	Data sources /	<a href="#">#8</a> For each variable of interest give sources of data and details of methods	4
11	measurement	of assessment (measurement). Describe comparability of assessment	
12		methods if there is more than one group. Give information separately	
13		for for exposed and unexposed groups if applicable.	
14			
15			
16			
17	Bias	<a href="#">#9</a> Describe any efforts to address potential sources of bias	4-5
18			
19	Study size	<a href="#">#10</a> Explain how the study size was arrived at	4
20			
21	Quantitative	<a href="#">#11</a> Explain how quantitative variables were handled in the analyses. If	4
22	variables	applicable, describe which groupings were chosen, and why	
23			
24			
25	Statistical	<a href="#">#12a</a> Describe all statistical methods, including those used to control for	4
26	methods	confounding	
27			
28			
29	Statistical	<a href="#">#12b</a> Describe any methods used to examine subgroups and interactions	4
30	methods		
31			
32			
33	Statistical	<a href="#">#12c</a> Explain how missing data were addressed	4
34	methods		
35			
36			
37	Statistical	<a href="#">#12d</a> If applicable, describe analytical methods taking account of sampling	4
38	methods	strategy	
39			
40			
41	Statistical	<a href="#">#12e</a> Describe any sensitivity analyses	4
42	methods		
43			
44	<b>Results</b>		
45			
46	Participants	<a href="#">#13a</a> Report numbers of individuals at each stage of study—eg numbers	4
47		potentially eligible, examined for eligibility, confirmed eligible,	
48		included in the study, completing follow-up, and analysed. Give	
49		information separately for for exposed and unexposed groups if	
50		applicable.	
51			
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55	Participants	<a href="#">#13b</a> Give reasons for non-participation at each stage	4
56			
57	Participants	<a href="#">#13c</a> Consider use of a flow diagram	na
58			
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60			

1	Descriptive data	<a href="#">#14a</a>	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	4
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6	Descriptive data	<a href="#">#14b</a>	Indicate number of participants with missing data for each variable of interest	4
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10	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	5
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13				
14	Main results	<a href="#">#16a</a>	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	5
15				
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18				
19	Main results	<a href="#">#16b</a>	Report category boundaries when continuous variables were categorized	5
20				
21	Main results	<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	5
22				
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25	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	5
26				
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28				
29	<b>Discussion</b>			
30				
31	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives	6
32				
33				
34	Limitations	<a href="#">#19</a>	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	3,7
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39	Interpretation	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	7
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44	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study results	7
45				
46				
47	<b>Other</b>			
48	<b>Information</b>			
49				
50				
51	Funding	<a href="#">#22</a>	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	10
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# BMJ Open

## Does Smoke-free legislation work for teens too? A logistic regression analysis of smoking prevalence and gender among 16-year-olds in Ireland, using the 1995-2015 ESPAD school surveys

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-032630.R1
Article Type:	Original research
Date Submitted by the Author:	20-Sep-2019
Complete List of Authors:	Li, Shasha; TobaccoFree Research Institute Ireland Keogan, Sheila; TobaccoFree Research Institute Ireland, Clancy, Luke; TobaccoFree Research Institute Ireland, Research
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Epidemiology, Smoking and tobacco, Addiction, Communication
Keywords:	Price,, Secondhand smoke, Advertising and Promotion,, Denormalisation, EPIDEMIOLOGY, Graphic Tobacco Images

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3 Does Smoke-free legislation work for teens too? A logistic regression analysis  
4 of smoking prevalence and gender among 16-year-olds in Ireland, using the  
5 1995-2015 ESPAD school surveys  
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8 Authors: Shasha Li<sup>1</sup>, PhD, Sheila Keogan<sup>1</sup>, MPhil, Luke Clancy<sup>1</sup>, MD.  
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26 Keywords: Price, Secondhand smoke, Advertising and Promotion,  
27 Denormalisation  
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30 Word Count 3179  
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55 Abstract  
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57 Objectives:  
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To assess the role of Tobacco Control Legislation (TCL) in youth smoking in Ireland. To examine the effects of Smokefree legislation on smoking in youth. To consider whether TCL contributed to the gender equalisation in prevalence in 16-year olds that occurred between 2003 and 2015.

#### Setting:

Data are from the 4 yearly European School Survey Project on Alcohol and Other Drugs (ESPAD) from 1995 to 2015. Total sample size was 12.394. A logistic regression model on grouped data was used. Dependent variable is whether a student was a smoker in last-30 day. Independent variables are time, gender and the policy indicators, workplace ban on smoking, Point-of-Sale (POS) display ban, the introduction of graphic images on packs and the average real price of cigarettes.

#### Results:

Smoking prevalence dropped from 41% in 1995 to 13% in 2015. The effects of policies differed between boys and girls.

For girls, the workplace bans, graphic images on packs, a unit real (CPI adjusted) price increase reduced prevalence by 7.31 % (95% CI 2.94-11.68), 8.80% (95% CI 2.60-15.01) and 5.87(95% CI 2.96-8.79) respectively. The POS ban did not have a significant effect in girls.

For boys, the workplace bans and a unit real price increase, reduced prevalence by 8.41% (95% CI 5.16 - 11.66) and 4.93% (95% CI 0.77-9.08) respectively, but POS gave an increase of 7.02% (95% CI 1.96-12.40). The introduction of graphic images on packs had an insignificant effect in boys.

#### Conclusions

TC legislation explains the out-of-trend reduction in youth smoking prevalence. The differential effects of the workplace ban, POS displays, real price changes and graphic images on packs help to explain the sharper decline in girls than boys.

These findings should remind policy makers to give increased consideration to the particular and differing effects on young people of any planned legislative changes in TCL.

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4 Article summary

5 Strengths and limitations of this study:

6  
7 The ESPAD survey provides the best available adolescent data on smoking  
8 prevalence in Ireland from 1995 to 2015.  
9

10 Nevertheless, the sample size is not ideally large and the interval between surveys is  
11 long at four years.  
12

13 The number of male and female smokers for the years 1999 and 2003 was  
14 calculated using published ESPAD Ireland data on prevalence and total sample  
15 size  
16

17 Most of the important Tobacco Control Legislation in Ireland occurred during period  
18 1995 to 2015 and their contribution to the reduction in prevalence in adolescent smoking  
19 is examined.  
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## 1 Introduction

2 Ireland is one of the pioneer countries in tobacco control and is consistently near, or at, the  
3 top of the European Tobacco Control Scale (TCS) which is based on the number and type of  
4 Tobacco Control (TC) interventions and completeness of their implementation [1]. The  
5 harmful effects of secondhand smoke had become well known since the 1980's and bans on  
6 smoking in the workplace had been introduced by many communities and some states  
7 particularly in the USA. Smoking in workplaces in Ireland was banned on a comprehensive  
8 national basis on the 29 March 2004, making Ireland the first country in the world to institute  
9 a comprehensive ban on smoking in workplaces. From that date onwards, under the Public  
10 Health (Tobacco) Acts 2002, it has been illegal to smoke in all enclosed workplaces,  
11 including bars, restaurants, clubs, offices, public buildings, and schools. The bans are strictly  
12 enforced[2]. While the 2004 smoke-free workplaces legislation has reduced adult smoking  
13 prevalence [3][4] and has helped to avoid at least 3,500 tobacco-related deaths in Ireland in  
14 the first three years [5], its impact on adolescents is less clear. A particularly large reduction,  
15 especially in girls, was observed in Irish adolescent smoking prevalence between 2003 and  
16 2015. Although the Smokefree legislation was not targeting adolescents, this study sets out to  
17 assess if it was effective in reducing adolescent smoking in Ireland and to see if it could help  
18 to explain the large fall in 30-day smoking prevalence, particularly in girls, occurring in  
19 recent years. Smoking in Irish girls exceeded that in boys for the 20 years preceding the  
20 introduction of strong tobacco control measures beginning in 2002. This was not unique in  
21 Europe but occurs in the context of the highest level of adult female smoking, reported in the  
22 world, being in the WHO Euro region[6].

23 Prevalence fell from 44.9 % in 1995 to 13.1 % in 2015 in girls and from 36.7 % to 13.1% in  
24 boys [7].

25 In Ireland, there were no school-specific TCL introduced between 1995 and 2015. However,  
26 Smokefree legislation (2004) and other policies that would potentially help to reduce  
27 adolescent smoking prevalence were introduced since 1995. The other TCLs were 1) a ban  
28 on packs of 10 cigarettes at the end of May 2007, 2) the point-of-sale (POS) advertising  
29 display ban of tobacco products introduced in 2009, and 3) the inclusion of graphic images on  
30 both sides of tobacco packs in 2011 (Appendix 1). The existing international evidence  
31 suggested that these interventions could be expected to advance tobacco control and help to  
32 reduce smoking in young people [8–10]. In particular, Ireland was the first country in EU to  
33 implement a ban on point-of-sale display, which came into effect on 1 July 2009. The  
34 legislation prohibited advertising of tobacco products in retail premises and mandated that  
35 tobacco products must be stored out of view of customers. It also prohibited vending  
36 machines except in licensed premises and registered clubs (in accordance with Regulations),  
37 and that all persons selling tobacco products by retail had to register with the Office of  
38 Tobacco Control (OTC). One of the motivations behind these legislative changes was to  
39 reduce awareness of smoking, especially among young people. Therefore, it is also of interest  
40 to assess if these laws contributed to the reduction in adolescent smoking prevalence.

## 41 Methods

### 42 Data

This study used data from the European School Survey Project on Alcohol and Other Drugs (ESPAD) in Ireland. The main purpose of the survey was to collect comparable data on substance use among 16-year-old students across Europe, in order to monitor trends within and between countries, including Ireland [8]. ESPAD surveys were conducted every four years from 1995 to 2015, resulting in six waves of data from 26 countries, and 35 countries participating in 2015. The sampling procedures, data collection and questionnaires used in Ireland were consistent with the international ESPAD study protocol [8]. School students born in specific calendar years were eligible and selected in Ireland using stratified random sampling. Data were collected anonymously through paper-and-pencil, self-completion questionnaire administered in the classroom. After standardised cleaning procedures, the datasets (2007, 2011 and 2015 waves) were obtained from the ESPAD official database. Full accounts of the methodology of the study in each survey year can be found in the respective reports of the ESPAD project[8–10].

Original raw datasets from the 1999 and 2003 waves were unavailable. However, smoking prevalence and sample size of both genders are available from officially published reports[11,12]. The number of smokers and non-smokers of both genders in those two surveys are reconstructed as shown in Table 1.

**Table 1 Reconstructed number of smokers form 6 ESPAD surveys from 1995 to 2015**

	Male smokers	Female smokers	Total smokers	Total survey sample
1995	328	421	749	1832
1999	355	491	846	2277
2003	343	442	785	2407
2007	194	325	519	2216
2011	207	254	461	2205
2015	98	92	190	1467

The final data were aggregated every four years from 1995 to 2015, with an average of 2,067 observations per survey year. The observed smoking prevalence estimates as the average of 0-1 smoker variable that indicates whether an individual in the sample smokes. The prevalence along the years are shown in Figure 1. Tobacco control policies which may have confounded the impact of workplace ban on adolescent smoking are included in the model. In particular, indicator variables for the introduction of the POS ban and graphic images shown on packages were included. Increasing price on cigarettes is found to be one of the most effective measures in reducing smoking, particularly among adolescents as they usually have less disposable money and cigarettes are therefore less affordable for them than they are for adults [13,14]. Ireland has increased the price of cigarettes every year since 1995, from 3.5 EUR in 1995 to 10.5 EUR in 2015. The real price changes, where price is adjusted for consumer price index (CPI) are shown in the Supplementary File 1. We used changes in real price, rather than changes in tobacco taxes, because of the industry and retailers' roles in pricing of tobacco products which may distort the effects of taxation [15].

Average real price therefore is included in the model to capture price effect.

Table 1 Reconstructed number of smokers from 6 ESPAD surveys from 1995 to 2015

1  
2  
3 784  
5 796  
7 808  
9 81 Figure 1 Trend of Irish adolescent smoking prevalence by gender (%) 1995-2015 ESPAD  
10 82 surveys11  
12 8313  
14 84 Statistical analysis15  
16 85 For statistical analysis, a logistic regression model on grouped data was used. All analyses  
17 86 were conducted separately for boys and girls because we found that they show the effects of  
18 87 individual TCL interventions more precisely than pooled data. We have included real price  
19 88 and policy indicators. Seven models are assessed. First, we look at the impact of real price on  
20 89 adolescent prevalence (Model 0). Then we assess the impact of workplace ban on adolescent  
21 90 smoking by adding a workplace ban indicator, together with price (Model 1).22  
23  
24 91 Then we repeat the first step by replacing the workplace ban by the POS ban indicator  
25 92 (Model 2) and graphic images indicator (Model 3). Pairwise combinations of the policy  
26 93 indicators are also considered (Model 4 – 6). Lastly, all policy indicators and price are  
27 94 included (Model 7). Various criteria are used to determine the best model. In particular,  
28 95 models with smaller Akaike information criterion (AIC) values and Bayesian information  
29 96 criterion (BIC) values are preferred. Likelihood ratio tests are used for comparing two nested  
30 97 models. A significant test suggests that the full model is an improvement on the reduced  
31 98 model. All analyses were performed with the Stata 13 (StataCorp. 2013. Stata Statistical  
32 99 Software: Release 13. College Station, TX: StataCorp LP.)33  
34  
35  
36 100 Patient and public involvement37  
38 101 No patients were involved. The principals of the schools involved were fully informed and  
39 102 cooperated in explaining the studies and administering the surveys. The results of each  
40 103 surveys were disseminated through the media and Dept of Health.41  
42 10443  
44 10545  
46 106 Results47  
48 10749  
50 108 The regression results of the seven models are presented in Supplementary File 2. For boys,  
51 109 all of the variables in each model are strongly significant except for graphic images. Average  
52 110 real price increase and introducing the workplace ban reduced smoking prevalence. Model 4  
53 111 provides the best fit to the data as shown in Table 2 (a). First, Model 4 has the smallest AIC  
54 112 among the seven models. Secondly, the likelihood ratio tests on Model 4 and Model 0-2 are  
55 113 all significant (all p values <0.02), which implies that Model 3 is an improvement on the  
56 114 reduced models. In addition, likelihood ratio test on Model 4 and Model 7 is insignificant (p  
57 115 value=0.81), which shows that Model 7 is not an improvement on Model 4. It is confirmed  
58  
59 116 by the insignificant coefficient of graphic images in Model 7.



117 Table 2 (b) shows how much the boys' prevalence was marginally affected by various  
 118 variables in the best fit model, i.e. Model 4. Controlling for price and POS ban, introducing  
 119 the workplace ban reduced the prevalence by 4.93% (95% CI 0.77%-9.08%), which is a  
 120 considerable reduction given the prevalence before the ban was 33%. The effect of real price  
 121 increase is also large and significant, a unit increase in the real price reduces the prevalence  
 122 by 8.41% (95% CI 5.16% - 11.66%). However, POS ban was associated with increased  
 123 prevalence by 7.02% (95% CI 1.65% -12.40%).

124 For girls, Model 5 provides the best fit as shown in Table 2 (a). First, the likelihood ratio tests  
 125 on Model 5 and Model 0, 1 and 3 are all significant (p value<0.01), suggesting that Model 5  
 126 is an improvement on the reduced models. In addition, likelihood ratio test on model 5 and 7  
 127 is insignificant (p value=0.20). Model 7 is not an improvement on Model 5, confirmed by the  
 128 insignificant coefficient of POS ban. Secondly, Model 5 has smallest AIC.

129 From Table 2 (b), we can see that introducing the workplace ban reduced girls' prevalence by  
 130 7.31% (95% CI 2.94%-11.68%), which is larger than the effect on boys, but without  
 131 statistically significant difference. In addition, the marginal effect of real price is 5.87% (95%  
 132 CI 2.96% - 8.79%), which is smaller than the price effect on boys. Introduction of graphic  
 133 images is associated with 8.80% (95% CI 2.60% - 15.01%) reduction in girls' prevalence, in  
 134 contrast to the insignificant impact on boys.

