BMJ Open

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

| | |
|---|---|
| Journal: | *BMJ Open* |
| 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<br>Keogan, Sheila; TobaccoFree Research Institute Ireland,<br>Clancy, Luke; TobaccoFree Research Institute Ireland, Research |
| Keywords: | Price,, Secondhand smoke, Advertising and Promotion,, Denormalisation, EPIDEMIOLOGY |
| | |

*I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.*

*The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.*

*Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.*

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

Authors: Shasha Li[1], PhD, Sheila Keogan[1], MPhil, Luke Clancy[1], MD.

Affiliation: [1]TobaccoFree Research Institute Ireland, Dublin

Corresponding Author: Luke Clancy,

Contact Details: TobaccoFree Research Institute Ireland,

Focas Research Institute,

TU Dublin, City Centre Campus, Kevin Street,

Dublin D08 NF82, Ireland

Email: lclancy@tri.ie

Manuscript Word Count: 2748

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

Authors: Shasha Li[1], PhD, Sheila Keogan[1], MPhil, Luke Clancy[1], MD.

Affiliation: [1]TobaccoFree Research Institute Ireland, Dublin

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% CI2.94-11.68), 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

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

## Patient and Public Involvement

No patients were involved. The principals of the schools involved were fully informed and cooperated in explaining the studies and administering the surveys. The results of each survey were disseminated through the media and Dept of Health.

## Statistical analysis

For statistical analysis, a logistic regression model on grouped data was used. All analyses were conducted separately for boys and girls. We have included real price and policy indicators. Seven models are assessed. First, we look at the impact of real price on adolescent prevalence (Model 0). Then we assess the impact of workplace ban on adolescent smoking by adding a workplace ban indicator, together with price (Model 1).

Then we repeat the first step by replacing the workplace ban by the POS ban indicator (Model 2) and graphic images indicator (Model 3). Pairwise combinations of the policy indicators are also considered (Model 4 – 6). Lastly, all policy indicators and price are included (Model 7). Various criteria are used to determine the best model. In particular, models with smaller Akaike information criterion (AIC) values and Bayesian information criterion (BIC) values are preferred. Likelihood ratio tests are used for comparing two nested models. A significant test suggests that the full model is an improvement on the reduced model. All analyses were performed with the Stata 13 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.)

## 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.

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

| | Regression results | | Reduction in prevalence | |
|---|---|---|---|---|
| VARIABLES | 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 regions1. 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**

## References:

1. Public Health (Tobacco) Act, 2002 [Internet]. Available from: http://www.irishstatutebook.ie/eli/2002/act/6/enacted/en/html

2. Frazer K, Callinan JE, McHugh J, van Baarsel S, Clarke A, Doherty K, et al. Legislative smoking bans for reducing harms from secondhand smoke exposure, smoking prevalence and tobacco consumption. Frazer K, editor. Cochrane Database Syst Rev [Internet]. 2016 Feb 4 [cited 2017 Dec 5];(2). Available from: http://doi.wiley.com/10.1002/14651858.CD005992.pub3

3. Wilson LM, Avila Tang E, Chander G, Hutton HE, Odelola OA, Elf JL, et al. Impact of tobacco control interventions on smoking initiation, cessation, and prevalence: a systematic review. J Environ Public Health. 2012;2012.

4. Stallings-Smith S, Zeka A, Goodman P, Kabir Z, Clancy L. Reductions in Cardiovascular, Cerebrovascular, and Respiratory Mortality following the National Irish Smoking Ban:

Interrupted Time-Series Analysis. Manzoli L, editor. PLoS One [Internet]. 2013 Apr 24 [cited 2017 Dec 6];8(4):e62063. Available from: http://dx.plos.org/10.1371/journal.pone.0062063

5. Li S, Keogan S, Taylor K, *Clancy l.* Decline of adolescent smoking in Ireland 1995–2015: trend analysis and associated factors BMJ Open 2018;8: e020708. doi: 10.1136

6. Edwards R, Ajmal A, Healey B, Hoek J. Impact of removing point-of-sale tobacco displays: Data from a New Zealand youth survey. Tob Control. 2017;26:392–8.

7. Van Hurck MM, Nuyts PAW, Monshouwer K, Kunst AE, Kuipers MAG. Impact of removing point-of-sale tobacco displays on smoking behaviour among adolescents in Europe: a quasi-experimental study. Tob Control [Internet]. 2018 Jul 20; Available from: http://tobaccocontrol.bmj.com/content/early/2018/07/19/tobaccocontrol-2018-054271.abstract

8. Dunlop S, Kite J, Grunseit AC, Rissel C, Perez DA, Dessaix A, et al. Out of sight and out of mind? Evaluating the impact of point-of-sale tobacco display bans on smoking-related beliefs and behaviors in a sample of Australian adolescents and young adults. Nicotine Tob Res. 2014;17(7):761–8.

9. The ESPAD GROUP. ESPAD Report 2015. Results from the European School Survey Project on Alcohol and Other Drugs [Internet]. Luxembourg; 2016 [cited 2017 Dec 6]. Available from: http://www.diva-portal.org/smash/record.jsf?pid=diva2:1052874

10. Hibell B, Guttormsson U, Ahlström S, Balakireva O. The 2007 ESPAD report: substance use among students in 35 European countries. 2009.

11. Hibell B, Guttormsson U, Ahlström S, Balakireva O. The 2011 ESPAD report: substance use among students in 36 European countries [Internet]. 2012 [cited 2017 Dec 6]. Available from: http://alcoholireland.ie/download/reports/alcohol_health/children_young_people/the-2011-espad_report.pdf

12. Hibell B, Andersson B, Bjarnason T, Ahlström S, Balakireva O, Kokkevi A, et al. The ESPAD report 2003: alcohol and other drug use among students in 35 European countries. 2004.

13. Hibell B, Andersson B, Ahlström S, Balakireva O, Bjarnason T, Kokkevi A, et al. The 1999 ESPAD report: alcohol and other drug use among students in 30 European countries. 2000.

14. Chaloupka FJ, Warner KE. The economics of smoking. Handb Heal Econ. 2000;1:1539–627.

15. Gallet CA, List JA. Cigarette demand: a meta-analysis of elasticities. Health Econ [Internet]. 2003 Oct [cited 2017 Dec 6];12(10):821–35. Available from: http://doi.wiley.com/10.1002/hec.765

16. Tauras JA, Huang J, Chaloupka FJ. Differential impact of tobacco control policies on youth sub-populations. International Journal of Environmental Research and Public Health. 2013.

17. Tauras JA. Con public policy deter smoking escalation among young adults? Journal of Policy Analysis and Management. 2005.

18. Wakefield MA, Chaloupka FJ, Kaufman NJ, Orleans CT, Barker DC, Ruel EE. Effect of restrictions on smoking at home, at school, and in public places on teenage smoking: cross sectional study. BMJ [Internet]. 2000 Aug 5;321(7257):333 LP-337. Available from: http://www.bmj.com/content/321/7257/333.abstract

19. AJ F, EA G, MM W, JP P. Association between household and workplace smoking restrictions and adolescent smoking. JAMA [Internet]. 2000 Aug 9;284(6):717–22. Available from: http://dx.doi.org/10.1001/jama.284.6.717

20. Fahy D, Trench B, Clancy L. Communicating Contentious Health Policy: Lessons From Ireland's Workplace Smoking Ban. Health Promot Pract. 2012;13(3):331–8.

21. McNeill A, Lewis S, Quinn C, Mulcahy M, Clancy L, Hastings G, et al. Evaluation of the removal of point-of-sale tobacco displays in Ireland. Tob Control. 2011;20(2):137.

22. Babineau K, Clancy L. Young people's perceptions of tobacco packaging: A comparison of EU Tobacco Products Directive & Ireland's Standardisation of Tobacco Act. BMJ Open. 2015;5(6).

23. Evans D, Farrell AO, Hickey P. Roll Your own Cigarettes in Ireland Key Patterns and Trends Roll Your Own Cigarettes in Ireland. Dublin; 2017.

24. Chaloupka FJ, Pacula RL. An examination of gender and race differences in youth smoking responsiveness to price and tobacco control policies. NBER Working Paper Series. 1998.

**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.

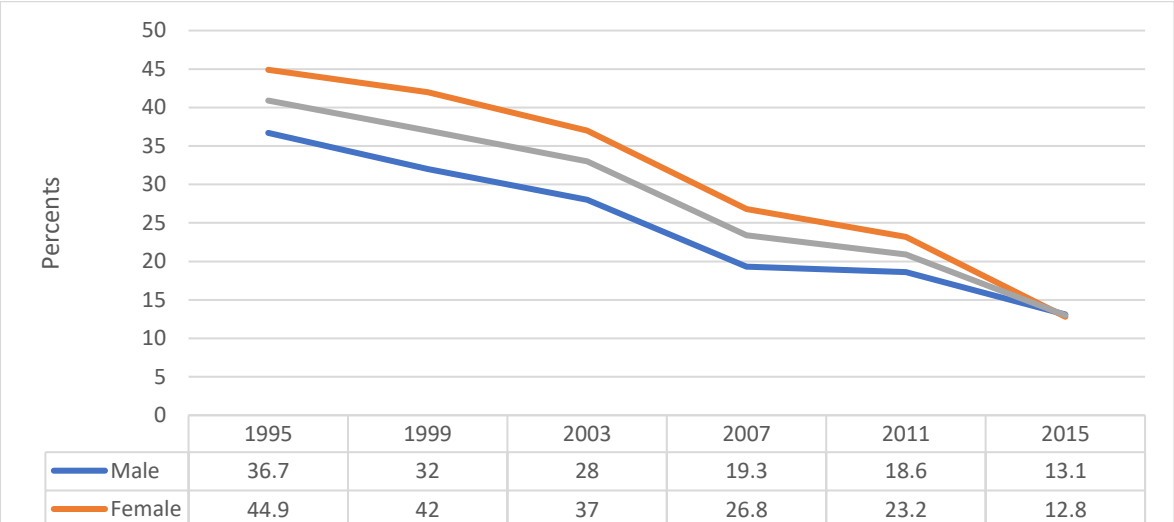
LC, SK and SL declare no competing interests.

**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

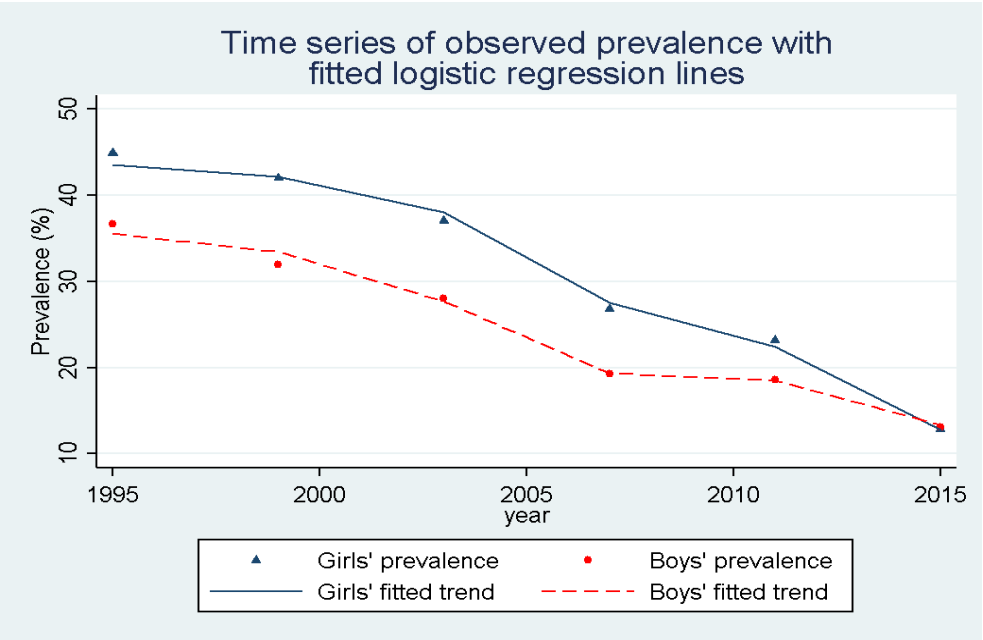
Project on Alcohol and Other Drugs (ESPAD) and various official reports available from http://www. espad. org/ reports- documents. With the 2003 data collection as a starting point, it was decided that all country datasets should be merged into a common database. After that also data from 2007 and 2011 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.pngg:

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



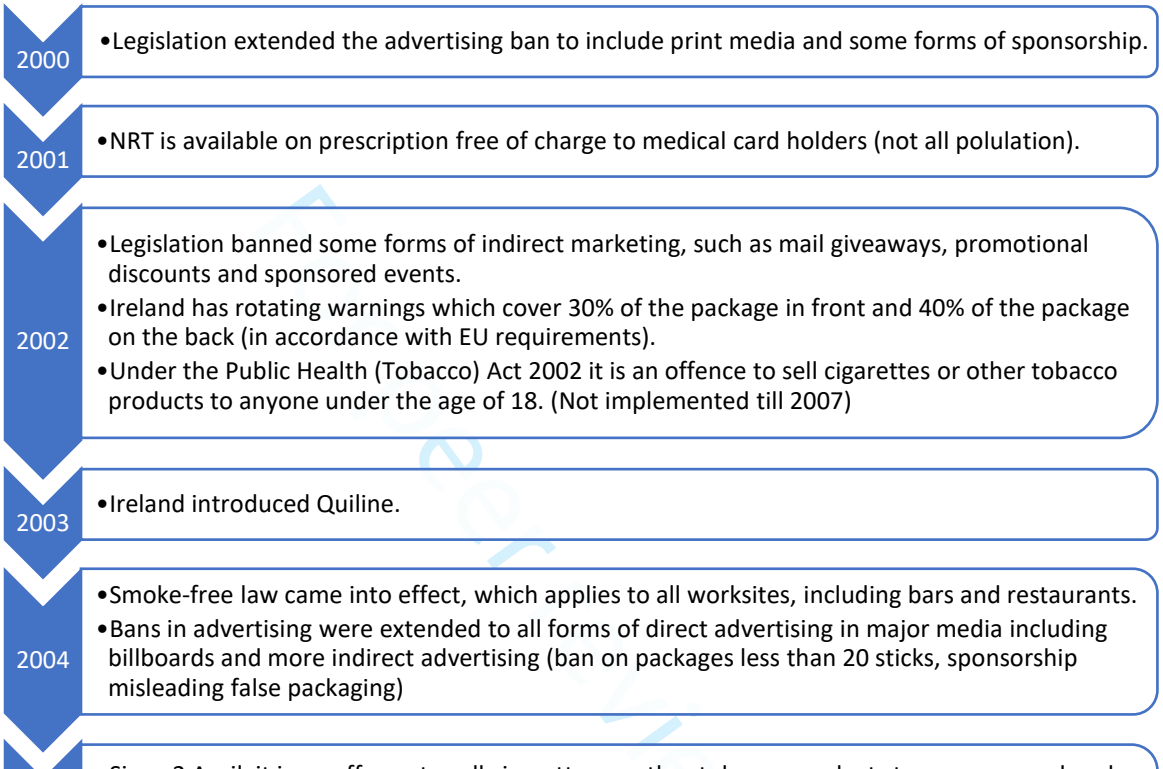

| | 1995 | 1999 | 2003 | 2007 | 2011 | 2015 |
|---|---|---|---|---|---|---|
| Male | 36.7 | 32 | 28 | 19.3 | 18.6 | 13.1 |
| Female | 44.9 | 42 | 37 | 26.8 | 23.2 | 12.8 |
| Total | 40.9 | 37 | 33 | 23.4 | 20.9 | 13 |

**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

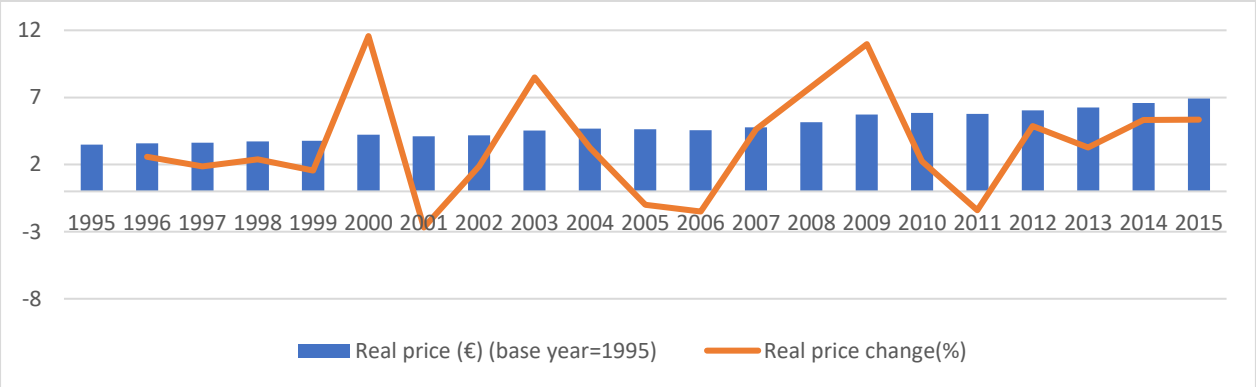
## Timeline of Tobacco Control Policies/ Interventions in Ireland, 2000 -2016



**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 | 3.8 | 3.9 | 4.1 | 4.8 | 4.9 | 5.2 | 5.8 | 6.2 | 6.3 | 6.4 | 7.0 | 7.9 | 8.4 | 8.5 | 8.6 | 9.1 | 9.5 | 10.0 | 10.5 |
| CPI (year 1995=100) | 100 | 102 | 103 | 106 | 107 | 113 | 119 | 124 | 129 | 131 | 135 | 140 | 147 | 153 | 146 | 145 | 148 | 151 | 152 | 152 | 151 |
| 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 | 6.6 | 6.9 |
| Real price change (%) | | 2.6 | 1.9 | 2.4 | 1.6 | 11.6 | -2.7 | 1.9 | 8.5 | 3.2 | -1.0 | -1.5 | 4.6 | 7.8 | 11.0 | 2.2 | -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*** | 0.75*** | 0.54*** | 0.64*** | 0.63*** | 0.78** | 0.53*** | 0.64*** |
| | (0.02) | (0.05) | (0.04) | (0.03) | (0.06) | (0.06) | (0.04) | (0.07) |
| Workplace ban | | 0.72** | | | 0.76* | 0.70** | | 0.75* |
| | | (0.08) | | | (0.09) | (0.09) | | (0.10) |
| POS ban | | | 1.57** | | 1.48* | | 1.59** | 1.47* |
| | | | (0.23) | | (0.23) | | (0.24) | (0.23) |
| Graphic images | | | | 1.09 | | 0.90 | 1.12 | 0.96 |
| | | | | (0.16) | | (0.15) | (0.17) | (0.16) |
| Constant | 2.39*** | 1.43 | 4.83*** | 2.55*** | 2.83** | 1.24 | 5.36*** | 2.66* |
| | (0.36) | (0.34) | (1.34) | (0.48) | (1.01) | (0.39) | (1.64) | (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<0.001, ** p<0.01, * p<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*** | 0.65*** | 0.52*** | 0.61*** | 0.58*** | 0.75*** | 0.54*** | 0.68*** |
| | (0.02) | (0.04) | (0.03) | (0.02) | (0.05) | (0.06) | (0.04) | (0.07) |
| Workplace ban | | 0.79* | | | 0.83 | 0.70** | | 0.73** |
| | | (0.08) | | | (0.09) | (0.08) | | (0.09) |
| POS ban | | | 1.36* | | 1.27 | | 1.35* | 1.20 |
| | | | (0.18) | | (0.18) | | (0.18) | (0.17) |
| Graphic images | | | | 0.80 | | 0.65** | 0.81 | 0.67* |
| | | | | (0.12) | | (0.10) | (0.12) | (0.11) |
| Constant | 5.24*** | 3.58*** | 8.46*** | 4.48*** | 5.65*** | 2.13** | 7.22*** | 3.11** |
| | (0.74) | (0.77) | (2.12) | (0.78) | (1.92) | (0.61) | (1.97) | (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<0.001, ** p<0.01, * p<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 sectionalreporting guidelines, and cite them as:

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

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

| | | | |
|---|---|---|---|
| | | recruitment, exposure, follow-up, and data collection | |
| Eligibility criteria | #6a | Give the eligibility criteria, and the sources and methods of selection of participants. | 4 |
| | #7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 5 |
| Data sources / measurement | #8 | For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable. | 4 |
| Bias | #9 | Describe any efforts to address potential sources of bias | 4-5 |
| Study size | #10 | Explain how the study size was arrived at | 4 |
| Quantitative variables | #11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why | 4 |
| Statistical methods | #12a | Describe all statistical methods, including those used to control for confounding | 4 |
| Statistical methods | #12b | Describe any methods used to examine subgroups and interactions | 4 |
| Statistical methods | #12c | Explain how missing data were addressed | 4 |
| Statistical methods | #12d | If applicable, describe analytical methods taking account of sampling strategy | 4 |
| Statistical methods | #12e | Describe any sensitivity analyses | 4 |
| **Results** | | | |
| Participants | #13a | Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable. | 4 |
| Participants | #13b | Give reasons for non-participation at each stage | 4 |
| Participants | #13c | Consider use of a flow diagram | na |

| | | | |
|---|---|---|---|
| Descriptive data | #14a | 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 |
| Descriptive data | #14b | Indicate number of participants with missing data for each variable of interest | 4 |
| Outcome data | #15 | Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable. | 5 |
| Main results | #16a | 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 |
| Main results | #16b | Report category boundaries when continuous variables were categorized | 5 |
| Main results | #16c | If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 5 |
| Other analyses | #17 | Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses | 5 |
| **Discussion** | | | |
| Key results | #18 | Summarise key results with reference to study objectives | 6 |
| Limitations | #19 | 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 |
| Interpretation | #20 | Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence. | 7 |
| Generalisability | #21 | Discuss the generalisability (external validity) of the study results | 7 |
| **Other Information** | | | |
| Funding | #22 | 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 |


This checklist was completed on 27. June 2019 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai

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: | *BMJ Open* |
| 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<br>Keogan, Sheila; TobaccoFree Research Institute Ireland,<br>Clancy, Luke; TobaccoFree Research Institute Ireland, Research |
| Primary Subject Heading: | Public health |
| Secondary Subject Heading: | Epidemiology, Smoking and tobacco, Addiction, Communication |
| Keywords: | Price,, Secondhand smoke, Advertising and Promotion,, Denormalisation, EPIDEMIOLOGY, Graphic Tobacco Images |
| | |

*I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.*

*The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.*

*Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.*

# 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

Authors: Shasha Li1, PhD, Sheila Keogan1, MPhil, Luke Clancy1, MD.

Affiliation (1) TobaccoFree Research Institute Ireland, Dublin

Corresponding Author: Luke Clancy,

Contact Details: TobaccoFree Research Institute Ireland,
Focas Research Institute,
TU Dublin, City Centre Campus, Kevin Street,
Dublin D08 NF82, Ireland

Email: lclancy@tri.ie

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

Word Count 3179



## Abstract

Objectives:

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% CI2.94-11.68), 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.

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 in Ireland was banned on a comprehensive national basis on the 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 bans are strictly enforced[2]. While the 2004 smoke-free workplaces legislation has reduced adult smoking prevalence [3][4] and has 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. Although the Smokefree legislation was not targeting adolescents, this study sets out to assess if it 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. Smoking in Irish girls exceeded that in boys for the 20 years preceding the introduction of strong tobacco control measures beginning in 2002. This 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].

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

In Ireland, there were no school-specific TCL introduced between 1995 and 2015. However, Smokefree legislation (2004) and other policies that would potentially help to reduce adolescent smoking prevalence were introduced since 1995. The other TCLs 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. 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 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

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

## Statistical analysis

For statistical analysis, a logistic regression model on grouped data was used. All analyses were conducted separately for boys and girls because we found that they show the effects of individual TCL interventions more precisely than pooled data. We have included real price and policy indicators. Seven models are assessed. First, we look at the impact of real price on adolescent prevalence (Model 0). Then we assess the impact of workplace ban on adolescent smoking by adding a workplace ban indicator, together with price (Model 1).

Then we repeat the first step by replacing the workplace ban by the POS ban indicator (Model 2) and graphic images indicator (Model 3). Pairwise combinations of the policy indicators are also considered (Model 4 – 6). Lastly, all policy indicators and price are included (Model 7). Various criteria are used to determine the best model. In particular, models with smaller Akaike information criterion (AIC) values and Bayesian information criterion (BIC) values are preferred. Likelihood ratio tests are used for comparing two nested models. A significant test suggests that the full model is an improvement on the reduced model. All analyses were performed with the Stata 13 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.)

## Patient and public involvement

No patients were involved. The principals of the schools involved were fully informed and cooperated in explaining the studies and administering the surveys. The results of each surveys were disseminated through the media and Dept of Health.

## 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, a unit increase in the real price reduces 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.

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*** | 0.75*** |
| | (0.52, 0.75) | (0.65, 0.86) |
| Workplace ban | 0.76* | 0.70** |
| | (0.60, 0.96) | (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

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,

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 the 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[20]. Another suggested that a workplace ban affects adolescents who are at work (through part-time jobs)[21]. 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 of Smokefree Legislation helped to denormalise smoking in general even though the law was primarily about the workplace[22]. 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 in 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)[23]. 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 that more than a fifth of children their own 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 tobacco 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[24,25]. 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 may have been partially 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[26,27].

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 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. The implications for the whole population, considering age and gender, should be considered for all TCLs being introduced by policy makers irrespective of the targeted segment of the population.

**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**

References:


1 Joossens, Luc, Raw M. The Tobacco Control Scale 2016 in Europe. Brussels: European Cancer League Associations. 2016. https://www.tobaccocontrolscale.org/2016-edition/. [accessed 19October 2018]

2 Irish Government. Public Health (Tobacco) Act 2002. 2002. https://www.tobaccocontrollaws.org/legislation/country/ireland/summary (accessed 17 Sep 2019).

3 Frazer K, Callinan JE, McHugh J, van Baarsel S, Clarke A, Doherty K, et al. Frazer K E. Legislative smoking bans for reducing harms from secondhand smoke exposure, smoking. 2016. http://doi.wiley.com/10.1002/14651858.CD005992.pub3

4 Wilson LM, Avila Tang E, Chander G, *et al.* Impact of tobacco control interventions on smoking initiation, cessation, and prevalence: A systematic review. J. Environ. Public Health. 2012. doi:10.1155/2012/961724

5 Stallings-Smith S, Zeka A, Goodman P, *et al.* Reductions in Cardiovascular, Cerebrovascular, and Respiratory Mortality following the National Irish Smoking Ban: Interrupted Time-Series Analysis. *PLoS One* Published Online First: 2013. doi:10.1371/journal.pone.0062063

6 World Health Organization (WHO). European tobacco use, trends report 2019.

7 Li S, Keogan S, Taylor K, *et al.* Decline of adolescent smoking in Ireland 1995-2015: Trend analysis and associated factors. *BMJ Open* Published Online First: 2018. doi:10.1136/bmjopen-2017-020708

8 Dunlop S, Kite J, Grunseit AC, *et al.* Out of sight and out of mind? Evaluating the impact of point-of-sale tobacco display bans on smoking-related beliefs and behaviors in a sample of australian adolescents and young adults. *Nicotine Tob Res* Published Online First: 2015. doi:10.1093/ntr/ntu180

9 Kraus, L; Håkan L, Guttormsson U, Leifman H, *et al.* Results from the European School Survey Project on Alcohol and Other Drugs. 2015. doi:10.1121/1.1610459

10 Björn Hibell, Ulf Guttormsson SA, www.espad.org Olga Balakireva, Thoroddur Bjarnason, Anna Kokkevi LK. The 2007 ESPAD Report; substance use among students in 35 European Countries. 2009.

11 Hibell B, Guttormsson U, Ahlström S, *et al. The 2011 ESPAD Report: Substance Use Among Students in 36 European Countries*. 2012. doi:ISBN: 978-91-7278-233-4

12 Hibell, Björn; Andersson, Barbro; Bjarnason, Thoroddur; Ahlström, Salme ; Balakireva, Olga; Kokkevi, Anna; Morgan M. The ESPAD report 2003 : alcohool and other drug use among students in 35 European countries. 2004. doi:91-7278-103-3

13 Hibell B, Andersson B, Ahlström S, Balakireva O, Bjarnason T, Kokkevi A et al. The 1999 ESPAD report: alcohol and other drug use among students in 30 European countries. Dublin: 2000. http://www.espad.org/sites/espad.org/files/The_1999_ESPAD_report.pdf

14 Chaloupka FJ, Warner KE. Chapter 29 The economics of smoking. Handb. Heal. Econ. 2000. doi:10.1016/S1574-0064(00)80042-6

15 Currie, L Townsend, J Leon Roux,M Godfrey,F Gallus,S Gilmore,AB Levy,D Nguyen,L Rosenqvist,G Clancy L. *Policy Recommendations for Tobacco Taxation in the European Union Integrated Research Findings from the PPACTE project*. 2012. http://www.tri.ie/uploads/3/1/3/6/31366051/ppacte_policy_recommendations_and_integrated_report.pdf

16 Kraus L, Seitz NN, Piontek D, *et al.* 'Are The Times A-Changin'? Trends in adolescent substance use in Europe. *Addiction* Published Online First: 2018. doi:10.1111/add.14201

17 Gallet CA, List JA. Cigarette demand: A meta-analysis of elasticities. *Health Econ* Published Online First: 2003. doi:10.1002/hec.765

18 Tauras JA, Huang J, Chaloupka FJ. Differential impact of tobacco control policies on youth sub-populations. Int. J. Environ. Res. Public Health. 2013. doi:10.3390/ijerph10094306

19 Currie LM, Blackman K, Clancy L, *et al.* The effect of tobacco control policies on smoking prevalence and smoking-attributable deaths in Ireland using the IrelandSS simulation model. *Tob Control* 2013;**22**:e25-32. doi:10.1136/tobaccocontrol-2011-050248

20 Tauras JA. Con public policy deter smoking escalation among young adults? J. Policy Anal. Manag. 2005. doi:10.1002/pam.20137

21 Wakefield MA, Chaloupka FJ, Kaufman NJ, *et al.* Effect of restrictions on smoking at home, at school, and in public places on teenage smoking: Cross sectional study. *Br Med J* 2000.