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Table 2a ESPAD 1995-2015 Logistic regression results from best fit models

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VARIABLES	Regression results (Odds ratios and CI)	
	Boy	Girl
Real price	0.63*** (0.52, 0.75)	0.75*** (0.65, 0.86)
Workplace ban	0.76* (0.60, 0.96)	0.70** (0.56, 0.86)
POS ban	1.48* (1.10, 2.00)	
Graphic images		0.65** (0.47, 0.88)
Constant	2.83** (1.40, 5.71)	2.13** (1.22, 3.72)
Observations	6,080	6,324
AIC	6657	7606
BIC	6684	7633

CI is confidence interval at 95% confidence level

\*\*\* p<0.001, \*\* p<0.01, \* p<0.05

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Table 2b ESPAD 1995-2015 Reduction in smoking prevalence from best fit models

VARIABLES	Marginal effect (Reduction in prevalence and CI)	
	Boy	Girl
Real price	-8.41%*** (-11.66%, -5.16%)	-5.87%*** (-8.79%, -2.96%)
Workplace ban	-4.93%* (-9.08%, -0.77%)	-7.31%** (-11.68%, -2.94%)
POS ban	7.02%* (1.65%, 12.40%)	
Graphic images		-8.80%** (-15.01%, -2.60%)

CI is confidence interval at 95% confidence level

\*\*\* p<0.001, \*\* p<0.01, \* p<0.05

Figure 2 Prevalence of smoking from ESPAD surveys from 1995-2015 showing that the best fit model matches the actual prevalence

## Discussion

Although there is a general decline in adolescent smoking prevalence in ESPAD countries, there is no evidence of convergence in the different countries or geographic regions [16]. In Ireland, there was a steep drop in adolescent smoking prevalence between 2003 and 2007 when the decline was similar in girls and boys but greater in girls. The results show that the workplace ban introduced in 2004 helps to explain the steep drop in prevalence when controlling for the real price effect, which itself is consistently found to be effective in other studies[17,18]. In particular, although the overall average real price increased for the 2003-2007 period compared to the previous period, the annual real price actually decreased for the two years 2004 to 2006. This reinforces the strong impact of the workplace ban on reducing smoking prevalence between the 2003 and 2007 period. In addition, the workplace ban rendered an estimated additional 5% reduction in actual smoking prevalence beyond price effect, which is a considerable effect given that the prevalence was 37% among females and 28% among males in 2003. The study however also confirms that real cigarette prices are strong determinants of youth smoking[17,18].

Furthermore, the other components of the WHO MPOWER policy package, consisting of a series of technical measures and resources to assist country-level implementation of the WHO Framework Convention on Tobacco Control (FCTC) e.g. smoking cessation services,

1  
2  
3 173 advertising, promotion and sponsorship, did not change significantly between 2003 and 2007.  
4 174 In particular, mass media campaigns stayed moderately funded for the whole period of 1995  
5 175 to 2015. Health warnings were moderate between 2003 and 2007, and cessation treatment  
6 176 and youth access were stable in the period [19]. Therefore, between 2003 and 2007, the only  
7 177 significant and positive change in tobacco control policies was the introduction of the  
8 178 workplace ban.

11 179 The mechanisms that explain the link between the workplace ban and adolescent smoking  
12 180 prevalence are uncertain and our data do not allow a further interrogation. However, some  
13 181 studies from other countries have provided some explanations. For example, one study shows  
14 182 that stronger public places restrictions had a significantly protective effect on smoking  
15 183 prevalence[20]. Another suggested that a workplace ban affects adolescents who are at work  
16 184 (through part-time jobs)[21]. It showed that adolescents who worked in smoke-free  
17 185 workplaces were only 68% (95% CI, 51%-90%) as likely to be smokers as adolescents who  
18 186 worked in a workplace with no smoking restrictions. It is also possible that the discourse  
19 187 around smoking which occurred pre-implementation of Smokefree Legislation helped to  
20 188 denormalise smoking in general even though the law was primarily about the workplace[22].  
21 189 The decrease in prevalence from 2007 to 2011 was much steeper in girls than boys. During  
22 190 this period, the annual real price decreased from 2010 to 2011 although the average real price  
23 191 for the period 2007 to 2011 increased slightly (Supplementary File 1). The model suggests  
24 192 that price has a greater marginal effect on boys than girls (8.4 % V 5.8 %). The decrease in  
25 193 the annual real price, which is not taken into account in the change of average real price in  
26 194 the model and the finding that the workplace ban seemed to have a greater effect in girls than  
27 195 boys (7.3% V 4.9%) may partially explain the difference in the rate of decline in prevalence.  
28 196 The impact of the POS ban on reducing youth smoking prevalence was not significant, which  
29 197 is consistent with the finding of the study by McNeill A. et al. (2011)[23]. They failed to find  
30 198 significant short-term changes in prevalence among youths or adults due to POS ban.  
31 199 However, their study showed that the proportion of youths believing that more than a fifth of  
32 200 children their own age smoked decreased from 62% to 46%,  $p < 0.001$ ). Post-legislation, 38%  
33 201 of teenagers thought it would make it easier for children not to smoke. Compliance was very  
34 202 high and the law was well supported. Recall of tobacco displays among teenagers reduced  
35 203 significantly post-legislation and there were encouraging signs that the law helped de-  
36 204 normalise smoking. While it was postulated at the time that it might take a longer time for the  
37 205 POS ban to effectively reduce smoking prevalence among youths, we have not seen it in this  
38 206 study based on a longer time series. Others however have seen more positive results in young  
39 207 people[24,25]. Context may be significant in this regard as our population were under age  
40 208 for legal purchase of cigarettes in Ireland and access in those circumstances occurs through  
41 209 other routes where POS displays may not be relevant. It does not however explain why the  
42 210 POS display ban was associated with a negative effect in boys in this analysis. It seems likely  
43 211 that this may have been partially a price effect because the real price actually declined in two  
44 212 of the relevant years (Supplementary File 1) but also there was a marked switch to cheaper  
45 213 roll your own cigarettes in both adults and teens[26,27].

55 214 In ESPAD countries, with different initial status from Ireland, generally, gender convergence  
56 215 is marked in smoking prevalence. In 1995, on average in ESPAD countries boys showed  
57 216 higher smoking prevalence than girls. In 2015, these differences were no longer apparent or  
58 217 became smaller. However, in 1995 Irish female adolescents had a much higher smoking

218 prevalence than male adolescents (45% VS 37%), price and workplace ban effects were  
219 marked in both genders but somewhat different. As discussed above price effect was stronger  
220 in boys than girls although there is no conclusive evidence on this in the literature[17,28].  
221 The impact of the POS ban differed between the two groups. In particular, POS ban did not  
222 significantly affect girls' smoking prevalence, while it is significantly and positively (7 %)   
223 related to boys' smoking prevalence. The introduction of graphic images on packs seemed to  
224 have a much greater impact on girls with an 8.8% marginal effect whereas it had no  
225 significant effect on boys. These differential effects on POS and graphic images with the  
226 lesser differentials for price and the workplace ban may explain why we observed that by the  
227 end of the period, the gender gap was closed, with female prevalence being less than male  
228 prevalence by 2015, consistent with most ESPAD countries.

229 One of the potential issues of the above analysis is that the sample size is not ideally large  
230 and the interval between each survey is long, as there were only six surveys between 1995  
231 and 2015. However, this is so far the best adolescent survey data in Ireland that provides  
232 adolescent smoking prevalence. Other surveys on smoking either didn't have enough  
233 adolescent samples (e.g. Survey on Lifestyle and Attitude to Nutrition and Healthy Ireland  
234 surveys), or were too recent to establish a baseline before the policies were introduced (e.g.  
235 Monthly phone interview surveys from National Tobacco Control Office from 2002), or had  
236 fewer data points (e.g. Health Behaviour in School-aged Children study had 5 waves between  
237 1998 and 2014). Another limitation is that the data of 1999 and 2003 were obtained by  
238 recalculating the number of male and female smokers based on prevalence and total sample  
239 size, a process which may have introduced very small inaccuracies. However, the results are  
240 clear cut and the margin of error compared to total sample is negligible. Therefore, the  
241 process should not have significant impact on the results.

## 242 Conclusions

243 Adolescent smoking prevalence dropped significantly in boys and girls in Ireland. This study  
244 found that the workplace ban introduced in 2004, to protect workers and customers from  
245 second-hand smoking, has significantly helped to explain the out-of-trend reduction in  
246 adolescent smoking prevalence. While removal of point of sale tobacco promotion may have  
247 reduced awareness of smoking among young people, there was no evidence of a beneficial  
248 effect on prevalence. Graphic images appear to have made a significant impact on girls'  
249 smoking prevalence but not on boys. In addition, we confirmed that price increase was  
250 consistently effective in both boys and girls. The implications for the whole population,  
251 considering age and gender, should be considered for all TCLs being introduced by policy  
252 makers irrespective of the targeted segment of the population.

253

## 254 **Figure 1 Trend of Irish adolescent smoking prevalence by gender (%) 1995-2015** 255 **ESPAD**

256 surveys

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## 258 **Figure 2 Prevalence of smoking from ESPAD surveys from 1995-2015 and fitted lines of** 259 **predicted prevalence from best fit models for boys and girls**

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5 **Funding:** Dept. of Health Ireland DOH RFT 2015

6  
7 Royal City of Dublin Hospital Trust RCDHT Grant 178

8  
9 The funders of the study had no role in study design, data collection, data analysis, data  
10 interpretation, or writing of the report. The corresponding author had full access to all the  
11 data in the study and had final responsibility for the decision to submit for publication.  
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19 **Ethical Approval:** Ethical approval was awarded by Dublin Institute of Technology,  
20 Research Ethics, Ethical Clearance Ref 18 -126.  
21

22 New approval for this use of the study data set was not considered necessary as ESPAD  
23 Ireland PI with full access to ESPAD data set. We used fully anonymised aggregate data.  
24  
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26

### 27 **Contributors**

28  
29 LC conceived the study. LC and SL designed the study. SL, SK and LC were involved in  
30 analysis of the data. SL drafted the first version of the manuscript. LC and SK had input into  
31 all redrafts. All authors read and approved the final version.  
32  
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### 37 **COI**

38  
39 LC, SK and SL declare no competing interests.  
40  
41  
42

### 43 **Data Sharing**

44  
45 No additional data available

46  
47 The data were from the European School Survey

48  
49 Project on Alcohol and Other Drugs (ESPAD) and various official reports available from  
50 <http://www.espad.org/reports-documents>. With the 2003 data collection as a starting point,  
51 it was decided that all country datasets should be merged into a common database. After that  
52 also data from 2007 and 2011 are available in separate databases. Initially, these databases  
53 were stored and maintained by the Databank Manager Thoroddur Bjarnson. During the 2015  
54 wave of ESPAD, the international database was compiled and standardised by CAN  
55 (Stockholm). Even though, since 2007, countries are obliged to deliver their national datasets  
56 to the database, there are—as stated in the database rules—no obligations to let other  
57 researchers use the national data without permission. In order to obtain a copy of a database,  
58 an application form has to be filled in and posted to the coordinators for further distribution to  
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3 the ESPAD Application Committee. The composition of the committee as well as restrictions  
4 around the database and its use are described and explained in the ESPAD database rules  
5 (database rules for ESPAD researchers and database rules for non-ESPAD researchers).  
6 When an application is approved, a contract is signed before a copy of the database is  
7 delivered. Approved applications are presented in a list, which also displays the deadline of  
8 the projects. ESPAD researchers are allowed to apply for the most recent database once the  
9 International ESPAD Report has been released. Non-ESPAD researchers are also allowed to  
10 work with ESPAD data. Access for non-ESPAD researchers is allowed after an embargo  
11 period determined by an assembly: ESPAD 2003 Database: accessible now. ESPAD 2007  
12 Database: was accessible since 1 July 2013. ESPAD 2011 Database: was accessible since 1  
13 July 2015. ESPAD 2015 Database: at present, it is only accessible to ESPAD researchers.  
14 [http://www.espad.org/sites/espad.org/themes/cs\\_espad/logo.png](http://www.espad.org/sites/espad.org/themes/cs_espad/logo.png):  
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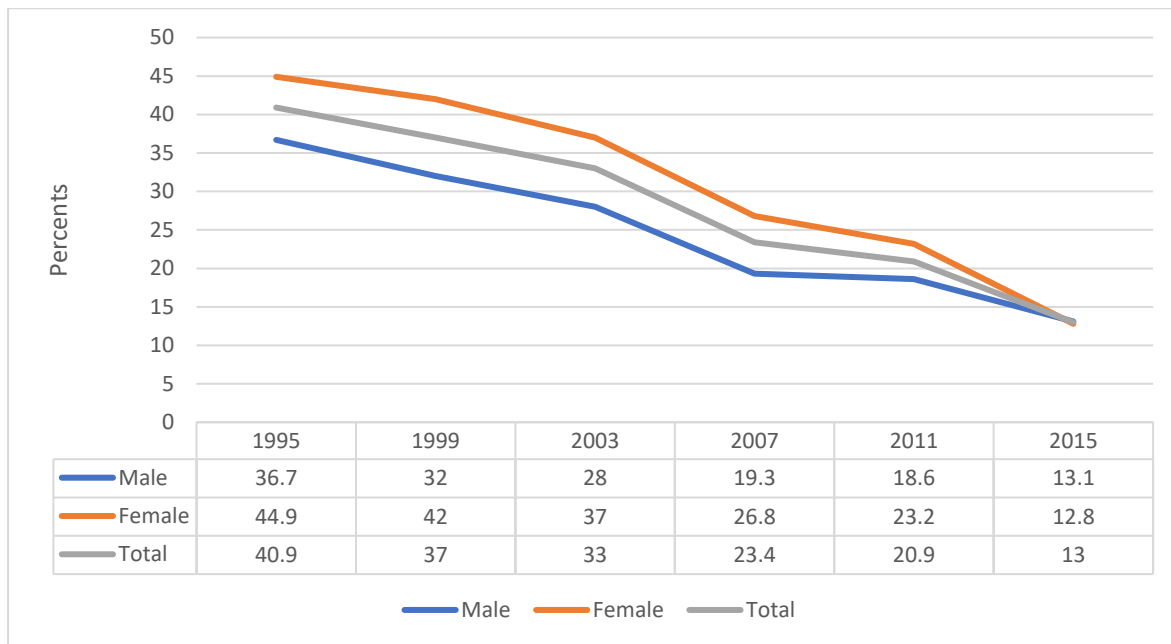
24 **Acknowledgements:** We wish to thank Focas Research Institute, Dublin Technical  
25 University for facilities and the ESPAD international researchers supported by EMCDDA  
26 contract CC.14.SDI.032 who compiled a common ESPAD Trend database (1995–2015)  
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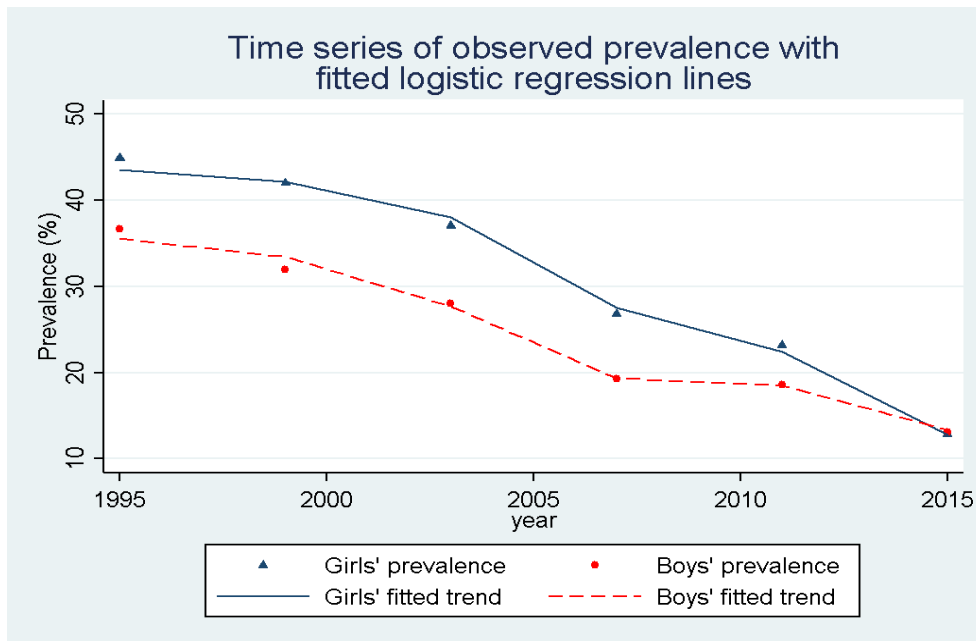
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**Figure 1 Trend of Irish adolescent smoking prevalence by gender (%) 1995-2015 ESPAD surveys**