22 Farkas AJ, Gilpin EA, White MM, *et al.* Association between household and workplace smoking restrictions and adolescent smoking. *J Am Med Assoc* Published Online First: 2000. doi:10.1001/jama.284.6.717

23 Fahy D, Trench B, Clancy L. Communicating Contentious Health Policy: Lessons From Ireland's Workplace Smoking Ban. *Health Promot Pract* Published Online First: 2012. doi:10.1177/1524839909341554

24 Van Hurck MM, Nuyts PAW, Monshouwer K, *et al.* Impact of removing point-of-sale tobacco displays on smoking behaviour among adolescents in Europe: A quasi-experimental study. *Tob Control* Published Online First: 2019. doi:10.1136/tobaccocontrol-2018-054271

25 Edwards R, Ajmal A, Healey B, *et al.* Impact of removing point-of-sale tobacco displays: Data from a New Zealand youth survey. *Tob Control* Published Online First: 2017. doi:10.1136/tobaccocontrol-2015-052764

26 McNeill A, Lewis S, Quinn C, *et al.* Evaluation of the removal of point-of-sale tobacco displays in Ireland. *Tob Control* Published Online First: 2011. doi:10.1136/tc.2010.038141

27 Babineau K, Clancy L. Young people's perceptions of tobacco packaging: A comparison of EU Tobacco Products Directive & Ireland's Standardisation of Tobacco Act. *BMJ Open* Published Online First: 2015. doi:10.1136/bmjopen-2014-007352

28 Evans D, Farrell AO HP. Roll Your own Cigarettes in Ireland Key Patterns and Trends Roll Your Own Cigarettes in Ireland. Dublin: 2017. https://www.drugsandalcohol.ie/27372/1/Roll-Your-Own-Report-2017.pdf

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

## 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.

## COI

LC, SK and SL declare no competing interests.

## Data Sharing

No additional data available

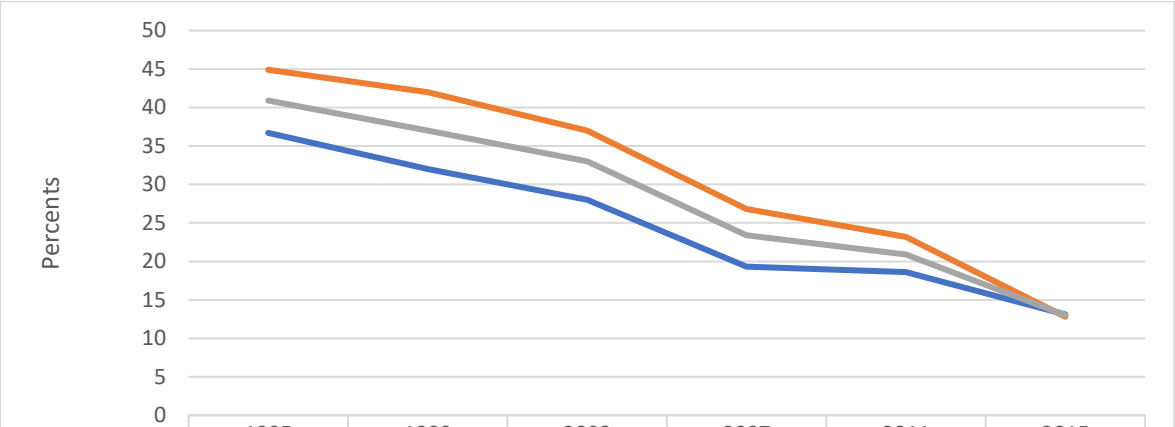
The data were from the European School Survey

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 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.pngg:

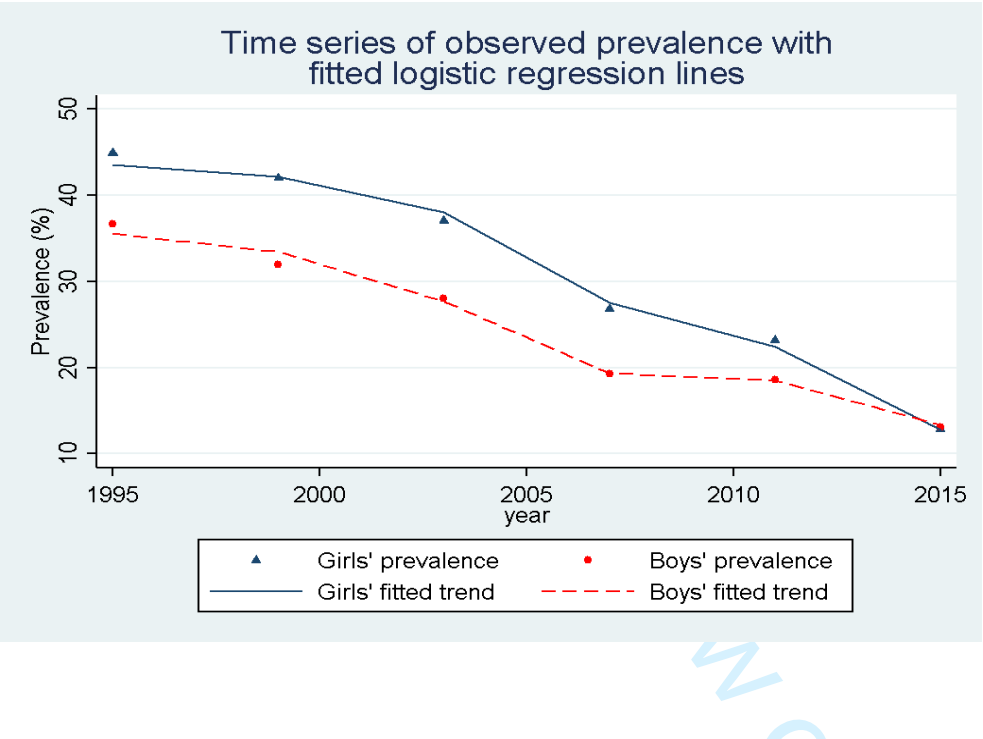
**Acknowledgements**: We wish to thank Focas Research Institute, Dublin Technical University for facilities and the ESPAD international researchers supported by EMCDDA contract CC.14.SDI.032 who compiled a common ESPAD Trend database (1995–2015)

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



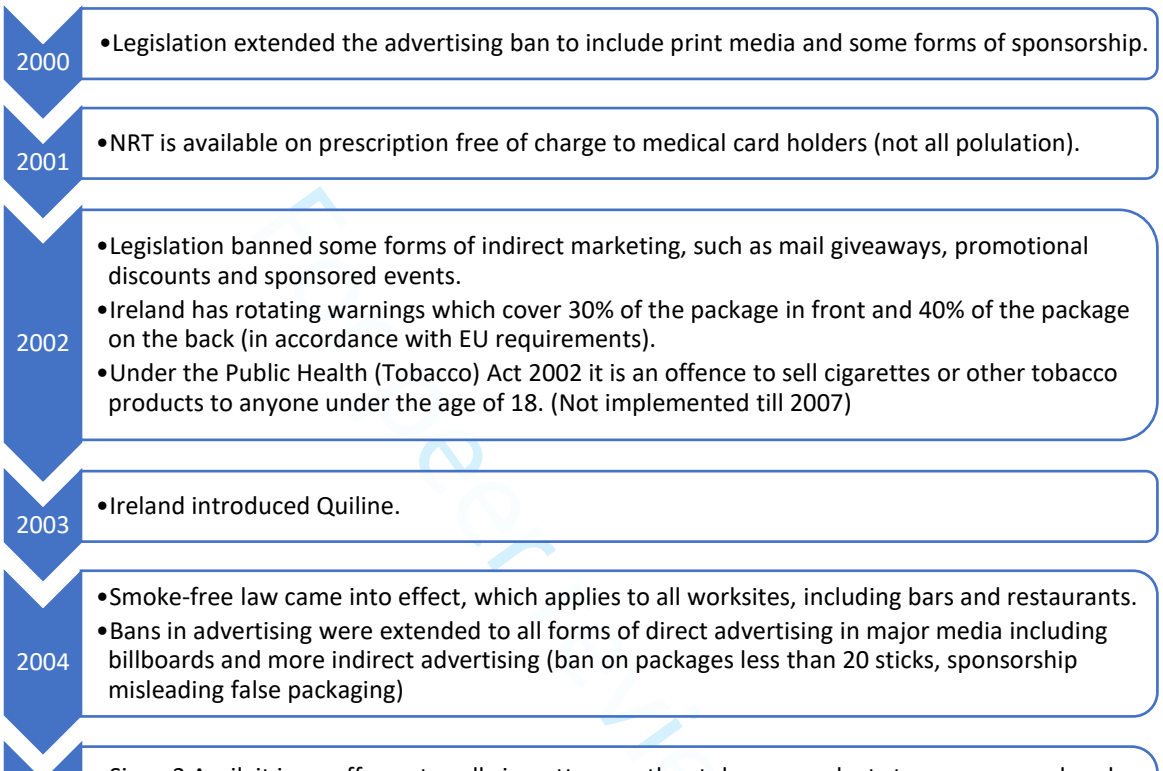

| | 1995 | 1999 | 2003 | 2007 | 2011 | 2015 |
|---|---|---|---|---|---|---|
| Male | 36.7 | 32 | 28 | 19.3 | 18.6 | 13.1 |
| Female | 44.9 | 42 | 37 | 26.8 | 23.2 | 12.8 |
| Total | 40.9 | 37 | 33 | 23.4 | 20.9 | 13 |