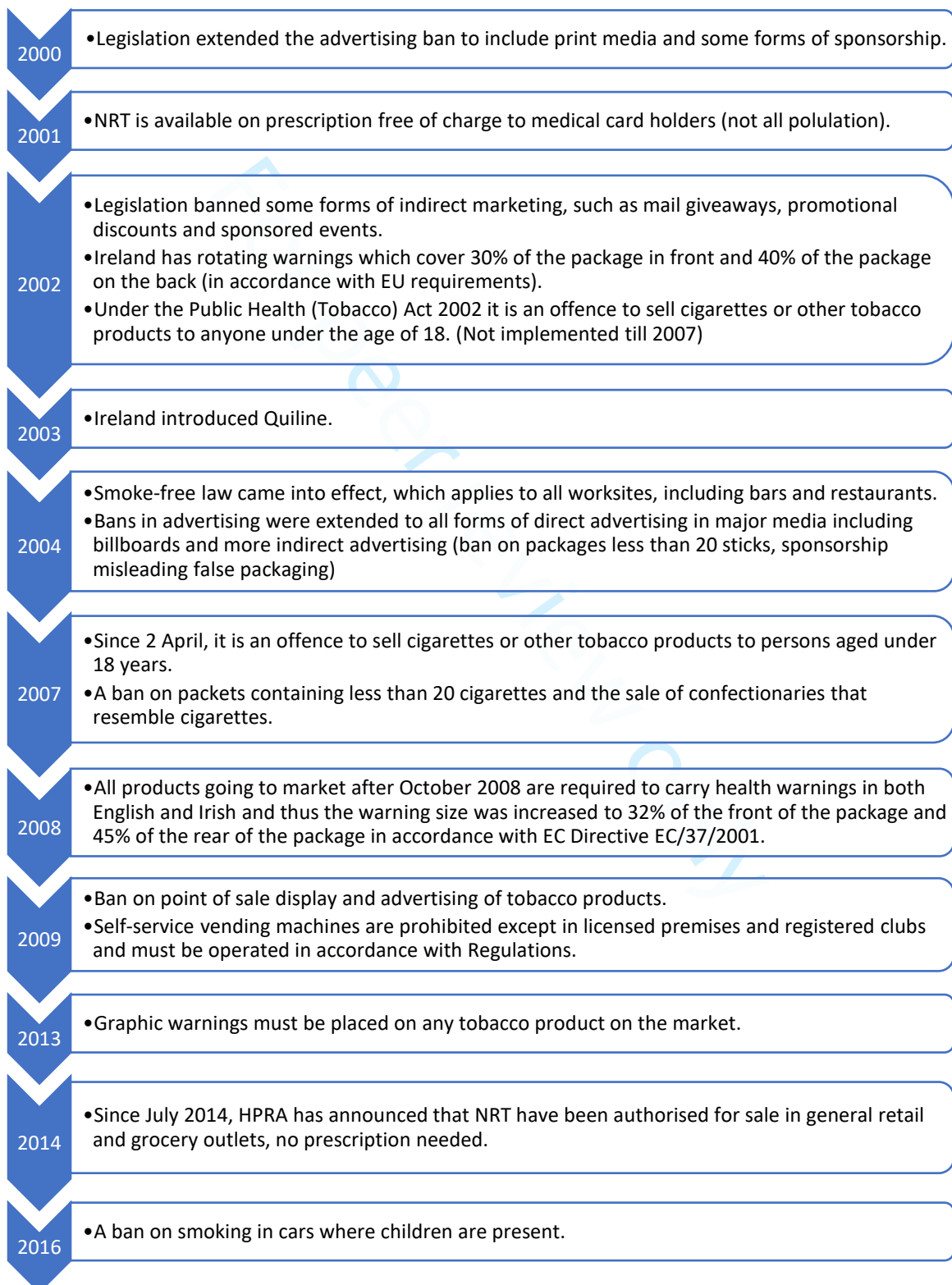
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Figure 2. Prevalence of smoking from ESPAD surveys from 1995-2015 and fitted lines of predicted prevalence from best fit models for boys and girls



## Appendix 1

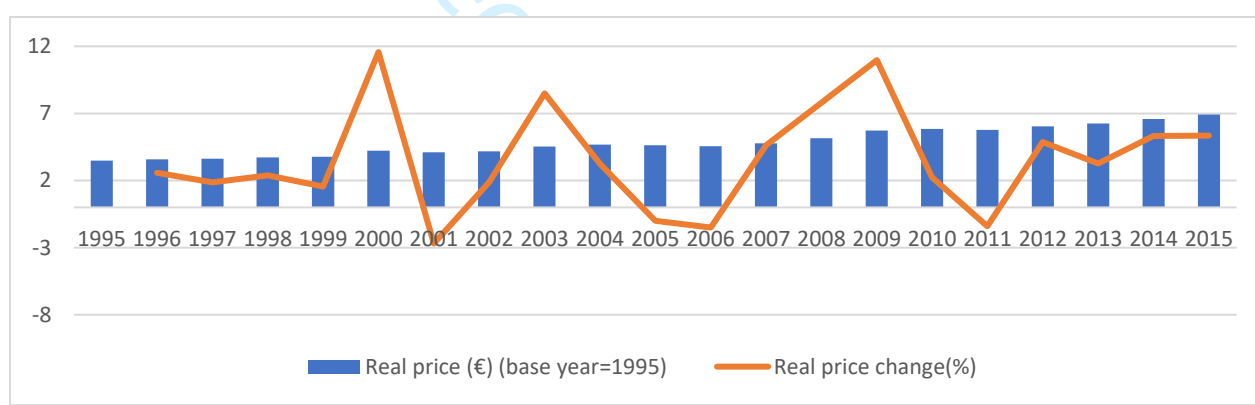
### Timeline of Tobacco Control Policies/ Interventions in Ireland, 2000 -2016



Supplementary File 1

Table 1 Real price (€) per package of 20 cigarettes in Ireland, 1995-2015

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Retail price	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5
CPI (year 1995=100)	100	102	103	106	107	109	112	114	119	120	125	127	130	134	136	140	141	144	145	148	150
Real price (base year=1995)	3.5	3.6	3.6	3.7	3.8	4.2	4.1	4.2	4.5	4.7	4.6	4.6	4.8	5.2	5.7	5.8	5.9	6.1	6.2	6.3	6.4
Real price change (%)	-	2.6	1.9	2.4	1.6	11.6	2.4	1.9	8.5	3.2	1.7	1.5	4.6	7.8	11.1	1.7	1.4	4.9	3.3	5.3	5.3



## Supplementary File 2

Irish ESPAD 1995 to 2015:

Logistic regression of male prevalence on factors from various models 1-7

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VARIABLES	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Real price	0.65*** (0.02)	0.75*** (0.05)	0.54*** (0.04)	0.64*** (0.03)	0.63*** (0.06)	0.78** (0.06)	0.53*** (0.04)	0.64*** (0.07)
Workplace ban		0.72** (0.08)			0.76* (0.09)	0.70** (0.09)		0.75* (0.10)
POS ban			1.57** (0.23)		1.48* (0.23)		1.59** (0.24)	1.47* (0.23)
Graphic images				1.09 (0.16)		0.90 (0.15)	1.12 (0.17)	0.96 (0.16)
Constant	2.39*** (0.36)	1.43 (0.34)	4.83*** (1.34)	2.55*** (0.48)	2.83** (1.01)	1.24 (0.39)	5.36*** (1.64)	2.66* (1.17)
Observations	6,080	6,080	6,080	6,080	6,080	6,080	6,080	6,080
AIC	6668	6662	6661	6669	6657	6663	6662	6659
BIC	6681	6682	6681	6689	6684	6690	6689	6693

Coefficients are odds ratios

SE in parentheses

\*\*\* p&lt;0.001, \*\* p&lt;0.01, \* p&lt;0.05

## Irish ESPAD 1995 to 2015

## Logistic regression of female prevalence on factors from various models 1-7

VARIABLES	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Real price	0.59*** (0.02)	0.65*** (0.04)	0.52*** (0.03)	0.61*** (0.02)	0.58*** (0.05)	0.75*** (0.06)	0.54*** (0.04)	0.68*** (0.07)
Workplace ban		0.79* (0.08)			0.83 (0.09)	0.70** (0.08)		0.73** (0.09)
POS ban			1.36* (0.18)		1.27 (0.18)		1.35* (0.18)	1.20 (0.17)
Graphic images				0.80 (0.12)		0.65** (0.10)	0.81 (0.12)	0.67* (0.11)
Constant	5.24*** (0.74)	3.58*** (0.77)	8.46*** (2.12)	4.48*** (0.78)	5.65*** (1.92)	2.13** (0.61)	7.22*** (1.97)	3.11** (1.29)
Observations	6,324	6,324	6,324	6,324	6,324	6,324	6,324	6,324
AIC	7615	7612	7612	7615	7611	7606	7611	7606
BIC	7629	7632	7632	7635	7638	7633	7639	7640

Coefficients are odds ratios

SE in parentheses

\*\*\* p&lt;0.001, \*\* p&lt;0.01, \* p&lt;0.05

# Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

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Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

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			Page Number
<b>Title and abstract</b>			
Title	<a href="#">#1a</a>	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	<a href="#">#1b</a>	Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background / rationale	<a href="#">#2</a>	Explain the scientific background and rationale for the investigation being reported	3
Objectives	<a href="#">#3</a>	State specific objectives, including any prespecified hypotheses	3
<b>Methods</b>			
Study design	<a href="#">#4</a>	Present key elements of study design early in the paper	4
Setting	<a href="#">#5</a>	Describe the setting, locations, and relevant dates, including periods of	4



		recruitment, exposure, follow-up, and data collection	
1			
2	Eligibility criteria	<a href="#">#6a</a> Give the eligibility criteria, and the sources and methods of selection of participants.	4
3			
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5			
6		<a href="#">#7</a> Clearly define all outcomes, exposures, predictors, potential	5
7		confounders, and effect modifiers. Give diagnostic criteria, if applicable	
8			
9			
10	Data sources /	<a href="#">#8</a> For each variable of interest give sources of data and details of methods	4
11	measurement	of assessment (measurement). Describe comparability of assessment	
12		methods if there is more than one group. Give information separately	
13		for for exposed and unexposed groups if applicable.	
14			
15			
16			
17	Bias	<a href="#">#9</a> Describe any efforts to address potential sources of bias	4-5
18			
19	Study size	<a href="#">#10</a> Explain how the study size was arrived at	4
20			
21	Quantitative	<a href="#">#11</a> Explain how quantitative variables were handled in the analyses. If	4
22	variables	applicable, describe which groupings were chosen, and why	
23			
24			
25	Statistical	<a href="#">#12a</a> Describe all statistical methods, including those used to control for	4
26	methods	confounding	
27			
28			
29	Statistical	<a href="#">#12b</a> Describe any methods used to examine subgroups and interactions	4
30	methods		
31			
32			
33	Statistical	<a href="#">#12c</a> Explain how missing data were addressed	4
34	methods		
35			
36			
37	Statistical	<a href="#">#12d</a> If applicable, describe analytical methods taking account of sampling	4
38	methods	strategy	
39			
40			
41	Statistical	<a href="#">#12e</a> Describe any sensitivity analyses	4
42	methods		
43			
44			
45	<b>Results</b>		
46			
47	Participants	<a href="#">#13a</a> Report numbers of individuals at each stage of study—eg numbers	4
48		potentially eligible, examined for eligibility, confirmed eligible,	
49		included in the study, completing follow-up, and analysed. Give	
50		information separately for for exposed and unexposed groups if	
51		applicable.	
52			
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55	Participants	<a href="#">#13b</a> Give reasons for non-participation at each stage	4
56			
57	Participants	<a href="#">#13c</a> Consider use of a flow diagram	na
58			
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60			

1	Descriptive data	<a href="#">#14a</a>	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	4
2				
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6	Descriptive data	<a href="#">#14b</a>	Indicate number of participants with missing data for each variable of interest	4
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10	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	5
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14	Main results	<a href="#">#16a</a>	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	5
15				
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18				
19	Main results	<a href="#">#16b</a>	Report category boundaries when continuous variables were categorized	5
20				
21	Main results	<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	5
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25	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	5
26				
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29	<b>Discussion</b>			
30				
31	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives	6
32				
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34	Limitations	<a href="#">#19</a>	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	3,7
35				
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39	Interpretation	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	7
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44	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study results	7
45				
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47	<b>Other</b>			
48	<b>Information</b>			
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50				
51	Funding	<a href="#">#22</a>	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	10
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# BMJ Open

## Does Smoke-free legislation work for teens too? A logistic regression analysis of smoking prevalence and gender among 16-year-olds in Ireland, using the 1995-2015 ESPAD school surveys

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-032630.R2
Article Type:	Original research
Date Submitted by the Author:	08-Nov-2019
Complete List of Authors:	Li, Shasha; TobaccoFree Research Institute Ireland, TU Dublin, Kevin Street, Dublin 8 Keogan, Sheila; TobaccoFree Research Institute Ireland, TU Dublin, Kevin Street, D8 Clancy, Luke; TobaccoFree Research Institute Ireland, TU Dublin, Kevin Street, Dublin 8
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Epidemiology, Smoking and tobacco, Addiction, Communication
Keywords:	Price,, Secondhand smoke, Advertising and Promotion,, Denormalisation, EPIDEMIOLOGY, Graphic Tobacco Images

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7 1995-2015 ESPAD school surveys  
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43 Keywords: Price, Secondhand smoke, Advertising and Promotion,  
44 Denormalisation  
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47 Word Count 3609  
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## Abstract

### Objectives:

To assess the role of Tobacco Control Legislation (TCL) in youth smoking in Ireland. To examine the effects of Smokefree legislation in youth. To consider whether TCL contributed to the gender equalisation in prevalence in 16-year olds seen between 2003 and 2015.

### Setting:

Data are from the 4 yearly European School Survey Project on Alcohol and Other Drugs (ESPAD) from 1995 to 2015. Total sample size was 12.394. A logistic regression model on grouped data was used. Dependent variable is whether a student was a smoker in last-30 day. Independent variables are time, gender and the policy indicators, workplace ban on smoking, Point-of-Sale (POS) display ban, the introduction of graphic images on packs and the average real price of cigarettes.

### Results:

Smoking prevalence dropped from 41% in 1995 to 13% in 2015. The effects of policies differed between boys and girls.

For girls, estimates for workplace bans, graphic images on packs, and a unit real (CPI adjusted) price increase reduced prevalence by 7.31 % (95% CI 2.94-11.68), 8.80% (95% CI 2.60-15.01) and 5.87(95% CI 2.96-8.79) respectively. The POS ban did not have a significant effect in girls.

For boys, estimates for workplace bans and a unit real price increase, reduced prevalence by 8.41% (95% CI 5.16 - 11.66) and 4.93% (95% CI 0.77-9.08) respectively, POS gave an increase of 7.02% (95% CI 1.96-12.40). The introduction of graphic images had an insignificant effect.

### Conclusions

TC legislation helps to explain the out-of-trend reduction in youth smoking prevalence. The estimated differential effects of the workplace ban, POS displays, real price changes and graphic images on packs help to explain the sharper decline in girls than boys.

These findings should remind policy makers to give increased consideration to the possible effects on young people of any legislative changes aimed at adults in TCL.

## Article summary

### Strengths and limitations of this study:

The ESPAD survey provides the best available adolescent data on smoking prevalence in Ireland from 1995 to 2015.

Nevertheless, the sample size is not ideally large and the interval between surveys is long at four years.

The number of male and female smokers for the years 1999 and 2003 was calculated using published ESPAD Ireland data on prevalence and total sample size

Most of the important Tobacco Control Legislation in Ireland occurred during period 1995 to 2015 and their contribution to the reduction in prevalence in adolescent smoking is examined.

## Introduction

Ireland is one of the pioneer countries in tobacco control and is consistently near, or at, the top of the European Tobacco Control Scale (TCS) which is based on the number and type of Tobacco Control (TC) interventions and completeness of their implementation [1]. The harmful effects of secondhand smoke had become well known since the 1980's and bans on smoking in the workplace had been introduced by many communities and some states particularly in the USA.

Smoking in workplaces was banned in Ireland on a comprehensive national basis on the 29 March 2004, making Ireland the first country in the world to institute a comprehensive national ban on smoking in workplaces. From that date onwards, under the Public Health (Tobacco) Acts 2002, it has been illegal to smoke in all enclosed workplaces, including bars, restaurants, clubs, offices, public buildings, and schools. The bans are strictly enforced[2]. While the 2004 smoke-free workplaces legislation has reduced adult smoking prevalence [3][4] and helped to avoid at least 3,500 tobacco-related deaths in Ireland in the first three years [5], its impact on adolescents is less clear.

A particularly large reduction, especially in girls, was observed in Irish adolescent smoking prevalence between 2003 and 2015. Smoking in Irish girls exceeded that in boys for the 20 years preceding the introduction of strong tobacco control measures beginning in 2002. This high prevalence in girls was not unique in Europe but occurs in the context of the highest level of adult female smoking, reported in the world, being in the WHO Euro region[6].