**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

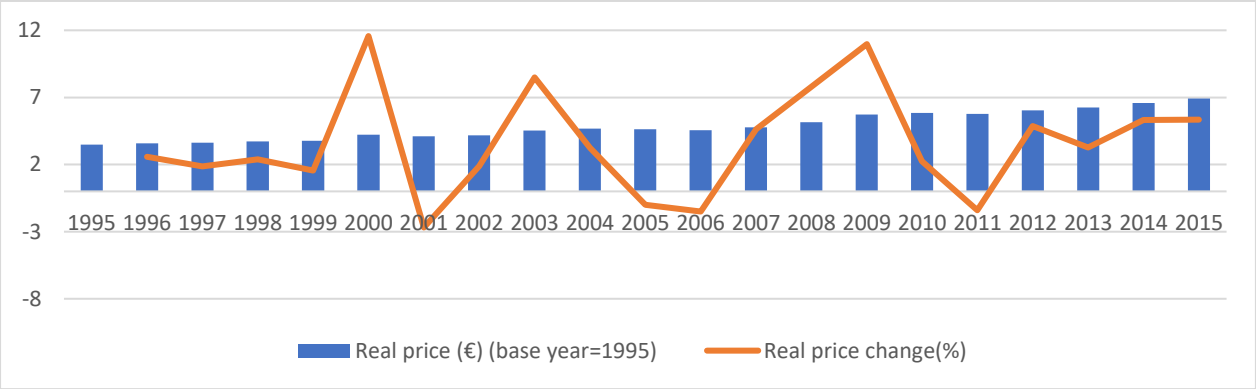
## Timeline of Tobacco Control Policies/ Interventions in Ireland, 2000 -2016



**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 | 3.35 | 3.36 | 3.38 | 3.39 | 4.1 | 4.48 | 4.49 | 5.2 | 5.58 | 6.2 | 6.3 | 6.4 | 7.0 | 7.9 | 8.4 | 8.5 | 8.6 | 9.1 | 9.5 | 10.00 | 10.5 |
| CPI (year 1995=100) | 100 | 102 | 103 | 106 | 107 | 113 | 119 | 124 | 129 | 131 | 135 | 140 | 147 | 153 | 146 | 145 | 148 | 151 | 152 | 152 | 151 |
| Real price (base year=1995) | 3.35 | 3.36 | 3.36 | 3.37 | 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 | 6.6 | 6.9 |
| Real price change (%) | | 2.6 | 1.9 | 2.4 | 1.6 | 11.6 | -2.7 | 1.9 | 8.5 | 3.2 | -1.0 | -1.5 | 4.6 | 7.8 | 11.0 | 2.2 | -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*** | 0.75*** | 0.54*** | 0.64*** | 0.63*** | 0.78** | 0.53*** | 0.64*** |
| | (0.02) | (0.05) | (0.04) | (0.03) | (0.06) | (0.06) | (0.04) | (0.07) |
| Workplace ban | | 0.72** | | | 0.76* | 0.70** | | 0.75* |
| | | (0.08) | | | (0.09) | (0.09) | | (0.10) |
| POS ban | | | 1.57** | | 1.48* | | 1.59** | 1.47* |
| | | | (0.23) | | (0.23) | | (0.24) | (0.23) |
| Graphic images | | | | 1.09 | | 0.90 | 1.12 | 0.96 |
| | | | | (0.16) | | (0.15) | (0.17) | (0.16) |
| Constant | 2.39*** | 1.43 | 4.83*** | 2.55*** | 2.83** | 1.24 | 5.36*** | 2.66* |
| | (0.36) | (0.34) | (1.34) | (0.48) | (1.01) | (0.39) | (1.64) | (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<0.001, ** p<0.01, * p<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*** | 0.65*** | 0.52*** | 0.61*** | 0.58*** | 0.75*** | 0.54*** | 0.68*** |
| | (0.02) | (0.04) | (0.03) | (0.02) | (0.05) | (0.06) | (0.04) | (0.07) |
| Workplace ban | | 0.79* | | | 0.83 | 0.70** | | 0.73** |
| | | (0.08) | | | (0.09) | (0.08) | | (0.09) |
| POS ban | | | 1.36* | | 1.27 | | 1.35* | 1.20 |
| | | | (0.18) | | (0.18) | | (0.18) | (0.17) |
| Graphic images | | | | 0.80 | | 0.65** | 0.81 | 0.67* |
| | | | | (0.12) | | (0.10) | (0.12) | (0.11) |
| Constant | 5.24*** | 3.58*** | 8.46*** | 4.48*** | 5.65*** | 2.13** | 7.22*** | 3.11** |
| | (0.74) | (0.77) | (2.12) | (0.78) | (1.92) | (0.61) | (1.97) | (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<0.001, ** p<0.01, * p<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 sectionalreporting guidelines, and cite them as:

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

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

| | | | |
|---|---|---|---|
| | | recruitment, exposure, follow-up, and data collection | |
| Eligibility criteria | #6a | Give the eligibility criteria, and the sources and methods of selection of participants. | 4 |
| | #7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 5 |
| Data sources / measurement | #8 | For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable. | 4 |
| Bias | #9 | Describe any efforts to address potential sources of bias | 4-5 |
| Study size | #10 | Explain how the study size was arrived at | 4 |
| Quantitative variables | #11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why | 4 |
| Statistical methods | #12a | Describe all statistical methods, including those used to control for confounding | 4 |
| Statistical methods | #12b | Describe any methods used to examine subgroups and interactions | 4 |
| Statistical methods | #12c | Explain how missing data were addressed | 4 |
| Statistical methods | #12d | If applicable, describe analytical methods taking account of sampling strategy | 4 |
| Statistical methods | #12e | Describe any sensitivity analyses | 4 |
| **Results** | | | |
| Participants | #13a | Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable. | 4 |
| Participants | #13b | Give reasons for non-participation at each stage | 4 |
| Participants | #13c | Consider use of a flow diagram | na |

| | | | |
|---|---|---|---|
| Descriptive data | #14a | 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 |
| Descriptive data | #14b | Indicate number of participants with missing data for each variable of interest | 4 |
| Outcome data | #15 | Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable. | 5 |
| Main results | #16a | 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 |
| Main results | #16b | Report category boundaries when continuous variables were categorized | 5 |
| Main results | #16c | If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 5 |
| Other analyses | #17 | Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses | 5 |
| **Discussion** | | | |
| Key results | #18 | Summarise key results with reference to study objectives | 6 |
| Limitations | #19 | 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 |
| Interpretation | #20 | Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence. | 7 |
| Generalisability | #21 | Discuss the generalisability (external validity) of the study results | 7 |
| **Other Information** | | | |
| Funding | #22 | 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 |


This checklist was completed on 27. June 2019 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai

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: | *BMJ Open* |
| 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<br>Keogan, Sheila; TobaccoFree Research Institute Ireland, TU Dublin, Kevin Street, D8<br>Clancy, Luke; TobaccoFree Research Institute Ireland, TU Dublin, Kevin Street, Dublin 8 |
| Primary Subject Heading: | Public health |
| Secondary Subject Heading: | Epidemiology, Smoking and tobacco, Addiction, Communication |
| Keywords: | Price,, Secondhand smoke, Advertising and Promotion,, Denormalisation, EPIDEMIOLOGY, Graphic Tobacco Images |
| | |

*I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.*

*The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.*

*Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.*

# 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

Authors: Shasha Li1, PhD, Sheila Keogan1, MPhil, Luke Clancy1, MD.

Affiliation (1) TobaccoFree Research Institute Ireland, Dublin

Corresponding Author: Luke Clancy,

Contact Details: TobaccoFree Research Institute Ireland,
Focas Research Institute,
TU Dublin, City Centre Campus, Kevin Street,
Dublin D08 NF82, Ireland

Email: lclancy@tri.ie

Phone 35312601966

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

Word Count 3609

## 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% CI2.94-11.68), 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 th~~at~~ 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

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 may distort the effects of taxation [15].

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

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

Statistical analysis

We did a regression analysis on pooled data (See Supplementary File 2). It showed that all policies are significantly related to prevalence changes. We also tried to find out if the impact of each policy variable differed between boys and girls by including interaction terms of gender indicator and policy variables either one at a time or all together. Model 2-5 in Supplementary File 2 suggest that the impact of workplace ban was not significantly different between boys and girls, while the impacts of other policies are larger on boys than girls. However, when all interaction terms are included at the same time as in Model 6 in Supplementary File 2, none of the interaction terms were significant. This implies that pooling boys and girls and building a common model including all policies and their interactions with gender indicator obscures the fact that some polices might not work for one group, but work for the other. In this way preventing us from revealing the true relationship between prevalence and policies in each group. For example, later we will show that inclusion of graphic images did not have significant impact on boys, while it worked for girls. Therefore, including an interaction of gender and graphic images in a pooled model will not help to improve the model fitting.

Based on the information above, from the pooled model and the fact that running separate models for boys and girls gives results at least as consistent as

pooled ones, we decided to show the main results from logistic regressions on grouped data separately for boys and girls (Supplementary File 3).

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

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

## Patient and public involvement

No patient involved

## Results

The regression results of the seven models are presented in Supplementary File 3. 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 showing that the best fit models match the actual prevalence**

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

| | Regression results (Odds ratios and CI) | |
|---|---|---|
| VARIABLES | Boy | Girl |
| Real price | 0.63*** | 0.75*** |
| | (0.52, 0.75) | (0.65, 0.86) |
| Workplace ban | 0.76* | 0.70** |
| | (0.60, 0.96) | (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**

| | Marginal effect (Reduction in prevalence and CI) | |
|---|---|---|
| VARIABLES | Boy | Girl |
| Real price | -8.41%*** | -5.87%*** |
| | (-11.66%, -5.16%) | (-8.79%, -2.96%) |
| Workplace ban | -4.93%* | -7.31%** |
| | (-9.08%, -0.77%) | (-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

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.