In Ireland, prevalence fell from 44.9 % in 1995 to 13.1 % in 2015 in girls and from 36.7 % to 13.1% in boys [7]. There were no school-specific TCL introduced between 1995 and 2015. However, Smokefree legislation (2004) and other policies that could potentially help to reduce adolescent smoking prevalence were introduced since 1995. These were 1) a ban on packs of 10 cigarettes at the end of May 2007, 2) the point-of-sale (POS) advertising display ban of tobacco products introduced in 2009, and 3) the inclusion of graphic images on both sides of tobacco packs in 2011 (Appendix 1). The existing international evidence suggested that these interventions could be expected to advance tobacco control and help to reduce smoking in young people [8–10].

In particular, Ireland was the first country in EU to implement a ban on point-of-sale display, which came into effect on 1 July 2009. The legislation prohibited advertising of tobacco products in retail premises and mandated that tobacco products must be stored out of view of customers. It also prohibited vending machines except in licensed premises and registered clubs (in accordance with Regulations), and that all persons selling tobacco products by retail had to register with the Office of Tobacco Control (OTC). One of the motivations behind these legislative changes was to reduce awareness of smoking, especially among young people.



This study sets out to assess if Smokefree legislation, which was not targeting adolescents, was effective in reducing adolescent smoking in Ireland, and to see if it could help to explain the large fall in 30-day smoking prevalence, particularly in girls, occurring in recent years. Also, to consider whether the other TC measures, which are described above, contributed to the gender equalisation in prevalence in 16-year olds that occurred between 2003 and 2015.

## Methods

### Data

This study used data from the European School Survey Project on Alcohol and Other Drugs (ESPAD) in Ireland. The main purpose of the survey was to collect comparable data on substance use among 16-year-old students across Europe, in order to monitor trends within and between countries, including Ireland [8]. ESPAD surveys were conducted every four years from 1995 to 2015, resulting in six waves of data from 26 countries, and 35 countries participating in 2015. The sampling procedures, data collection and questionnaires used in Ireland were consistent with the international ESPAD study protocol [8]. School students born in specific calendar years were eligible and selected in Ireland using stratified random sampling.

Data were collected anonymously through paper-and-pencil, self-completion questionnaire administered in the classroom. After standardised cleaning procedures, the datasets (2007, 2011 and 2015 waves) were obtained from the ESPAD official database. Full accounts of the methodology of the study in each survey year can be found in the respective reports of the ESPAD project[8–10].

Original raw datasets from the 1999 and 2003 waves were unavailable. However, smoking prevalence and sample size of both genders are available from officially published reports[11,12]. The number of smokers and non-smokers of both genders in those two surveys are reconstructed as shown in Table 1.

**Table 1 Reconstructed number of smokers form 6 ESPAD surveys from 1995 to 2015**

	Male smokers	Female smokers	Total smokers	Total survey sample
1995	328	421	749	1832
1999	355	491	846	2277
2003	343	442	785	2407
2007	194	325	519	2216
2011	207	254	461	2205
2015	98	92	190	1467

The final data were aggregated every four years from 1995 to 2015, with an average of 2,067 observations per survey year. The observed smoking

1  
2  
3 prevalence estimates as the average of 0-1 smoker variable that indicates  
4 whether an individual in the sample smokes. The prevalence along the years are  
5 shown in Figure 1. Tobacco control policies which may have confounded the  
6 impact of workplace ban on adolescent smoking are included in the model. In  
7 particular, indicator variables for the introduction of the POS ban and graphic  
8 images shown on packages were included.  
9

10  
11 Increasing price on cigarettes is found to be one of the most effective measures  
12 in reducing smoking, particularly among adolescents as they usually have less  
13 disposable money and cigarettes are therefore less affordable for them than they  
14 are for adults [13,14]. Ireland has increased the price of cigarettes every year  
15 since 1995, from 3.5 EUR in 1995 to 10.5 EUR in 2015.  
16

17  
18 The real price changes, where price is adjusted for consumer price index (CPI)  
19 are shown in the Supplementary File 1. We used changes in real price, rather  
20 than changes in tobacco taxes, because of the industry and retailers' roles in  
21 pricing of tobacco products may distort the effects of taxation [15].  
22

23  
24 Average real price therefore is included in the model to capture price effect.  
25  
26  
27

### 28 **Figure 1 Trend of Irish adolescent smoking prevalence by gender (%)** 29 **1995-2015 ESPAD surveys** 30 31

#### 32 Statistical analysis 33

34 We did a regression analysis on pooled data (See Supplementary File 2). It  
35 showed that all policies are significantly related to prevalence changes. We also  
36 tried to find out if the impact of each policy variable differed between boys and  
37 girls by including interaction terms of gender indicator and policy variables  
38 either one at a time or all together. Model 2-5 in Supplementary File 2 suggest  
39 that the impact of workplace ban was not significantly different between boys  
40 and girls, while the impacts of other policies are larger on boys than girls.  
41 However, when all interaction terms are included at the same time as in Model  
42 6 in Supplementary File 2, none of the interaction terms were significant. This  
43 implies that pooling boys and girls and building a common model including all  
44 policies and their interactions with gender indicator obscures the fact that some  
45 policies might not work for one group, but work for the other. In this way  
46 preventing us from revealing the true relationship between prevalence and  
47 policies in each group. For example, later we will show that inclusion of graphic  
48 images did not have significant impact on boys, while it worked for girls.  
49 Therefore, including an interaction of gender and graphic images in a pooled  
50 model will not help to improve the model fitting.  
51  
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53  
54 Based on the information above, from the pooled model and the fact that  
55 running separate models for boys and girls gives results at least as consistent as  
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1  
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3 pooled ones, we decided to show the main results from logistic regressions on  
4 grouped data separately for boys and girls (Supplementary File 3).  
5  
6  
7

8 We have included real price and policy indicators. Seven models are assessed.  
9 First, we look at the impact of real price on adolescent prevalence (Model 0).  
10 Then we assess the impact of workplace ban on adolescent smoking by adding a  
11 workplace ban indicator, together with price (Model 1). Then we repeat the first  
12 step by replacing the workplace ban by the POS ban indicator (Model 2) and  
13 graphic images indicator (Model 3). Pairwise combinations of the policy  
14 indicators are also considered (Model 4 – 6). Lastly, all policy indicators and  
15 price are included (Model 7). Various criteria are used to determine the best  
16 model. In particular, models with smaller Akaike information criterion (AIC)  
17 values and Bayesian information criterion (BIC) values are preferred.  
18 Likelihood ratio tests are used for comparing two nested  
19 models. A significant test suggests that the full model is an improvement on the  
20 reduced model.  
21  
22

23 All analyses were performed with the Stata 13 (StataCorp. 2013. Stata  
24 Statistical Software: Release 13. College Station, TX: StataCorp LP.)  
25  
26  
27  
28  
29

### 30 Patient and public involvement

31 No patient involved  
32  
33  
34  
35

### 36 Results

37 The regression results of the seven models are presented in Supplementary File  
38 3. For boys, all of the variables in each model are strongly significant except for  
39 graphic images. Average real price increase and introducing the workplace ban  
40 reduced smoking prevalence. Model 4 provides the best fit to the data as shown  
41 in Table 2 (a). First, Model 4 has the smallest AIC among the seven models.  
42 Secondly, the Likelihood ratio tests on Model 4 and Model 0 -2 are all  
43 significant (all p values <0.02), which implies that Model 3 is an improvement  
44 on the reduced models. In addition, likelihood ratio test on Model 4 and Model  
45 7 is insignificant (p value=0.81), which shows that Model 7 is not an  
46 improvement on Model 4. It is confirmed by the insignificant coefficient of  
47 graphic images in Model 7.  
48  
49  
50  
51  
52

53 Table 2 (b) shows how much the boys' prevalence was marginally affected by  
54 various variables in the best fit model, i.e. Model 4. Controlling for price and  
55 POS ban, introducing the workplace ban reduced the prevalence by 4.93% (95%  
56 CI 0.77%-9.08%), which is a considerable reduction given the prevalence  
57 before the ban was 33%. The effect of real price increase is also large and  
58 significant, with a unit increase in the real price could reduce the prevalence by  
59  
60

8.41% (95% CI 5.16% - 11.66%). However, POS ban was associated with increased prevalence by 7.02% (95% CI 1.65% -12.40%).

For girls, Model 5 provides the best fit as shown in Table 2 (a). First, the likelihood ratio tests on Model 5 and Model 0, 1 and 3 are all significant (p value<0.01), suggesting that Model 5 is an improvement on the reduced models. In addition, likelihood ratio test on model 5 and 7 is insignificant (p value=0.20). Model 7 is not an improvement on Model 5, confirmed by the insignificant coefficient of POS ban. Secondly, Model 5 has smallest AIC.

From Table 2 (b), we can see that introducing the workplace ban reduced girls' prevalence by 7.31% (95% CI 2.94%-11.68%), which is larger than the effect on boys, but without statistically significant difference. In addition, the marginal effect of real price is 5.87% (95% CI 2.96% - 8.79%), which is smaller than the price effect on boys. Introduction of graphic images is associated with 8.80% (95% CI 2.60% - 15.01%) reduction in girls' prevalence, in contrast to the insignificant impact on boys.

The best fit models for boys and girls match the actual prevalence, of smoking from the ESPAD surveys from 1995-2015, well (Figure 2.)

**Figure 2 Prevalence of smoking from ESPAD surveys from 1995-2015 showing that the best fit models match the actual prevalence**

**Discussion Table 2a ESPAD 1995-2015 Logistic regression results from best fit models**

VARIABLES	Regression results (Odds ratios and CI)	
	Boy	Girl
Real price	0.63*** (0.52, 0.75)	0.75*** (0.65, 0.86)
Workplace ban	0.76* (0.60, 0.96)	0.70** (0.56, 0.86)
POS ban	1.48* (1.10, 2.00)	

Graphic images		0.65**
		(0.47, 0.88)
Constant	2.83**	2.13**
	(1.40, 5.71)	(1.22, 3.72)
Observations	6,080	6,324
AIC	6657	7606
BIC	6684	7633

CI is confidence interval at 95% confidence level

\*\*\* p<0.001, \*\* p<0.01, \* p<0.05

**Table 2b ESPAD 1995-2015 Reduction in smoking prevalence from best fit models**

VARIABLES	Marginal effect (Reduction in prevalence and CI)	
	Boy	Girl
Real price	-8.41%*** (-11.66%, -5.16%)	-5.87%*** (-8.79%, -2.96%)
Workplace ban	-4.93%* (-9.08%, -0.77%)	-7.31%** (-11.68%, -2.94%)
POS ban	7.02%* (1.65%, 12.40%)	
Graphic images		-8.80%** (-15.01%, -2.60%)

CI is confidence interval at 95% confidence level

\*\*\* p<0.001, \*\* p<0.01, \* p<0.05

Although there is a general decline in adolescent smoking prevalence in ESPAD countries, there is no evidence of convergence in the different countries or geographic regions [16]. In Ireland, there was a steep drop in adolescent smoking prevalence between 2003 and 2007 when the decline was similar in girls and boys but greater in girls. The results show that the workplace ban introduced in 2004 helps to explain the steep drop in prevalence when controlling for the real price effect, which itself is consistently found to be effective in other studies[17,18]. In particular, although the overall average real price increased for the 2003-2007 period compared to the previous period, the



1  
2  
3 annual real price actually decreased for the two years, 2005 and 2006. This  
4 reinforces the strong impact of the workplace ban on reducing smoking  
5 prevalence between the 2003 and 2007 period. In addition, the workplace ban  
6 rendered an estimated additional 5% reduction in actual smoking prevalence  
7 beyond price effect, which is a considerable effect given that the prevalence was  
8 37% among females and 28% among males in 2003. The study however also  
9 confirms that real cigarette prices are strong determinants of youth  
10 smoking[17,18].  
11  
12

13  
14 The other components of the WHO MPOWER policy package, consisting of a  
15 series of technical measures and resources to assist country-level  
16 implementation of the WHO Framework Convention on Tobacco Control  
17 (FCTC) e.g. smoking cessation services, advertising, promotion and  
18 sponsorship, did not change significantly between 2003 and 2007. In particular,  
19 mass media campaigns stayed moderately funded for the whole period of 1995  
20 to 2015. Health warnings were moderate between 2003 and 2007, and cessation  
21 treatment and youth access were stable in the period [19]. Therefore, between  
22 2003 and 2007, the only significant and positive change in tobacco control  
23 policies was the introduction of workplace ban.  
24  
25

26  
27 The mechanisms that explain the link between the workplace ban and  
28 adolescent smoking prevalence are uncertain and our data do not allow a further  
29 interrogation. However, some studies from other countries have provided some  
30 explanations [20]. For example, one study shows that stronger public places  
31 restrictions had a significantly protective effect on smoking prevalence[21].  
32 Another suggested that a workplace ban affects adolescents who are at work  
33 (through part-time jobs)[22]. It showed that adolescents who worked in smoke-  
34 free workplaces were only 68% (95% CI, 51%-90%) as likely to be smokers as  
35 adolescents who worked in a workplace with no smoking restrictions. It is also  
36 possible that the discourse around smoking which occurred pre-implementation  
37 of Smokefree Legislation helped to denormalise smoking in general even  
38 though the law was primarily about the workplace[23]. The decrease in  
39 prevalence from 2007 to 2011 was much steeper in girls than boys.  
40  
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42  
43 During this period, the annual real price decreased from 2010 to 2011 although  
44 the average real price for the period 2007 to 2011 increased slightly  
45 (Supplementary File 1). The model suggests that price has a greater marginal  
46 effect on boys than girls (8.4 % V 5.8 %). The decrease in the annual real price,  
47 which is not taken into account in the change of average real price in the model  
48 and the finding that the workplace ban seemed to have a greater effect in girls  
49 than boys (7.3% V 4.9%) may partially explain the difference in the rate of  
50 decline of prevalence.  
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53  
54 The impact of the POS ban on reducing youth smoking prevalence was not  
55 significant, which is consistent with the finding of the study by McNeill A. et al.  
56 (2011) [24]. They failed to find significant short-term changes in prevalence  
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3 among youths or adults due to POS ban. However, their study showed that the  
4 proportion of youths believing that more than a fifth of children their own age  
5 smoked decreased from 62% to 46%,  $p < 0.001$ ). Post-legislation, 38% of  
6 teenagers thought it would make it easier for children not to smoke. Compliance  
7 was very high and the law was well supported. Recall of tobacco displays  
8 among teenagers reduced significantly post-legislation and there were  
9 encouraging signs that the law helped de-normalise smoking. While it was  
10 postulated at the time that it might take a longer time for the POS ban to  
11 effectively reduce smoking prevalence among youths, we have not seen it in  
12 this study based on a longer time series. Others however have seen more  
13 positive results in young people[25,26].

14  
15 Context may be significant in this regard as our population were under age for  
16 legal purchase of cigarettes in Ireland and access in those circumstances occurs  
17 through other routes where POS displays may not be relevant. It does not  
18 however explain why the POS display ban was associated with a negative effect  
19 in boys in this analysis. It seems likely that this may have been partially a price  
20 effect because the real price actually declined in two of the relevant years  
21 (Supplementary File 1) 2005 and 2006 but also there was a marked switch to  
22 cheaper roll your own cigarettes in both adults and teens[27,28].

23  
24 In ESPAD countries, with different initial status from Ireland, generally, gender  
25 convergence is marked in smoking prevalence. In 1995, on average in ESPAD  
26 countries boys showed higher smoking prevalence than girls. In 2015, these  
27 differences were no longer apparent or became smaller. However, in 1995 Irish  
28 female adolescents had a much higher smoking prevalence than male  
29 adolescents (45% VS 37%), price and workplace ban effects were marked in  
30 both genders but somewhat different. As discussed above price effect was  
31 stronger in boys than girls although there is no conclusive evidence on this in  
32 the literature[17,28]. The impact of the POS ban differed between the two  
33 groups. In particular, POS ban did not significantly affect girls' smoking  
34 prevalence, while it is significantly and positively (7 %) related to boys'  
35 smoking prevalence.

36  
37 The introduction of graphic images on packs seemed to have a much greater  
38 impact on girls with an 8.8% marginal effect whereas it had no significant effect  
39 on boys. These differential effects on POS and graphic images with the lesser  
40 differentials for price and the workplace ban may explain why we observed that  
41 by the end of the period, the gender gap was closed, with female prevalence  
42 being less than male prevalence by 2015, consistent with most ESPAD  
43 countries.

44  
45 One of the potential issues of the above analysis is that the sample size is not  
46 ideally large and the interval between each survey is long, as there were only six  
47 surveys between 1995 and 2015. However, this is so far the best adolescent  
48 survey data in Ireland that provides adolescent smoking prevalence. Other  
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3 surveys on smoking either didn't have enough adolescent samples (e.g. Survey  
4 on Lifestyle and Attitude to Nutrition and Healthy Ireland surveys), or were too  
5 recent to establish a baseline before the policies were introduced (e.g. Monthly  
6 phone interview surveys from National Tobacco Control Office from 2002), or  
7 had fewer data points (e.g. Health Behaviour in School-aged Children study had  
8 5 waves between 1998 and 2014). Another limitation is that the data of 1999  
9 and 2003 were obtained by recalculating the number of male and female  
10 smokers based on prevalence and total sample size, a process which may have  
11 introduced very small inaccuracies. However, the results are clear cut and the  
12 margin of error compared to total sample is negligible. Therefore, the process  
13 should not have significant impact on the results.  
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### 18 Conclusions

19  
20 Adolescent smoking prevalence dropped significantly in boys and girls in  
21 Ireland. This study found that the workplace ban introduced in 2004, to protect  
22 workers and customers from second-hand smoking, has significantly helped to  
23 explain the out-of-trend reduction in adolescent smoking prevalence. While  
24 removal of point of sale tobacco promotion may have reduced awareness of  
25 smoking among young people, there was no evidence of a beneficial effect on  
26 prevalence. Graphic images appear to have made a significant impact on girls'  
27 smoking prevalence but not on boys. In addition, we confirmed that price  
28 increase was consistently effective in both boys and girls. The implications for  
29 the whole population, considering age and gender, should be considered for all  
30 TCLs being introduced by policy makers irrespective of the targeted segment of  
31 the population.  
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**Figure 1 Trend of Irish adolescent smoking prevalence by gender (%)  
1995-2015 ESPAD surveys**

**Figure 2 Prevalence of smoking from ESPAD surveys from 1995-2015 and  
fitted lines of predicted prevalence from best fit models for boys and girls**

**Contributors**

LC conceived the study. LC and SL designed the study. SL, SK and LC were involved in analysis of the data. SL drafted the first version of the manuscript. LC and SK had input into all redrafts. All authors read and approved the final version.

**Funding:**

Dept. of Health Ireland RFT                      DOH RFT ESPAD 2015

Royal City of Dublin Hospital Trust      RCDHT Grant 178

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

**Ethical Approval:** Ethical approval was awarded by Dublin Institute of Technology, Research Ethics, Ethical Clearance Ref 18 -126.

New approval for this use of the study data set was not considered necessary as ESPAD Ireland PI with full access to ESPAD data set. We used fully anonymised aggregate data.

**COI**

LC, SK and SL declare no competing interests.

**Data Sharing**

No additional data available

The data were from the European School Survey Project on Alcohol and Other Drugs (ESPAD) and various official reports available from <http://www.espad.org/reports-documents>. With the 2003 data collection as a starting point, it was

1  
2  
3 decided that all country datasets should be merged into a common database.  
4 After that also data from 2007 and 2011 are available in separate databases.  
5 Initially, these databases were stored and maintained by the Databank Manager  
6 Thoroddur Bjarnson. During the 2015 wave of ESPAD, the international  
7 database was compiled and standardised by CAN (Stockholm). Even though,  
8 since 2007, countries are obliged to deliver their national datasets to the  
9 database, there are—as stated in the database rules—no obligations to let other  
10 researchers use the national data without permission. In order to obtain a copy  
11 of a database, an application form has to be filled in and posted to the  
12 coordinators for further distribution to the ESPAD Application Committee. The  
13 composition of the committee as well as restrictions around the database and its  
14 use are described and explained in the ESPAD database rules (database rules for  
15 ESPAD researchers and database rules for non-ESPAD researchers). When an  
16 application is approved, a contract is signed before a copy of the database is  
17 delivered. Approved applications are presented in a list, which also displays the  
18 deadline of the projects. ESPAD researchers are allowed to apply for the most  
19 recent database once the International ESPAD Report has been released. Non-  
20 ESPAD researchers are also allowed to work with ESPAD data. Access for non-  
21 ESPAD researchers is allowed after an embargo period determined by an  
22 assembly: ESPAD 2003 Database: accessible now. ESPAD 2007 Database: was  
23 accessible since 1 July 2013. ESPAD 2011 Database: was accessible since 1  
24 July 2015. ESPAD 2015 Database: at present, it is only accessible to ESPAD  
25 researchers. [http://www.espad.org/sites/espad.org/themes/cs\\_espad/logo.png](http://www.espad.org/sites/espad.org/themes/cs_espad/logo.png):  
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39 **Acknowledgements:** We wish to thank Focas Research Institute, TU Dublin for  
40 facilities and the ESPAD international researchers supported by EMCDDA  
41 contract CC.14.SDI.032 who compiled a common ESPAD Trend database  
42 (1995–2015).  
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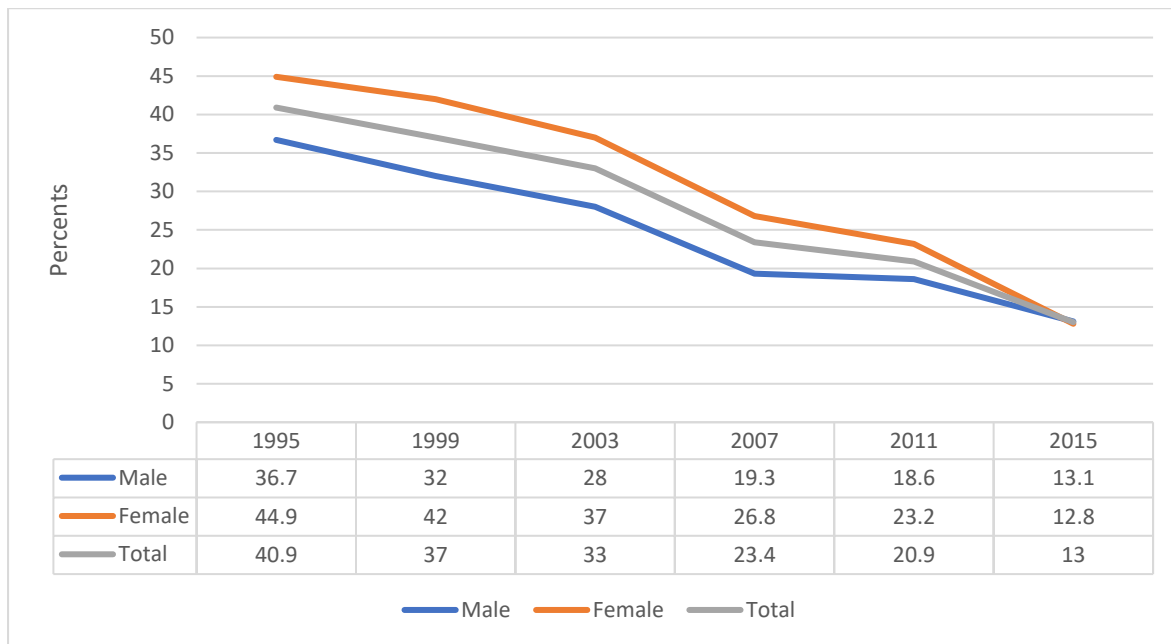
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For peer review only

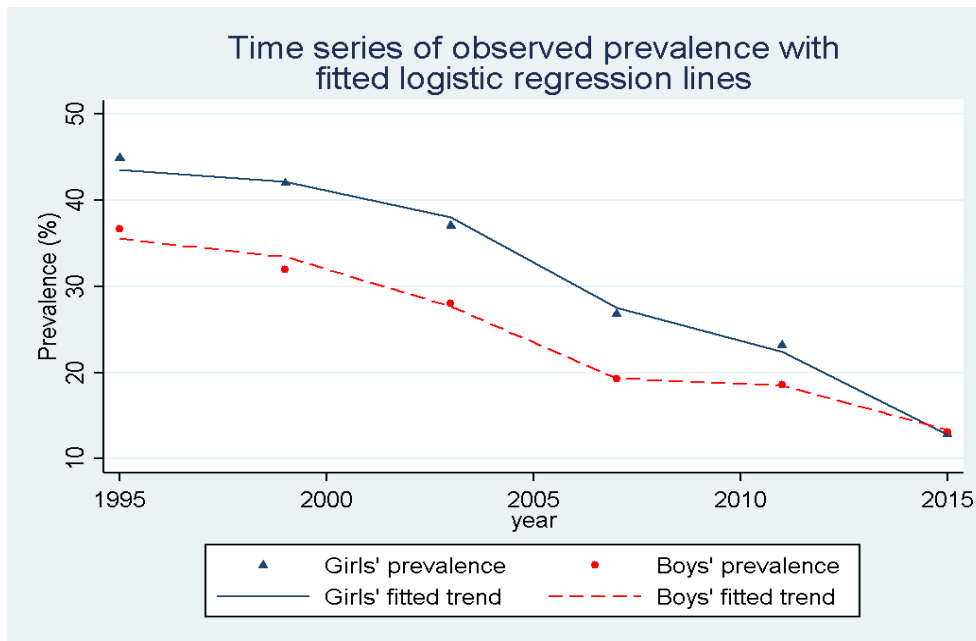
**Figure 1 Trend of Irish adolescent smoking prevalence by gender (%) 1995-2015 ESPAD surveys**



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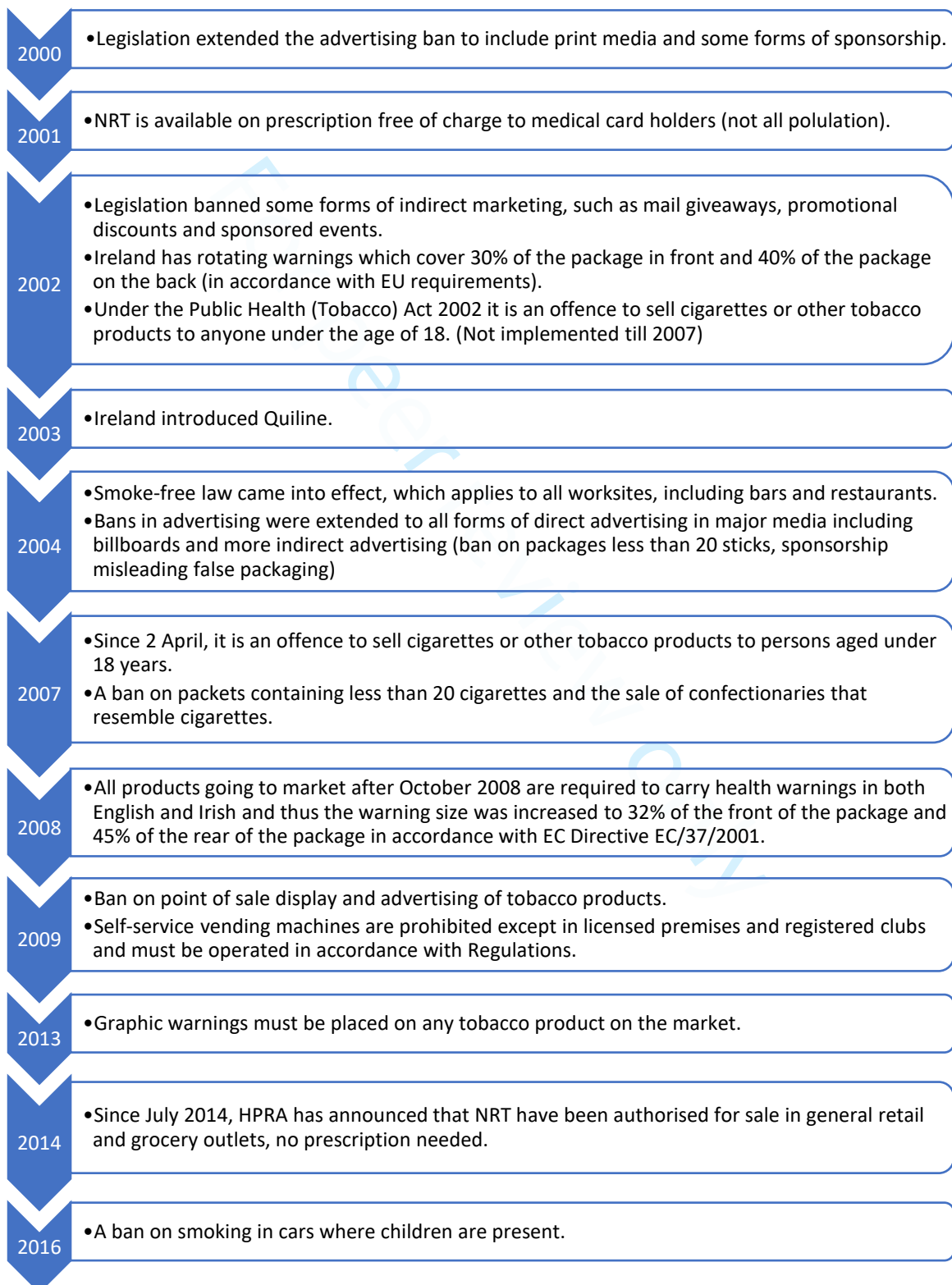
Figure 2. Prevalence of smoking from ESPAD surveys from 1995-2015 and fitted lines of predicted prevalence from best fit models for boys and girls





## Appendix 1

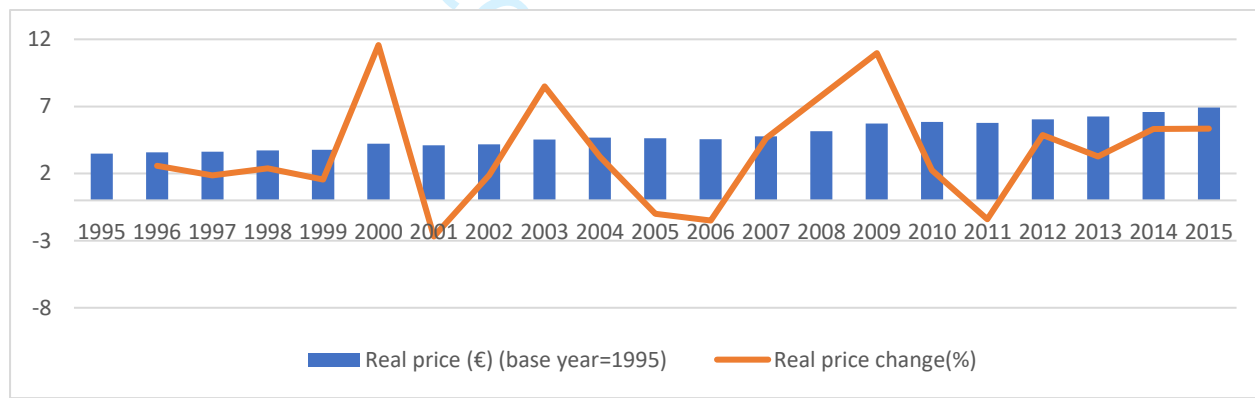
### Timeline of Tobacco Control Policies/ Interventions in Ireland, 2000 -2016



Supplementary File 1

Table 1 Real price (€) per package of 20 cigarettes in Ireland, 1995-2015

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Retail price	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5
CPI (year 1995=100)	100	102	103	106	107	109	112	114	119	120	125	127	130	133	136	138	141	142	145	147	148
Real price (base year=1995)	3.5	3.6	3.6	3.7	3.8	4.2	4.1	4.2	4.5	4.7	4.6	4.6	4.8	5.2	5.7	5.8	6.0	6.1	6.2	6.3	6.4
Real price change (%)	-	2.6	1.9	2.4	1.6	11.6	2.4	1.9	8.5	3.2	1.7	1.5	4.6	7.8	11.1	1.7	2.4	1.6	4.9	3.3	5.5



## Supplementary File 2

## Logistic regression results from different models based on pooled sample

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Real price	0.66*** (0.56 - 0.77)	0.63*** (0.54 - 0.74)	0.66*** (0.56 - 0.77)	0.66*** (0.56 - 0.77)	0.66*** (0.56 - 0.77)	0.68*** (0.55 - 0.84)
Workplace ban	0.74*** (0.63 - 0.88)	0.74*** (0.63 - 0.88)	0.71*** (0.59 - 0.85)	0.74*** (0.62 - 0.88)	0.74*** (0.62 - 0.88)	0.73** (0.58 - 0.92)
POS ban	1.31** (1.07 - 1.61)	1.31** (1.07 - 1.61)	1.31* (1.06 - 1.60)	1.18 (0.95 - 1.48)	1.31** (1.07 - 1.61)	1.20 (0.91 - 1.58)
Graphic images	0.80* (0.64 - 1.00)	0.80* (0.64 - 1.00)	0.80* (0.64 - 1.00)	0.80* (0.64 - 1.00)	0.65** (0.50 - 0.86)	0.67* (0.49 - 0.92)
Female	0.70*** (0.65 - 0.76)	0.46*** (0.31 - 0.69)	0.67*** (0.61 - 0.74)	0.67*** (0.61 - 0.73)	0.68*** (0.63 - 0.74)	0.85 (0.26 - 2.79)
Female*Real price		1.10* (1.01 - 1.21)				0.94 (0.69 - 1.28)
Female*Workplace ban			1.12 (0.95 - 1.32)			1.03 (0.73 - 1.45)
Female*POS ban				1.25*		1.23

				(1.03 -		(0.81 -
				1.52)		1.86)
Female*Graphic images					1.51*	1.44
					(1.10 -	(0.92 -
					2.08)	2.25)
Constant	3.42***	4.17***	3.48***	3.49***	3.46***	3.11**
	(1.89 -	(2.24 -	(1.92 -	(1.93 -	(1.91 -	(1.38 -
	6.17)	7.75)	6.30)	6.31)	6.25)	7.00)
Observations	12,404	12,404	12,404	12,404	12,404	12,404
AIC	14265	14263	14265	14262	14261	14265
BIC	14310	14315	14317	14314	14313	14340

CI is confidence interval at 95% confidence level

\*\*\* p<0.001, \*\* p<0.01, \* p<0.05

The table above shows the regression results based on the pooled sample. There are 6 models, with different specifications. Model 1 is the baseline including gender indicator, but without any interaction terms. Model 2- Model 5 each has gender indicator interacted with each of the policy variables one at a time. Model 6 has the gender indicator interacted with all of the policy variables at the same time.