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 [20]. For example, one study shows that stronger public places restrictions had a significantly protective effect on smoking prevalence[21]. Another suggested that a workplace ban affects adolescents who are at work (through part-time jobs)[22]. 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 of Smokefree Legislation helped to denormalise smoking in general even though the law was primarily about the workplace[23]. 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) [24]. 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 that more than a fifth of children their own 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 tobacco 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[25,26].

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 may have been partially a price effect because the real price actually declined in two of the relevant years (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 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. The implications for the whole population, considering age and gender, should be considered for all TCLs being introduced by policy makers irrespective of the targeted segment of the population.

**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

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.pngg:

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

References:

1 Joossens, Luc, Raw M. The Tobacco Control Scale 2016 in Europe. Brussels: European Cancer League Associations. 2016. https://www.tobaccocontrolscale.org/2016-edition/. [accessed 19October 2018]

2 Irish Government. Public Health (Tobacco) Act 2002. 2002. https://www.tobaccocontrollaws.org/legislation/country/ireland/summary

(accessed 17 Sep 2019).

3 Frazer K, Callinan JE, McHugh J, van Baarsel S, Clarke A, Doherty K, et al. Frazer K E. Legislative smoking bans for reducing harms from secondhand smoke exposure, smoking. 2016. http://doi.wiley.com/10.1002/14651858.CD005992.pub3

4 Wilson LM, Avila Tang E, Chander G, *et al.* Impact of tobacco control interventions on smoking initiation, cessation, and prevalence: A systematic review. J. Environ. Public Health. 2012. doi:10.1155/2012/961724

5 Stallings-Smith S, Zeka A, Goodman P, *et al.* Reductions in Cardiovascular, Cerebrovascular, and Respiratory Mortality following the National Irish Smoking Ban: Interrupted Time-Series Analysis. *PLoS One* Published Online First: 2013. doi:10.1371/journal.pone.0062063

6 World Health Organization (WHO). European tobacco use, trends report 2019.

7 Li S, Keogan S, Taylor K, *et al.* Decline of adolescent smoking in Ireland 1995-2015: Trend analysis and associated factors. *BMJ Open* Published Online First: 2018. doi:10.1136/bmjopen-2017-020708

8 Dunlop S, Kite J, Grunseit AC, *et al.* Out of sight and out of mind? Evaluating the impact of point-of-sale tobacco display bans on smoking-related beliefs and behaviors in a sample of australian adolescents and young adults. *Nicotine Tob Res* Published Online First: 2015. doi:10.1093/ntr/ntu180

9 Kraus, L; Håkan L, Guttormsson U, Leifman H, *et al.* Results from the European School Survey Project on Alcohol and Other Drugs. 2015. doi:10.1121/1.1610459

10 Björn Hibell, Ulf Guttormsson SA, www.espad.org Olga Balakireva, Thoroddur Bjarnason, Anna Kokkevi LK. The 2007 ESPAD Report; substance use among students in 35 European Countries. 2009.

11 Hibell B, Guttormsson U, Ahlström S, *et al. The 2011 ESPAD Report: Substance Use Among Students in 36 European Countries*. 2012. doi:ISBN: 978-91-7278-233-4

12 Hibell, Björn; Andersson, Barbro; Bjarnason, Thoroddur; Ahlström, Salme ; Balakireva, Olga; Kokkevi, Anna; Morgan M. The ESPAD report 2003 : alcohool and other drug use among students in 35 European countries. 2004. doi:91-7278-103-3

13 Hibell B, Andersson B, Ahlström S, Balakireva O, Bjarnason T, Kokkevi A et al. The 1999 ESPAD report: alcohol and other drug use among students in 30 European countries. Dublin: 2000. http://www.espad.org/sites/espad.org/files/The_1999_ESPAD_report.pdf

14 Chaloupka FJ, Warner KE. Chapter 29 The economics of smoking. Handb. Heal. Econ. 2000. doi:10.1016/S1574-0064(00)80042-6

15 Currie, L Townsend, J Leon Roux,M Godfrey,F Gallus,S Gilmore,AB Levy,D Nguyen,L Rosenqvist,G Clancy L. *Policy Recommendations for Tobacco Taxation in the European Union Integrated Research Findings from the PPACTE project*. 2012. http://www.tri.ie/uploads/3/1/3/6/31366051/ppacte_policy_recommendations_and_integrated_report.pdf

16 Kraus L, Seitz NN, Piontek D, *et al.* 'Are The Times A-Changin'? Trends in adolescent substance use in Europe. *Addiction* Published Online First: 2018. doi:10.1111/add.14201

17 Gallet CA, List JA. Cigarette demand: A meta-analysis of elasticities. *Health Econ* Published Online First: 2003. doi:10.1002/hec.765

18 Tauras JA, Huang J, Chaloupka FJ. Differential impact of tobacco control policies on youth sub-populations. Int. J. Environ. Res. Public Health. 2013. doi:10.3390/ijerph10094306

19 Currie LM, Blackman K, Clancy L, *et al.* The effect of tobacco control policies on smoking prevalence and smoking-attributable deaths in Ireland using the IrelandSS simulation model. *Tob Control* 2013;**22**:e25-32. doi:10.1136/tobaccocontrol-2011-050248

20 Tauras JA. Can public policy deter smoking escalation among young adults? J. Policy Anal. Manag. 2005. doi:10.1002/pam.20137

21 Wakefield MA, Chaloupka FJ, Kaufman NJ, *et al.* Effect of restrictions on smoking at home, at school, and in public places on teenage smoking: Cross sectional study. *Br Med J* 2000.

22 Farkas AJ, Gilpin EA, White MM, *et al.* Association between household and workplace smoking restrictions and adolescent smoking. *J Am Med Assoc* Published Online First: 2000. doi:10.1001/jama.284.6.717

23 Fahy D, Trench B, Clancy L. Communicating Contentious Health Policy: Lessons From Ireland's Workplace Smoking Ban. *Health Promot Pract* Published Online First: 2012. doi:10.1177/1524839909341554

24 McNeill A, Lewis S, Quinn C, *et al.* Evaluation of the removal of point-of-sale tobacco displays in Ireland. *Tob Control* Published Online First: 2011. doi:10.1136/tc.2010.038141

25 Van Hurck MM, Nuyts PAW, Monshouwer K, *et al.* Impact of removing point-of-sale tobacco displays on smoking behaviour among adolescents in Europe: A quasi-experimental study. *Tob Control* Published Online First: 2019. doi:10.1136/tobaccocontrol-2018-054271

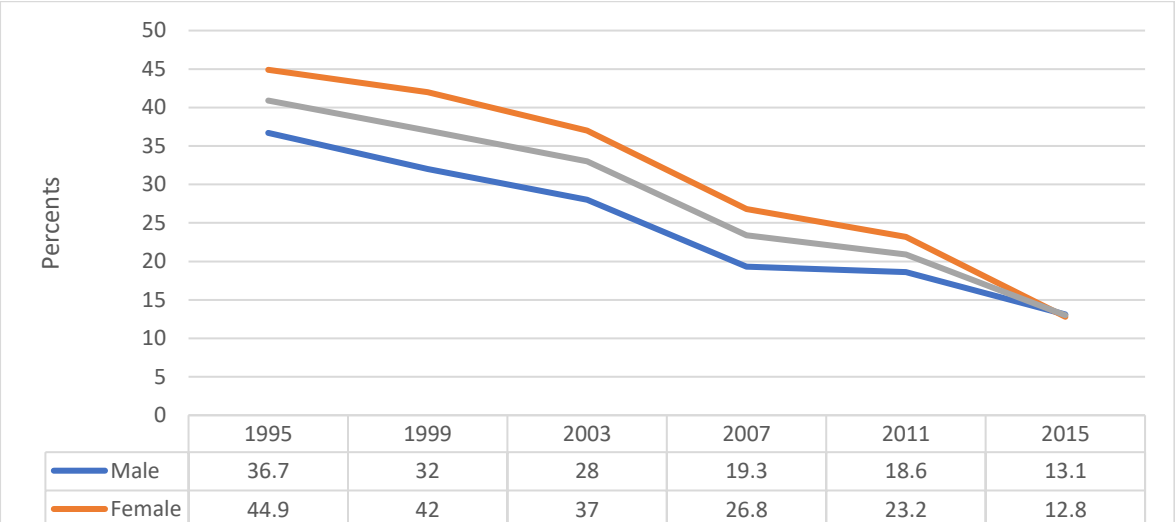
26 Edwards R, Ajmal A, Healey B, *et al.* Impact of removing point-of-sale

tobacco displays: Data from a New Zealand youth survey. *Tob Control* Published Online First: 2017. doi:10.1136/tobaccocontrol-2015-052764

27 Babineau K, Clancy L. Young people's perceptions of tobacco packaging: A comparison of EU Tobacco Products Directive & Ireland's Standardisation of Tobacco Act. *BMJ Open* Published Online First: 2015. doi:10.1136/bmjopen-2014-007352