Real price, workplace ban and graphic images consistently remain significant across all the models. The magnitude of the coefficients also lies between the values from the gender-specific models.

POS ban stays significant in most of the models. However, it loses significance when interacted with gender indicator (Model 4) and the fully interacted model (Model 6).

The results are consistent with the gender specific model Supplementary Files 1 & 2 . In particular, Model 3 supports that workplace ban coefficients are not significantly different between boys and girls, while Model 2 confirms that real price effect is larger on boys than girls.

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3 According to our gender specific models and various post-estimation tests, we  
4 saw that real price and workplace ban both had significant impacts on  
5 prevalence, and real price had larger impact on boys than girls. It has been  
6 confirmed by the model 2 shown in the table above.  
7  
8

9  
10 Noticing that in the final Model 6, which includes all the interactions, all the  
11 interaction terms lose significance.  
12

13 It implies that pooling boys and girls and building a common model including  
14 all policies and their interactions with gender indicator obscures the fact that  
15 some polices might not work for one group, but work for the other , thus  
16 preventing us from revealing the true relationship between prevalence and  
17 policies in each group.  
18  
19

20  
21 For example, gender specific results show that inclusion of graphic images did  
22 not have significant impact on boys, while it worked for girls. Therefore,  
23 including an interaction of gender and graphic images in a pooled model will  
24 not help to improve the model fitting.  
25  
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27  
28 In summary, based on the information above from pooled model and the fact  
29 that running separate models for boys and girls gives results at least as  
30 consistent as pooled ones, we decided to show the main results from logistic  
31 regressions on grouped data separately or boys and girls.  
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34 Models with gender interactions based on pooled data serve as a robustness  
35 check for the gender specific models and supports the main results and  
36 conclusions.  
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## Supplementary File 3

Irish ESPAD 1995 to 2015:

Logistic regression of male prevalence on factors from various models 1-7

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VARIABLES	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Real price	0.65*** (0.02)	0.75*** (0.05)	0.54*** (0.04)	0.64*** (0.03)	0.63*** (0.06)	0.78** (0.06)	0.53*** (0.04)	0.64*** (0.07)
Workplace ban		0.72** (0.08)			0.76* (0.09)	0.70** (0.09)		0.75* (0.10)
POS ban			1.57** (0.23)		1.48* (0.23)		1.59** (0.24)	1.47* (0.23)
Graphic images				1.09 (0.16)		0.90 (0.15)	1.12 (0.17)	0.96 (0.16)
Constant	2.39*** (0.36)	1.43 (0.34)	4.83*** (1.34)	2.55*** (0.48)	2.83** (1.01)	1.24 (0.39)	5.36*** (1.64)	2.66* (1.17)
Observations	6,080	6,080	6,080	6,080	6,080	6,080	6,080	6,080
AIC	6668	6662	6661	6669	6657	6663	6662	6659
BIC	6681	6682	6681	6689	6684	6690	6689	6693

Coefficients are odds ratios

SE in parentheses

\*\*\* p&lt;0.001, \*\* p&lt;0.01, \* p&lt;0.05

## Irish ESPAD 1995 to 2015

## Logistic regression of female prevalence on factors from various models 1-7

VARIABLES	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Real price	0.59*** (0.02)	0.65*** (0.04)	0.52*** (0.03)	0.61*** (0.02)	0.58*** (0.05)	0.75*** (0.06)	0.54*** (0.04)	0.68*** (0.07)
Workplace ban		0.79* (0.08)			0.83 (0.09)	0.70** (0.08)		0.73** (0.09)
POS ban			1.36* (0.18)		1.27 (0.18)		1.35* (0.18)	1.20 (0.17)
Graphic images				0.80 (0.12)		0.65** (0.10)	0.81 (0.12)	0.67* (0.11)
Constant	5.24*** (0.74)	3.58*** (0.77)	8.46*** (2.12)	4.48*** (0.78)	5.65*** (1.92)	2.13** (0.61)	7.22*** (1.97)	3.11** (1.29)
Observations	6,324	6,324	6,324	6,324	6,324	6,324	6,324	6,324
AIC	7615	7612	7612	7615	7611	7606	7611	7606
BIC	7629	7632	7632	7635	7638	7633	7639	7640

Coefficients are odds ratios

SE in parentheses

\*\*\* p&lt;0.001, \*\* p&lt;0.01, \* p&lt;0.05



# Reporting checklist for cross sectional study.

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Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

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			Page Number
<b>Title and abstract</b>			
Title	<a href="#">#1a</a>	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	<a href="#">#1b</a>	Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background / rationale	<a href="#">#2</a>	Explain the scientific background and rationale for the investigation being reported	3
Objectives	<a href="#">#3</a>	State specific objectives, including any prespecified hypotheses	3
<b>Methods</b>			
Study design	<a href="#">#4</a>	Present key elements of study design early in the paper	4
Setting	<a href="#">#5</a>	Describe the setting, locations, and relevant dates, including periods of	4

		recruitment, exposure, follow-up, and data collection	
1			
2	Eligibility criteria	<a href="#">#6a</a> Give the eligibility criteria, and the sources and methods of selection of participants.	4
3			
4			
5			
6		<a href="#">#7</a> Clearly define all outcomes, exposures, predictors, potential	5
7		confounders, and effect modifiers. Give diagnostic criteria, if applicable	
8			
9			
10	Data sources /	<a href="#">#8</a> For each variable of interest give sources of data and details of methods	4
11	measurement	of assessment (measurement). Describe comparability of assessment	
12		methods if there is more than one group. Give information separately	
13		for for exposed and unexposed groups if applicable.	
14			
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16			
17	Bias	<a href="#">#9</a> Describe any efforts to address potential sources of bias	4-5
18			
19	Study size	<a href="#">#10</a> Explain how the study size was arrived at	4
20			
21	Quantitative	<a href="#">#11</a> Explain how quantitative variables were handled in the analyses. If	4
22	variables	applicable, describe which groupings were chosen, and why	
23			
24			
25	Statistical	<a href="#">#12a</a> Describe all statistical methods, including those used to control for	4
26	methods	confounding	
27			
28			
29	Statistical	<a href="#">#12b</a> Describe any methods used to examine subgroups and interactions	4
30	methods		
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33	Statistical	<a href="#">#12c</a> Explain how missing data were addressed	4
34	methods		
35			
36			
37	Statistical	<a href="#">#12d</a> If applicable, describe analytical methods taking account of sampling	4
38	methods	strategy	
39			
40			
41	Statistical	<a href="#">#12e</a> Describe any sensitivity analyses	4
42	methods		
43			
44	<b>Results</b>		
45			
46	Participants	<a href="#">#13a</a> Report numbers of individuals at each stage of study—eg numbers	4
47		potentially eligible, examined for eligibility, confirmed eligible,	
48		included in the study, completing follow-up, and analysed. Give	
49		information separately for for exposed and unexposed groups if	
50		applicable.	
51			
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55	Participants	<a href="#">#13b</a> Give reasons for non-participation at each stage	4
56			
57	Participants	<a href="#">#13c</a> Consider use of a flow diagram	na
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1	Descriptive data	<a href="#">#14a</a>	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	4
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6	Descriptive data	<a href="#">#14b</a>	Indicate number of participants with missing data for each variable of interest	4
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10	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	5
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14	Main results	<a href="#">#16a</a>	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	5
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16				
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19	Main results	<a href="#">#16b</a>	Report category boundaries when continuous variables were categorized	5
20				
21	Main results	<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	5
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25	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	5
26				
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29	<b>Discussion</b>			
30				
31	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives	6
32				
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34	Limitations	<a href="#">#19</a>	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	3,7
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39	Interpretation	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	7
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44	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study results	7
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47	<b>Other</b>			
48	<b>Information</b>			
49				
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51	Funding	<a href="#">#22</a>	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	10
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# BMJ Open

## Does Smoke-free legislation work for teens too? A logistic regression analysis of smoking prevalence and gender among 16-year-olds in Ireland, using the 1995-2015 ESPAD school surveys

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2019-032630.R3
Article Type:	Original research
Date Submitted by the Author:	27-Feb-2020
Complete List of Authors:	Li, Shasha; TobaccoFree Research Institute Ireland, TU Dublin, Kevin Street, Dublin 8 Keogan, Sheila; TobaccoFree Research Institute Ireland, TU Dublin, Kevin Street, D8 Clancy, Luke; TobaccoFree Research Institute Ireland, TU Dublin, Kevin Street, Dublin 8
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Epidemiology, Smoking and tobacco, Addiction, Communication
Keywords:	Price,, Secondhand smoke, Advertising and Promotion,, Denormalisation, EPIDEMIOLOGY, Graphic Tobacco Images

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43 Keywords: Price, Secondhand smoke, Advertising and Promotion,  
44 Denormalisation  
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47 Word Count 2935  
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## Abstract

### Objectives:

To assess the role of Tobacco Control Legislation (TCL) in youth smoking in Ireland. To examine the effects of Smokefree legislation in youth. To consider whether TCL contributed to the gender equalisation in prevalence in 16-year olds seen between 2003 and 2015.

### Setting:

Data are from the 4 yearly European School Survey Project on Alcohol and Other Drugs (ESPAD) from 1995 to 2015. Total sample size was 12.394. A logistic regression model on grouped data was used. Dependent variable is whether a student was a smoker in last-30 day. Independent variables are time, gender and the policy indicators, workplace ban on smoking, Point-of-Sale (POS) display ban, the introduction of graphic images on packs and the average real price of cigarettes.

### Results:

Smoking prevalence dropped from 41% in 1995 to 13% in 2015. The effects of policies differed between boys and girls.

For girls, estimates for workplace bans, graphic images on packs, and a unit real (CPI adjusted) price increase reduced prevalence by 7.31 % (95% CI 2.94-11.68), 8.80% (95% CI 2.60-15.01) and 5.87(95% CI 2.96-8.79) respectively. The POS ban did not have a significant effect in girls.

For boys, estimates for workplace bans and a unit real price increase, reduced prevalence by 8.41% (95% CI 5.16 - 11.66) and 4.93% (95% CI 0.77-9.08) respectively, POS gave an increase of 7.02% (95% CI 1.96-12.40). The introduction of graphic images had an insignificant effect.

### Conclusions

TC legislation helps to explain the out-of-trend reduction in youth smoking prevalence. The estimated differential effects of the workplace ban, POS displays, real price changes and graphic images on packs help to explain the sharper decline in girls than boys.

These findings should remind policy makers to give increased consideration to the possible effects on young people of any legislative changes aimed at adults in TCL.



## Article summary

### Strengths and limitations of this study:

The ESPAD survey provides the best available adolescent data on smoking prevalence in Ireland from 1995 to 2015.

Nevertheless, the sample size is not ideally large and the interval between surveys is long at four years.

The number of male and female smokers for the years 1999 and 2003 was calculated using published ESPAD Ireland data on prevalence and total sample size

Most of the important Tobacco Control Legislation in Ireland occurred during period 1995 to 2015 and their contribution to the reduction in prevalence in adolescent smoking is examined.

## Introduction

Ireland is one of the pioneer countries in tobacco control and is consistently near, or at, the top of the European Tobacco Control Scale (TCS) which is based on the number and type of Tobacco Control (TC) interventions and completeness of their implementation [1]. The harmful effects of secondhand smoke had become well known since the 1980's and bans on smoking in the workplace had been introduced by many communities and some states particularly in the USA.

Smoking in workplaces was banned in Ireland on a comprehensive national basis on the 29 March 2004, making Ireland the first country in the world to institute a comprehensive national ban on smoking in workplaces. From that date onwards, under the Public Health (Tobacco) Acts 2002, it has been illegal to smoke in all enclosed workplaces, including bars, restaurants, clubs, offices, public buildings, and schools. The bans are strictly enforced[2]. While the 2004 smoke-free workplaces legislation has reduced adult smoking prevalence [3][4] and helped to avoid at least 3,500 tobacco-related deaths in Ireland in the first three years [5], its impact on adolescents is less clear.

A particularly large reduction, especially in girls, was observed in Irish adolescent smoking prevalence between 2003 and 2015. Smoking in Irish girls exceeded that in boys for the 20 years preceding the introduction of strong tobacco control measures beginning in 2002. This high prevalence in girls was not unique in Europe but occurs in the context of the highest level of adult female smoking, reported in the world, being in the WHO Euro region[6].

In Ireland, prevalence fell from 44.9 % in 1995 to 13.1 % in 2015 in girls and from 36.7 % to 13.1% in boys [7]. There were no school-specific TCL introduced between 1995 and 2015. However, Smokefree legislation (2004) and other policies that could potentially help to reduce adolescent smoking prevalence were introduced since 1995. These were 1) a ban on packs of 10 cigarettes at the end of May 2007, 2) the point-of-sale (POS) advertising display ban of tobacco products introduced in 2009, and 3) the inclusion of graphic images on both sides of tobacco packs in 2011 (Appendix 1). The existing international evidence suggested that these interventions could be expected to advance tobacco control and help to reduce smoking in young people [8–10].

In particular, Ireland was the first country in EU to implement a ban on point-of-sale display, which came into effect on 1 July 2009. The legislation prohibited advertising of tobacco products in retail premises and mandated that tobacco products must be stored out of view of customers. It also prohibited vending machines except in licensed premises and registered clubs (in accordance with Regulations), and that all persons selling tobacco products by retail had to register with the Office of Tobacco Control (OTC). One of the motivations behind these legislative changes was to reduce awareness of smoking, especially among young people.

This study sets out to assess if Smokefree legislation, which was not targeting adolescents, was effective in reducing adolescent smoking in Ireland, and to see if it could help to explain the large fall in 30-day smoking prevalence, particularly in girls, occurring in recent years. Also, to consider whether the other TC measures, which are described above, contributed to the gender equalisation in prevalence in 16-year olds that occurred between 2003 and 2015.

## Methods

### Data

This study used data from the European School Survey Project on Alcohol and Other Drugs (ESPAD) in Ireland. The main purpose of the survey was to collect comparable data on substance use among 16-year-old students across Europe, in order to monitor trends within and between countries, including Ireland [8]. ESPAD surveys were conducted every four years from 1995 to 2015, resulting in six waves of data from 26 countries, and 35 countries participating in 2015. The sampling procedures, data collection and questionnaires used in Ireland were consistent with the international ESPAD study protocol [8]. School students born in specific calendar years were eligible and selected in Ireland using stratified random sampling.

Data were collected anonymously through paper-and-pencil, self-completion questionnaire administered in the classroom. After standardised cleaning procedures, the datasets (2007, 2011 and 2015 waves) were obtained from the ESPAD official database. Full accounts of the methodology of the study in each survey year can be found in the respective reports of the ESPAD project[8–10].

Original raw datasets from the 1999 and 2003 waves were unavailable. However, smoking prevalence and sample size of both genders are available from officially published reports[11,12]. The number of smokers and non-smokers of both genders in those two surveys are reconstructed as shown in Table 1.

**Table 1 Reconstructed number of smokers form 6 ESPAD surveys from 1995 to 2015**

	Male smokers	Female smokers	Total smokers	Total survey sample
1995	328	421	749	1832
1999	355	491	846	2277
2003	343	442	785	2407
2007	194	325	519	2216
2011	207	254	461	2205
2015	98	92	190	1467

1  
2  
3 The final data were aggregated every four years from 1995 to 2015, with an  
4 average of 2,067 observations per survey year. The observed smoking  
5 prevalence estimates as the average of 0-1 smoker variable that indicates  
6 whether an individual in the sample smokes. The prevalence along the years are  
7 shown in Figure 1. Tobacco control policies which may have confounded the  
8 impact of workplace ban on adolescent smoking are included in the model. In  
9 particular, indicator variables for the introduction of the POS ban and graphic  
10 images shown on packages were included.

11  
12  
13  
14 Increasing price on cigarettes is found to be one of the most effective measures  
15 in reducing smoking, particularly among adolescents as they usually have less  
16 disposable money and cigarettes are therefore less affordable for them than they  
17 are for adults [13,14]. Ireland has increased the price of cigarettes every year  
18 since 1995, from 3.5 EUR in 1995 to 10.5 EUR in 2015.

19  
20  
21 The real price changes, where price is adjusted for consumer price index (CPI)  
22 are shown in the Supplementary File 1. We used changes in real price, rather  
23 than changes in tobacco taxes, because of the industry and retailers' roles in  
24 pricing of tobacco products may distort the effects of taxation [15].

25  
26  
27 Average real price therefore is included in the model to capture price effect.  
28  
29

### 30 31 **Figure 1 Trend of Irish adolescent smoking prevalence by gender (%)** 32 **1995-2015 ESPAD surveys** 33

#### 34 35 Statistical analysis

36  
37 Seven models are assessed. First, we look at the impact of real price on  
38 adolescent prevalence (Model 0). Then we assess the impact of workplace ban  
39 on adolescent smoking by adding a workplace ban indicator, together with price  
40 (Model 1). Then we repeat the first step by replacing the workplace ban by the  
41 POS ban indicator (Model 2) and graphic images indicator (Model 3). Pairwise  
42 combinations of the policy indicators are also considered (Model 4 – 6). Lastly,  
43 all policy indicators and price are included (Model 7). Various criteria are used  
44 to determine the best model. In particular, models with smaller Akaike  
45 information criterion (AIC) values and Bayesian information criterion (BIC)  
46 values are preferred. Likelihood ratio tests are used for comparing two nested  
47 models. A significant test suggests that the full model is an improvement on the  
48 reduced model.  
49

50  
51 All analyses were performed with the Stata 13 (StataCorp. 2013. Stata  
52 Statistical Software: Release 13. College Station, TX: StataCorp LP.)  
53

54  
55 We show the main results from logistic regressions on grouped data separately  
56 for boys and girls (Supplementary File 2).  
57  
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60

## Patient and public involvement

No patient involved

## Results

The regression results of the seven models are presented in Supplementary File 2. For boys, all of the variables in each model are strongly significant except for graphic images. Average real price increase and introducing the workplace ban reduced smoking prevalence. Model 4 provides the best fit to the data as shown in Table 2 (a). First, Model 4 has the smallest AIC among the seven models. Secondly, the Likelihood ratio tests on Model 4 and Model 0-2 are all significant (all p values <0.02), which implies that Model 3 is an improvement on the reduced models. In addition, likelihood ratio test on Model 4 and Model 7 is insignificant (p value=0.81), which shows that Model 7 is not an improvement on Model 4. It is confirmed by the insignificant coefficient of graphic images in Model 7.

Table 2 (b) shows how much the boys' prevalence was marginally affected by various variables in the best fit model, i.e. Model 4. Controlling for price and POS ban, introducing the workplace ban reduced the prevalence by 4.93% (95% CI 0.77%-9.08%), which is a considerable reduction given the prevalence before the ban was 33%. The effect of real price increase is also large and significant, with a unit increase in the real price could reduce the prevalence by 8.41% (95% CI 5.16% - 11.66%). However, POS ban was associated with increased prevalence by 7.02% (95% CI 1.65% -12.40%).

For girls, Model 5 provides the best fit as shown in Table 2 (a). First, the likelihood ratio tests on Model 5 and Model 0, 1 and 3 are all significant (p value<0.01), suggesting that Model 5 is an improvement on the reduced models. In addition, likelihood ratio test on model 5 and 7 is insignificant (p value=0.20). Model 7 is not an improvement on Model 5, confirmed by the insignificant coefficient of POS ban. Secondly, Model 5 has smallest AIC.

From Table 2 (b), we can see that introducing the workplace ban reduced girls' prevalence by 7.31% (95% CI 2.94%-11.68%), which is larger than the effect on boys, but without statistically significant difference. In addition, the marginal effect of real price is 5.87% (95% CI 2.96% - 8.79%), which is smaller than the price effect on boys. Introduction of graphic images is associated with 8.80% (95% CI 2.60% - 15.01%) reduction in girls' prevalence, in contrast to the insignificant impact on boys.

The best fit models for boys and girls match the actual prevalence, of smoking from the ESPAD surveys from 1995-2015, well (Figure 2.)

Figure 2 Prevalence of smoking from ESPAD surveys from 1995-2015 and fitted lines of predicted prevalence from best fit models for boys and girls

**Table 2a ESPAD 1995-2015 Logistic regression results from best fit models**

VARIABLES	Regression results (Odds ratios and CI)	
	Boy	Girl
Real price	0.63*** (0.52, 0.75)	0.75*** (0.65, 0.86)
Workplace ban	0.76* (0.60, 0.96)	0.70** (0.56, 0.86)
POS ban	1.48* (1.10, 2.00)	
Graphic images		0.65** (0.47, 0.88)
Constant	2.83** (1.40, 5.71)	2.13** (1.22, 3.72)
Observations	6,080	6,324
AIC	6657	7606
BIC	6684	7633

CI is confidence interval at 95% confidence level

\*\*\* p<0.001, \*\* p<0.01, \* p<0.05

**Table 2b ESPAD 1995-2015 Reduction in smoking prevalence from best fit models**

VARIABLES	Marginal effect (Reduction in prevalence and CI)	
	Boy	Girl
Real price	-8.41%***	-5.87%***



Workplace ban	(-11.66%, -5.16%) -4.93%*	(-8.79%, -2.96%) -7.31%**
POS ban	(-9.08%, -0.77%) 7.02%*	(-11.68%, -2.94%)
Graphic images	(1.65%, 12.40%)	-8.80%** (-15.01%, -2.60%)

CI is confidence interval at 95% confidence level

\*\*\* p<0.001, \*\* p<0.01, \* p<0.05

## Discussion

Although there is a general decline in adolescent smoking prevalence in ESPAD countries, there is no evidence of convergence in the different countries or geographic regions [16]. In Ireland, there was a steep drop in adolescent smoking prevalence between 2003 and 2007 when the decline was similar in girls and boys but greater in girls. The results show that the workplace ban introduced in 2004 helps to explain the steep drop in prevalence when controlling for the real price effect, which itself is consistently found to be effective in other studies[17,18]. In particular, although the overall average real price increased for the 2003-2007 period compared to the previous period, the annual real price actually decreased for the two years, 2005 and 2006. This reinforces the strong impact of the workplace ban on reducing smoking prevalence between the 2003 and 2007 period. In addition, the workplace ban rendered an estimated additional 5% reduction in actual smoking prevalence beyond price effect, which is a considerable effect given that the prevalence was 37% among females and 28% among males in 2003. The study however also confirms that real cigarette prices are strong determinants of youth smoking[17,18].

The other components of the WHO MPOWER policy package, consisting of a series of technical measures and resources to assist country-level implementation of the WHO Framework Convention on Tobacco Control (FCTC) e.g. smoking cessation services, advertising, promotion and sponsorship, did not change significantly between 2003 and 2007. In particular, mass media campaigns stayed moderately funded for the whole period of 1995 to 2015. Health warnings were moderate between 2003 and 2007, and cessation treatment and youth access were stable in the period [19]. Therefore, between 2003 and 2007, the only significant and positive change in tobacco control policies was the introduction of workplace ban.



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2  
3 The mechanisms that explain the link between the workplace ban and  
4 adolescent smoking prevalence are uncertain and our data do not allow a further  
5 interrogation. However, some studies from other countries have provided some  
6 explanations [20]. For example, one study shows that stronger public places  
7 restrictions had a significantly protective effect on smoking prevalence[21].  
8  
9 Another suggested that a workplace ban affects adolescents who are at work  
10 (through part-time jobs)[22]. It showed that adolescents who worked in smoke-  
11 free workplaces were only 68% (95% CI, 51%-90%) as likely to be smokers as  
12 adolescents who worked in a workplace with no smoking restrictions. It is also  
13 possible that the discourse around smoking which occurred pre-implementation  
14 of Smokefree Legislation helped to denormalise smoking in general even  
15 though the law was primarily about the workplace[23]. The decrease in  
16 prevalence from 2007 to 2011 was much steeper in girls than boys.  
17  
18

19  
20  
21 During this period, the annual real price decreased from 2010 to 2011 although  
22 the average real price for the period 2007 to 2011 increased slightly  
23 (Supplementary File 1). The model suggests that price has a greater marginal  
24 effect on boys than girls (8.4 % V 5.8 %). The decrease in the annual real price,  
25 which is not taken into account in the change of average real price in the model  
26 and the finding that the workplace ban seemed to have a greater effect in girls  
27 than boys (7.3% V 4.9%) may partially explain the difference in the rate of  
28 decline of prevalence.  
29  
30  
31

32 The impact of the POS ban on reducing youth smoking prevalence was not  
33 significant, which is consistent with the finding of the study by McNeill A. et al.  
34 (2011) [24]. They failed to find significant short-term changes in prevalence  
35 among youths or adults due to POS ban. However, their study showed that the  
36 proportion of youths believing that more than a fifth of children their own age  
37 smoked decreased from 62% to 46%,  $p < 0.001$ ). Post-legislation, 38% of  
38 teenagers thought it would make it easier for children not to smoke. Compliance  
39 was very high and the law was well supported. Recall of tobacco displays  
40 among teenagers reduced significantly post-legislation and there were  
41 encouraging signs that the law helped de-normalise smoking. While it was  
42 postulated at the time that it might take a longer time for the POS ban to  
43 effectively reduce smoking prevalence among youths, we have not seen it in  
44 this study based on a longer time series. Others however have seen more  
45 positive results in young people[25,26].  
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51 Context may be significant in this regard as our population were under age for  
52 legal purchase of cigarettes in Ireland and access in those circumstances occurs  
53 through other routes where POS displays may not be relevant. It does not  
54 however explain why the POS display ban was associated with a negative effect  
55 in boys in this analysis. It seems likely that this may have been partially a price  
56 effect because the real price actually declined in two of the relevant years  
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(Supplementary File 1) 2005 and 2006 but also there was a marked switch to cheaper roll your own cigarettes in both adults and teens[27,28].

In ESPAD countries, with different initial status from Ireland, generally, gender convergence is marked in smoking prevalence. In 1995, on average in ESPAD countries boys showed higher smoking prevalence than girls. In 2015, these differences were no longer apparent or became smaller. However, in 1995 Irish female adolescents had a much higher smoking prevalence than male adolescents (45% VS 37%), price and workplace ban effects were marked in both genders but somewhat different. As discussed above price effect was stronger in boys than girls although there is no conclusive evidence on this in the literature[17,28]. The impact of the POS ban differed between the two groups. In particular, POS ban did not significantly affect girls' smoking prevalence, while it is significantly and positively (7 %) related to boys' smoking prevalence.

The introduction of graphic images on packs seemed to have a much greater impact on girls with an 8.8% marginal effect whereas it had no significant effect on boys. These differential effects on POS and graphic images with the lesser differentials for price and the workplace ban may explain why we observed that by the end of the period, the gender gap was closed, with female prevalence being less than male prevalence by 2015, consistent with most ESPAD countries.

One of the potential issues of the above analysis is that the sample size is not ideally large and the interval between each survey is long, as there were only six surveys between 1995 and 2015. However, this is so far the best adolescent survey data in Ireland that provides adolescent smoking prevalence. Other surveys on smoking either didn't have enough adolescent samples (e.g. Survey on Lifestyle and Attitude to Nutrition and Healthy Ireland surveys), or were too recent to establish a baseline before the policies were introduced (e.g. Monthly phone interview surveys from National Tobacco Control Office from 2002), or had fewer data points (e.g. Health Behaviour in School-aged Children study had 5 waves between 1998 and 2014). Another limitation is that the data of 1999 and 2003 were obtained by recalculating the number of male and female smokers based on prevalence and total sample size, a process which may have introduced very small inaccuracies. However, the results are clear cut and the margin of error compared to total sample is negligible. Therefore, the process should not have significant impact on the results.

## Conclusions

Adolescent smoking prevalence dropped significantly in boys and girls in Ireland. This study found that the workplace ban introduced in 2004, to protect workers and customers from second-hand smoking, has significantly helped to explain the out-of-trend reduction in adolescent smoking prevalence. While removal of point of sale tobacco promotion may have reduced awareness of

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3 smoking among young people, there was no evidence of a beneficial effect on  
4 prevalence. Graphic images appear to have made a significant impact on girls'  
5 smoking prevalence but not on boys. In addition, we confirmed that price  
6 increase was consistently effective in both boys and girls. The implications for  
7 the whole population, considering age and gender, should be considered for all  
8 TCLs being introduced by policy makers irrespective of the targeted segment of  
9 the population.  
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**Figure 1 Trend of Irish adolescent smoking prevalence by gender (%)  
1995-2015 ESPAD surveys**

**Figure 2 Prevalence of smoking from ESPAD surveys from 1995-2015 and  
fitted lines of predicted prevalence from best fit models for boys and girls**

**Contributors**

LC conceived the study. LC and SL designed the study. SL, SK and LC were involved in analysis of the data. SL drafted the first version of the manuscript. LC and SK had input into all redrafts. All authors read and approved the final version.

**Funding:**

Dept. of Health Ireland RFT                      DOH RFT ESPAD 2015

Royal City of Dublin Hospital Trust      RCDHT Grant 178

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

**Ethical Approval:** Ethical approval was awarded by Dublin Institute of Technology, Research Ethics, Ethical Clearance Ref 18 -126.

New approval for this use of the study data set was not considered necessary as ESPAD Ireland PI with full access to ESPAD data set. We used fully anonymised aggregate data.

**Competing Interest**

LC, SK and SL declare no competing interests.