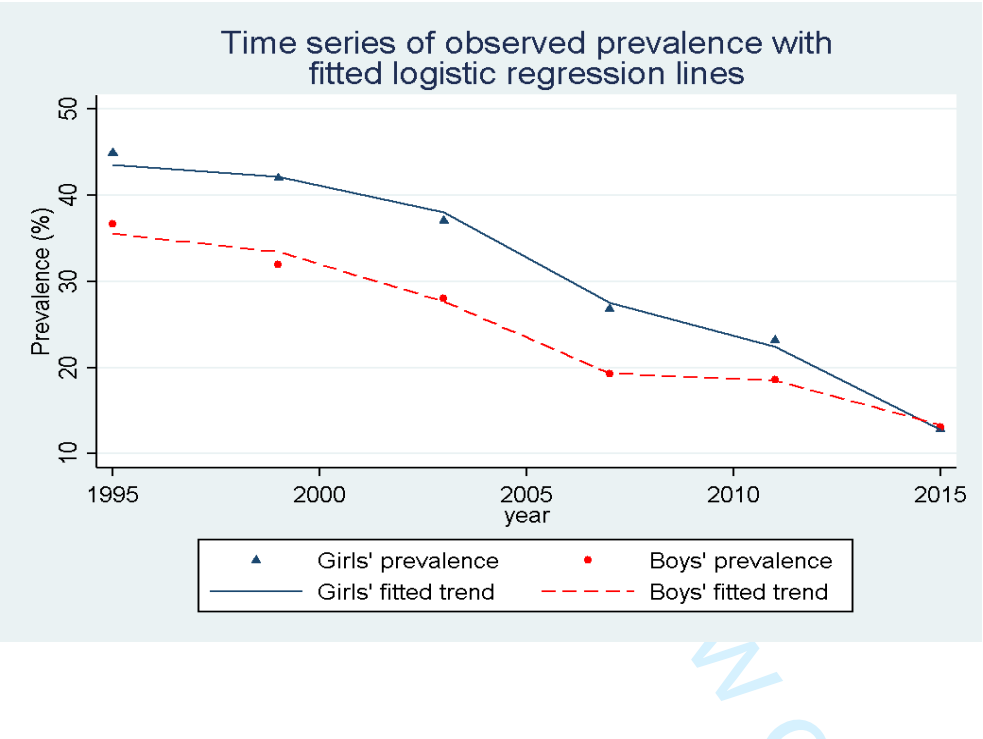
28 Evans D, Farrell AO HP. Roll Your own Cigarettes in Ireland Key Patterns and Trends Roll Your Own Cigarettes in Ireland. Dublin: 2017. https://www.drugsandalcohol.ie/27372/1/Roll-Your-Own-Report-2017.pdf

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



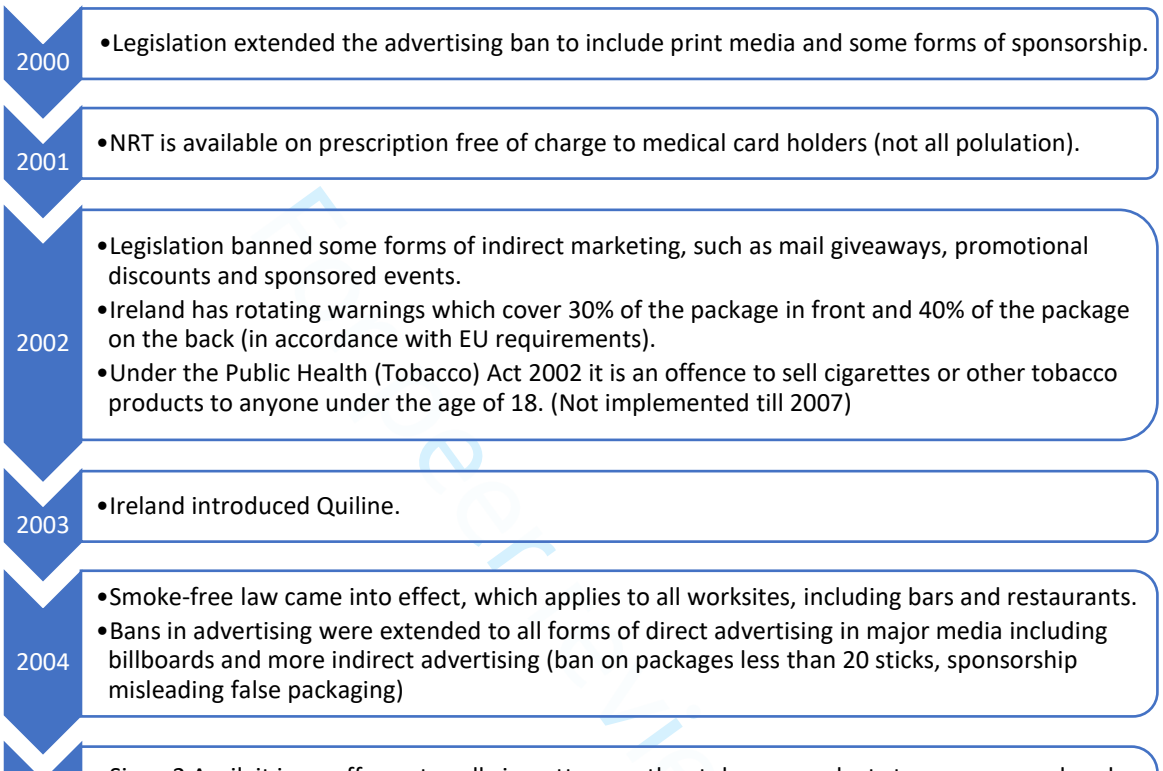

| | 1995 | 1999 | 2003 | 2007 | 2011 | 2015 |
|---|---|---|---|---|---|---|
| Male | 36.7 | 32 | 28 | 19.3 | 18.6 | 13.1 |
| Female | 44.9 | 42 | 37 | 26.8 | 23.2 | 12.8 |
| Total | 40.9 | 37 | 33 | 23.4 | 20.9 | 13 |

**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

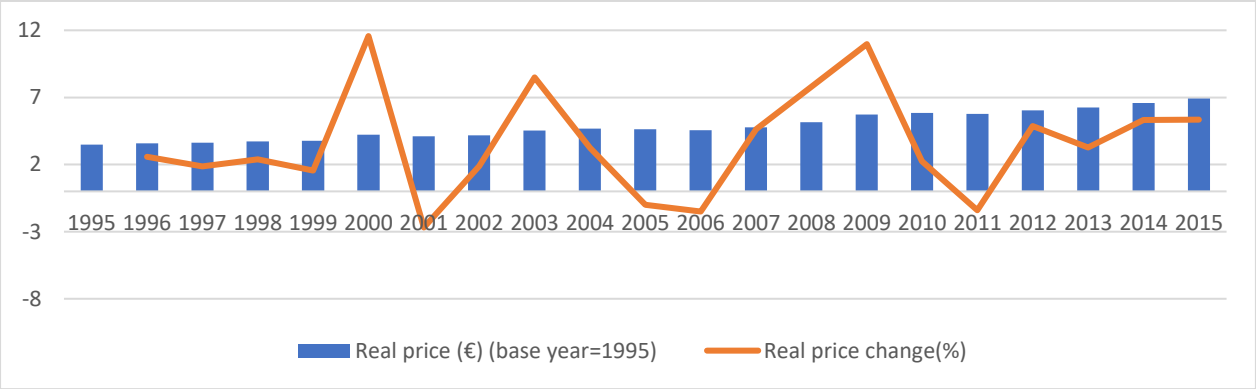
## Timeline of Tobacco Control Policies/ Interventions in Ireland, 2000 -2016



**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 | 3.8 | 3.9 | 4.1 | 4.8 | 4.9 | 5.2 | 5.8 | 6.2 | 6.3 | 6.4 | 7.0 | 7.9 | 8.4 | 8.5 | 8.6 | 9.1 | 9.5 | 10.0 | 10.5 |
| CPI (year 1995=100) | 100 | 102 | 103 | 106 | 107 | 113 | 119 | 124 | 129 | 131 | 135 | 140 | 147 | 153 | 146 | 145 | 148 | 151 | 152 | 152 | 151 |
| 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 | 6.6 | 6.9 |
| Real price change (%) | | 2.6 | 1.9 | 2.4 | 1.6 | 11.6 | -2.7 | 1.9 | 8.5 | 3.2 | -1.0 | -1.5 | 4.6 | 7.8 | 11.0 | 2.2 | -1.4 | 4.9 | 3.3 | 5.3 | 5.3 |



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

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | (1.03 - 1.52) | | (0.81 - 1.86) |
| Female*Graphic images | | | | | 1.51* | 1.44 |
| | | | | | (1.10 - 2.08) | (0.92 - 2.25) |
| Constant | 3.42*** | 4.17*** | 3.48*** | 3.49*** | 3.46*** | 3.11** |
| | (1.89 - 6.17) | (2.24 - 7.75) | (1.92 - 6.30) | (1.93 - 6.31) | (1.91 - 6.25) | (1.38 - 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 indictor 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.

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

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

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

For example, gender specific results show that inclusion of graphic images did not have significant impact on boys, while it worked for girls. Therefore, including an interaction of gender and graphic images in a pooled model will not help to improve the model fitting.

In summary, based on the information above from pooled model and the fact that running separate models for boys and girls gives results at least as consistent as pooled ones, we decided to show the main results from logistic regressions on grouped data separately or boys and girls.

Models with gender interactions based on pooled data serve as a robustness check for the gender specific models and supports the main results and conclusions.