**Data Sharing**

No additional data available

The data were from the European School Survey Project on Alcohol and Other Drugs (ESPAD) and various official reports available from <http://www.espad.org/reports-documents>. With the 2003 data collection as a starting point, it was

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3 decided that all country datasets should be merged into a common database.  
4 After that also data from 2007 and 2011 are available in separate databases.  
5 Initially, these databases were stored and maintained by the Databank Manager  
6 Thoroddur Bjarnson. During the 2015 wave of ESPAD, the international  
7 database was compiled and standardised by CAN (Stockholm). Even though,  
8 since 2007, countries are obliged to deliver their national datasets to the  
9 database, there are—as stated in the database rules—no obligations to let other  
10 researchers use the national data without permission. In order to obtain a copy  
11 of a database, an application form has to be filled in and posted to the  
12 coordinators for further distribution to the ESPAD Application Committee. The  
13 composition of the committee as well as restrictions around the database and its  
14 use are described and explained in the ESPAD database rules (database rules for  
15 ESPAD researchers and database rules for non-ESPAD researchers). When an  
16 application is approved, a contract is signed before a copy of the database is  
17 delivered. Approved applications are presented in a list, which also displays the  
18 deadline of the projects. ESPAD researchers are allowed to apply for the most  
19 recent database once the International ESPAD Report has been released. Non-  
20 ESPAD researchers are also allowed to work with ESPAD data. Access for non-  
21 ESPAD researchers is allowed after an embargo period determined by an  
22 assembly: ESPAD 2003 Database: accessible now. ESPAD 2007 Database: was  
23 accessible since 1 July 2013. ESPAD 2011 Database: was accessible since 1  
24 July 2015. ESPAD 2015 Database: at present, it is only accessible to ESPAD  
25 researchers. [http://www.espad.org/sites/espad.org/themes/cs\\_espad/logo.png](http://www.espad.org/sites/espad.org/themes/cs_espad/logo.png):  
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39 **Acknowledgements:** We wish to thank Focas Research Institute, TU Dublin for  
40 facilities and the ESPAD international researchers supported by EMCDDA  
41 contract CC.14.SDI.032 who compiled a common ESPAD Trend database  
42 (1995–2015).  
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**Figure 1 Trend of Irish adolescent smoking prevalence by gender (%) 1995-2015 ESPAD surveys**

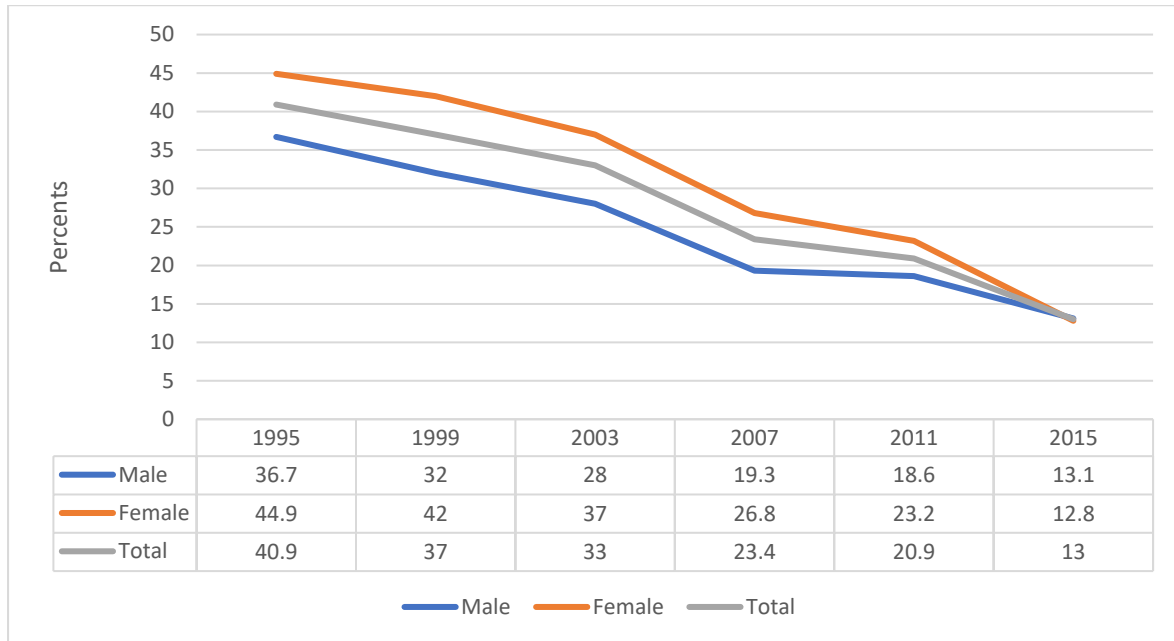
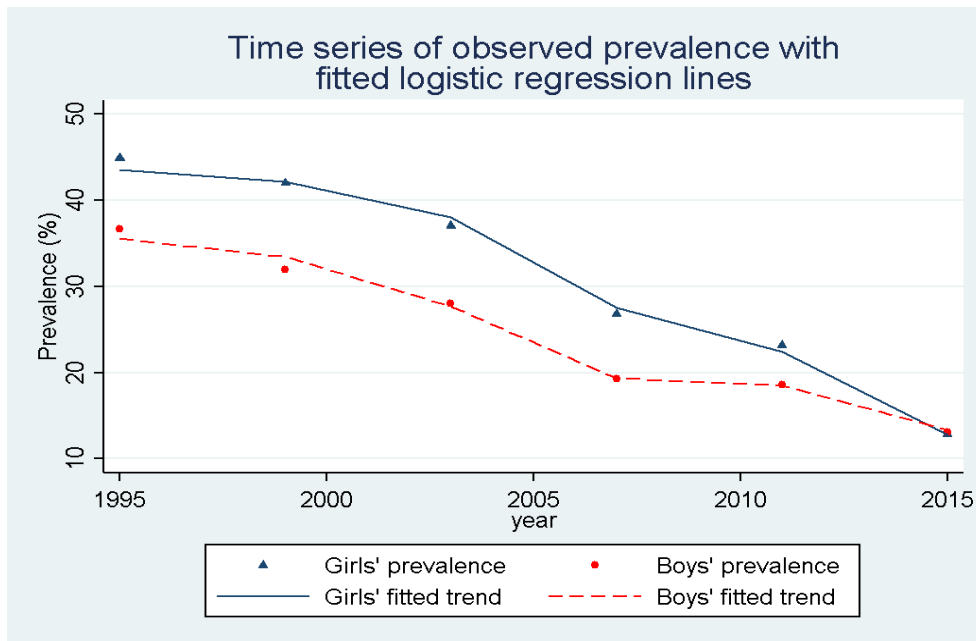
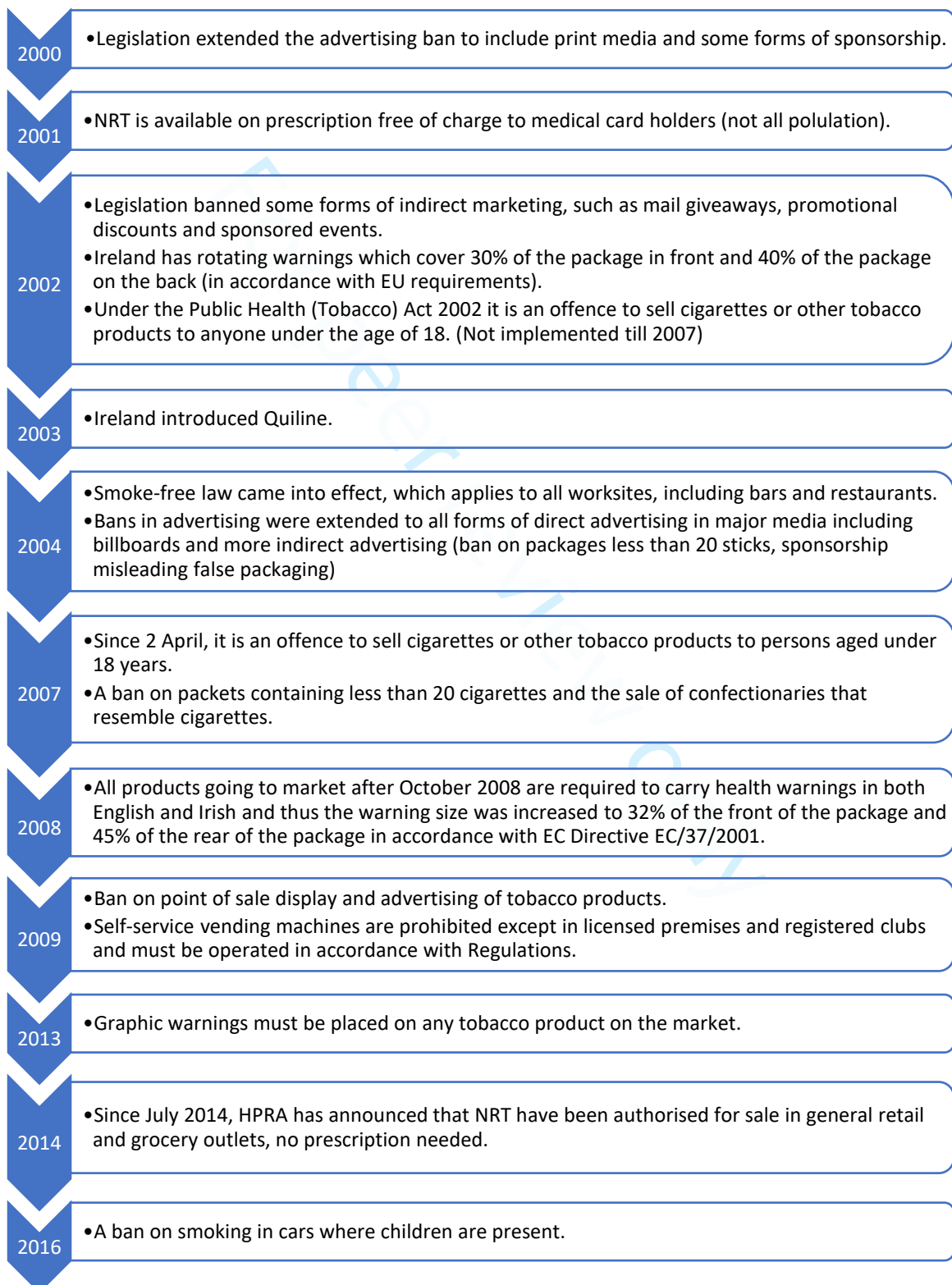


Figure 2. Prevalence of smoking from ESPAD surveys from 1995-2015 and fitted lines of predicted prevalence from best fit models for boys and girls



## Appendix 1

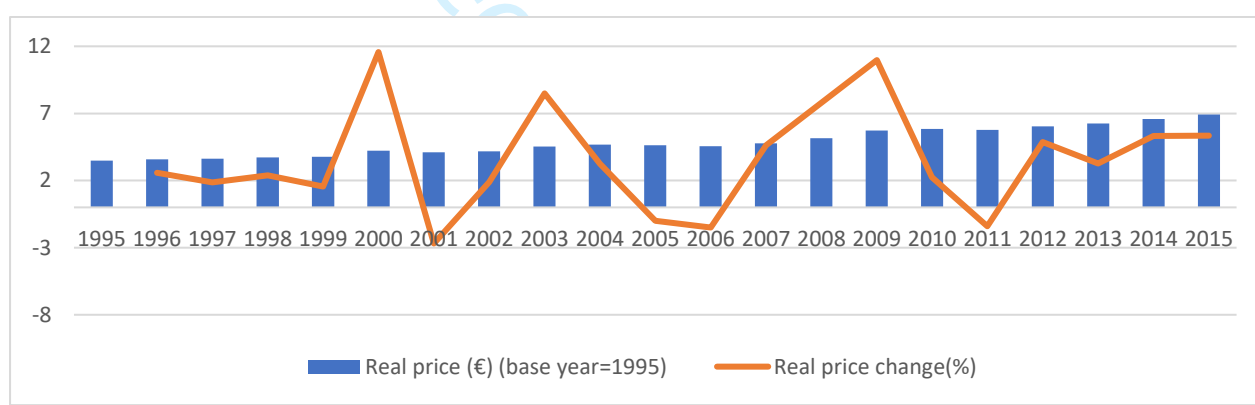
### Timeline of Tobacco Control Policies/ Interventions in Ireland, 2000 -2016



Supplementary File 1

Table 1 Real price (€) per package of 20 cigarettes in Ireland, 1995-2015

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Retail price	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5
CPI (year 1995=100)	100	102	103	106	107	113	119	124	129	133	140	147	150	153	156	158	161	162	165	166	167
Real price (base year=1995)	3.5	3.6	3.6	3.7	3.8	4.2	4.1	4.2	4.5	4.7	4.6	4.6	4.8	4.9	5.1	5.2	5.3	5.4	5.5	5.6	5.7
Real price change (%)	-	2.6	1.9	2.4	1.6	11.6	2.4	11.9	8.5	3.2	1.7	1.5	4.6	7.8	1.2	2.4	1.9	4.9	3.3	5.3	5.3



## Supplementary File 2

Irish ESPAD 1995 to 2015:

Logistic regression of male prevalence on factors from various models 1-7

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VARIABLES	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Real price	0.65*** (0.02)	0.75*** (0.05)	0.54*** (0.04)	0.64*** (0.03)	0.63*** (0.06)	0.78** (0.06)	0.53*** (0.04)	0.64*** (0.07)
Workplace ban		0.72** (0.08)			0.76* (0.09)	0.70** (0.09)		0.75* (0.10)
POS ban			1.57** (0.23)		1.48* (0.23)		1.59** (0.24)	1.47* (0.23)
Graphic images				1.09 (0.16)		0.90 (0.15)	1.12 (0.17)	0.96 (0.16)
Constant	2.39*** (0.36)	1.43 (0.34)	4.83*** (1.34)	2.55*** (0.48)	2.83** (1.01)	1.24 (0.39)	5.36*** (1.64)	2.66* (1.17)
Observations	6,080	6,080	6,080	6,080	6,080	6,080	6,080	6,080
AIC	6668	6662	6661	6669	6657	6663	6662	6659
BIC	6681	6682	6681	6689	6684	6690	6689	6693

Coefficients are odds ratios

SE in parentheses

\*\*\* p&lt;0.001, \*\* p&lt;0.01, \* p&lt;0.05

## Irish ESPAD 1995 to 2015

## Logistic regression of female prevalence on factors from various models 1-7

VARIABLES	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Real price	0.59*** (0.02)	0.65*** (0.04)	0.52*** (0.03)	0.61*** (0.02)	0.58*** (0.05)	0.75*** (0.06)	0.54*** (0.04)	0.68*** (0.07)
Workplace ban		0.79* (0.08)			0.83 (0.09)	0.70** (0.08)		0.73** (0.09)
POS ban			1.36* (0.18)		1.27 (0.18)		1.35* (0.18)	1.20 (0.17)
Graphic images				0.80 (0.12)		0.65** (0.10)	0.81 (0.12)	0.67* (0.11)
Constant	5.24*** (0.74)	3.58*** (0.77)	8.46*** (2.12)	4.48*** (0.78)	5.65*** (1.92)	2.13** (0.61)	7.22*** (1.97)	3.11** (1.29)
Observations	6,324	6,324	6,324	6,324	6,324	6,324	6,324	6,324
AIC	7615	7612	7612	7615	7611	7606	7611	7606
BIC	7629	7632	7632	7635	7638	7633	7639	7640

Coefficients are odds ratios

SE in parentheses

\*\*\* p&lt;0.001, \*\* p&lt;0.01, \* p&lt;0.05

# Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

## Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

			Page Number
<b>Title and abstract</b>			
Title	<a href="#">#1a</a>	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	<a href="#">#1b</a>	Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background / rationale	<a href="#">#2</a>	Explain the scientific background and rationale for the investigation being reported	3
Objectives	<a href="#">#3</a>	State specific objectives, including any prespecified hypotheses	3
<b>Methods</b>			
Study design	<a href="#">#4</a>	Present key elements of study design early in the paper	4
Setting	<a href="#">#5</a>	Describe the setting, locations, and relevant dates, including periods of	4



		recruitment, exposure, follow-up, and data collection	
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2	Eligibility criteria	<a href="#">#6a</a> Give the eligibility criteria, and the sources and methods of selection of	4
3		participants.	
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6		<a href="#">#7</a> Clearly define all outcomes, exposures, predictors, potential	5
7		confounders, and effect modifiers. Give diagnostic criteria, if applicable	
8			
9			
10	Data sources /	<a href="#">#8</a> For each variable of interest give sources of data and details of methods	4
11	measurement	of assessment (measurement). Describe comparability of assessment	
12		methods if there is more than one group. Give information separately	
13		for for exposed and unexposed groups if applicable.	
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17	Bias	<a href="#">#9</a> Describe any efforts to address potential sources of bias	4-5
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19	Study size	<a href="#">#10</a> Explain how the study size was arrived at	4
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21	Quantitative	<a href="#">#11</a> Explain how quantitative variables were handled in the analyses. If	4
22	variables	applicable, describe which groupings were chosen, and why	
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25	Statistical	<a href="#">#12a</a> Describe all statistical methods, including those used to control for	4
26	methods	confounding	
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29	Statistical	<a href="#">#12b</a> Describe any methods used to examine subgroups and interactions	4
30	methods		
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33	Statistical	<a href="#">#12c</a> Explain how missing data were addressed	4
34	methods		
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37	Statistical	<a href="#">#12d</a> If applicable, describe analytical methods taking account of sampling	4
38	methods	strategy	
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41	Statistical	<a href="#">#12e</a> Describe any sensitivity analyses	4
42	methods		
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45	<b>Results</b>		
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47	Participants	<a href="#">#13a</a> Report numbers of individuals at each stage of study—eg numbers	4
48		potentially eligible, examined for eligibility, confirmed eligible,	
49		included in the study, completing follow-up, and analysed. Give	
50		information separately for for exposed and unexposed groups if	
51		applicable.	
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55	Participants	<a href="#">#13b</a> Give reasons for non-participation at each stage	4
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57	Participants	<a href="#">#13c</a> Consider use of a flow diagram	na
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1	Descriptive data	<a href="#">#14a</a>	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	4
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6	Descriptive data	<a href="#">#14b</a>	Indicate number of participants with missing data for each variable of interest	4
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10	Outcome data	<a href="#">#15</a>	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	5
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14	Main results	<a href="#">#16a</a>	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	5
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18				
19	Main results	<a href="#">#16b</a>	Report category boundaries when continuous variables were categorized	5
20				
21	Main results	<a href="#">#16c</a>	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	5
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25	Other analyses	<a href="#">#17</a>	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	5
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29	<b>Discussion</b>			
30				
31	Key results	<a href="#">#18</a>	Summarise key results with reference to study objectives	6
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33				
34	Limitations	<a href="#">#19</a>	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	3,7
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39	Interpretation	<a href="#">#20</a>	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	7
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44	Generalisability	<a href="#">#21</a>	Discuss the generalisability (external validity) of the study results	7
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47	<b>Other</b>			
48	<b>Information</b>			
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51	Funding	<a href="#">#22</a>	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	10
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