**Supplementary File 3**

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*** | 0.75*** | 0.54*** | 0.64*** | 0.63*** | 0.78** | 0.53*** | 0.64*** |
| | (0.02) | (0.05) | (0.04) | (0.03) | (0.06) | (0.06) | (0.04) | (0.07) |
| Workplace ban | | 0.72** | | | 0.76* | 0.70** | | 0.75* |
| | | (0.08) | | | (0.09) | (0.09) | | (0.10) |
| POS ban | | | 1.57** | | 1.48* | | 1.59** | 1.47* |
| | | | (0.23) | | (0.23) | | (0.24) | (0.23) |
| Graphic images | | | | 1.09 | | 0.90 | 1.12 | 0.96 |
| | | | | (0.16) | | (0.15) | (0.17) | (0.16) |
| Constant | 2.39*** | 1.43 | 4.83*** | 2.55*** | 2.83** | 1.24 | 5.36*** | 2.66* |
| | (0.36) | (0.34) | (1.34) | (0.48) | (1.01) | (0.39) | (1.64) | (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<0.001, ** p<0.01, * p<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*** | 0.65*** | 0.52*** | 0.61*** | 0.58*** | 0.75*** | 0.54*** | 0.68*** |
| | (0.02) | (0.04) | (0.03) | (0.02) | (0.05) | (0.06) | (0.04) | (0.07) |
| Workplace ban | | 0.79* | | | 0.83 | 0.70** | | 0.73** |
| | | (0.08) | | | (0.09) | (0.08) | | (0.09) |
| POS ban | | | 1.36* | | 1.27 | | 1.35* | 1.20 |
| | | | (0.18) | | (0.18) | | (0.18) | (0.17) |
| Graphic images | | | | 0.80 | | 0.65** | 0.81 | 0.67* |
| | | | | (0.12) | | (0.10) | (0.12) | (0.11) |
| Constant | 5.24*** | 3.58*** | 8.46*** | 4.48*** | 5.65*** | 2.13** | 7.22*** | 3.11** |
| | (0.74) | (0.77) | (2.12) | (0.78) | (1.92) | (0.61) | (1.97) | (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<0.001, ** p<0.01, * p<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 sectionalreporting guidelines, and cite them as:

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

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

| | | | |
|---|---|---|---|
| | | recruitment, exposure, follow-up, and data collection | |
| Eligibility criteria | #6a | Give the eligibility criteria, and the sources and methods of selection of participants. | 4 |
| | #7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 5 |
| Data sources / measurement | #8 | For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable. | 4 |
| Bias | #9 | Describe any efforts to address potential sources of bias | 4-5 |
| Study size | #10 | Explain how the study size was arrived at | 4 |
| Quantitative variables | #11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why | 4 |
| Statistical methods | #12a | Describe all statistical methods, including those used to control for confounding | 4 |
| Statistical methods | #12b | Describe any methods used to examine subgroups and interactions | 4 |
| Statistical methods | #12c | Explain how missing data were addressed | 4 |
| Statistical methods | #12d | If applicable, describe analytical methods taking account of sampling strategy | 4 |
| Statistical methods | #12e | Describe any sensitivity analyses | 4 |
| **Results** | | | |
| Participants | #13a | Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable. | 4 |
| Participants | #13b | Give reasons for non-participation at each stage | 4 |
| Participants | #13c | Consider use of a flow diagram | na |

| | | | |
|---|---|---|---|
| Descriptive data | #14a | 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 |
| Descriptive data | #14b | Indicate number of participants with missing data for each variable of interest | 4 |
| Outcome data | #15 | Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable. | 5 |
| Main results | #16a | 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 |
| Main results | #16b | Report category boundaries when continuous variables were categorized | 5 |
| Main results | #16c | If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 5 |
| Other analyses | #17 | Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses | 5 |
| **Discussion** | | | |
| Key results | #18 | Summarise key results with reference to study objectives | 6 |
| Limitations | #19 | 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 |
| Interpretation | #20 | Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence. | 7 |
| Generalisability | #21 | Discuss the generalisability (external validity) of the study results | 7 |
| **Other Information** | | | |
| Funding | #22 | 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 |

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: | *BMJ Open* |
| 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<br>Keogan, Sheila; TobaccoFree Research Institute Ireland, TU Dublin, Kevin Street, D8<br>Clancy, Luke; TobaccoFree Research Institute Ireland, TU Dublin, Kevin Street, Dublin 8 |
| Primary Subject Heading: | Public health |
| Secondary Subject Heading: | Epidemiology, Smoking and tobacco, Addiction, Communication |
| Keywords: | Price,, Secondhand smoke, Advertising and Promotion,, Denormalisation, EPIDEMIOLOGY, Graphic Tobacco Images |
| | |

*I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.*

*The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.*

*Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.*

# 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

Authors: Shasha Li1, PhD, Sheila Keogan1, MPhil, Luke Clancy1, MD.

Affiliation (1) TobaccoFree Research Institute Ireland, Dublin

Corresponding Author: Luke Clancy,

Contact Details: TobaccoFree Research Institute Ireland,
Focas Research Institute,
TU Dublin, City Centre Campus, Kevin Street,
Dublin D08 NF82, Ireland

Email: lclancy@tri.ie

Phone 35312601966

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

Word Count 2935

## 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% CI2.94-11.68), 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 th~~at~~ 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 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 may distort the effects of taxation [15].

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

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

Statistical analysis

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

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

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

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%*** |

| | | |
|---|---|---|
| | (-11.66%, -5.16%) | (-8.79%, -2.96%) |
| Workplace ban | -4.93%* | -7.31%** |
| | (-9.08%, -0.77%) | (-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

## 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.

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 [20]. For example, one study shows that stronger public places restrictions had a significantly protective effect on smoking prevalence[21]. Another suggested that a workplace ban affects adolescents who are at work (through part-time jobs)[22]. 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 of Smokefree Legislation helped to denormalise smoking in general even though the law was primarily about the workplace[23]. 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) [24]. 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 that more than a fifth of children their own 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 tobacco 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[25,26].

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 may have been partially a price effect because the real price actually declined in two of the relevant years

(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

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. The implications for the whole population, considering age and gender, should be considered for all TCLs being introduced by policy makers irrespective of the targeted segment of the population.

**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

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.pngg:

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

References:

1 Joossens, Luc, Raw M. The Tobacco Control Scale 2016 in Europe. Brussels: European Cancer League Associations. 2016. https://www.tobaccocontrolscale.org/2016-edition/. [accessed 19October 2018]

2 Irish Government. Public Health (Tobacco) Act 2002. 2002. https://www.tobaccocontrollaws.org/legislation/country/ireland/summary

(accessed 17 Sep 2019).

3 Frazer K, Callinan JE, McHugh J, van Baarsel S, Clarke A, Doherty K, et al. Frazer K E. Legislative smoking bans for reducing harms from secondhand smoke exposure, smoking. 2016. http://doi.wiley.com/10.1002/14651858.CD005992.pub3

4 Wilson LM, Avila Tang E, Chander G, *et al.* Impact of tobacco control interventions on smoking initiation, cessation, and prevalence: A systematic review. J. Environ. Public Health. 2012. doi:10.1155/2012/961724

5 Stallings-Smith S, Zeka A, Goodman P, *et al.* Reductions in Cardiovascular, Cerebrovascular, and Respiratory Mortality following the National Irish Smoking Ban: Interrupted Time-Series Analysis. *PLoS One* Published Online First: 2013. doi:10.1371/journal.pone.0062063

6 World Health Organization (WHO). European tobacco use, trends report 2019.

7 Li S, Keogan S, Taylor K, *et al.* Decline of adolescent smoking in Ireland 1995-2015: Trend analysis and associated factors. *BMJ Open* Published Online First: 2018. doi:10.1136/bmjopen-2017-020708

8 Dunlop S, Kite J, Grunseit AC, *et al.* Out of sight and out of mind? Evaluating the impact of point-of-sale tobacco display bans on smoking-related beliefs and behaviors in a sample of australian adolescents and young adults. *Nicotine Tob Res* Published Online First: 2015. doi:10.1093/ntr/ntu180

9 Kraus, L; Håkan L, Guttormsson U, Leifman H, *et al.* Results from the European School Survey Project on Alcohol and Other Drugs. 2015. doi:10.1121/1.1610459

10 Björn Hibell, Ulf Guttormsson SA, www.espad.org Olga Balakireva, Thoroddur Bjarnason, Anna Kokkevi LK. The 2007 ESPAD Report; substance use among students in 35 European Countries. 2009.

11 Hibell B, Guttormsson U, Ahlström S, *et al. The 2011 ESPAD Report: Substance Use Among Students in 36 European Countries*. 2012. doi:ISBN: 978-91-7278-233-4

12 Hibell, Björn; Andersson, Barbro; Bjarnason, Thoroddur; Ahlström, Salme ; Balakireva, Olga; Kokkevi, Anna; Morgan M. The ESPAD report 2003 : alcohool and other drug use among students in 35 European countries. 2004. doi:91-7278-103-3

13 Hibell B, Andersson B, Ahlström S, Balakireva O, Bjarnason T, Kokkevi A et al. The 1999 ESPAD report: alcohol and other drug use among students in 30 European countries. Dublin: 2000. http://www.espad.org/sites/espad.org/files/The_1999_ESPAD_report.pdf

14 Chaloupka FJ, Warner KE. Chapter 29 The economics of smoking. Handb. Heal. Econ. 2000. doi:10.1016/S1574-0064(00)80042-6

15 Currie, L Townsend, J Leon Roux,M Godfrey,F Gallus,S Gilmore,AB Levy,D Nguyen,L Rosenqvist,G Clancy L. *Policy Recommendations for Tobacco Taxation in the European Union Integrated Research Findings from the PPACTE project*. 2012. http://www.tri.ie/uploads/3/1/3/6/31366051/ppacte_policy_recommendations_and_integrated_report.pdf

16 Kraus L, Seitz NN, Piontek D, *et al.* 'Are The Times A-Changin'? Trends in adolescent substance use in Europe. *Addiction* Published Online First: 2018. doi:10.1111/add.14201

17 Gallet CA, List JA. Cigarette demand: A meta-analysis of elasticities. *Health Econ* Published Online First: 2003. doi:10.1002/hec.765

18 Tauras JA, Huang J, Chaloupka FJ. Differential impact of tobacco control policies on youth sub-populations. Int. J. Environ. Res. Public Health. 2013. doi:10.3390/ijerph10094306

19 Currie LM, Blackman K, Clancy L, *et al.* The effect of tobacco control policies on smoking prevalence and smoking-attributable deaths in Ireland using the IrelandSS simulation model. *Tob Control* 2013;**22**:e25-32. doi:10.1136/tobaccocontrol-2011-050248

20 Tauras JA. Can public policy deter smoking escalation among young adults? J. Policy Anal. Manag. 2005. doi:10.1002/pam.20137

21 Wakefield MA, Chaloupka FJ, Kaufman NJ, *et al.* Effect of restrictions on smoking at home, at school, and in public places on teenage smoking: Cross sectional study. *Br Med J* 2000.

22 Farkas AJ, Gilpin EA, White MM, *et al.* Association between household and workplace smoking restrictions and adolescent smoking. *J Am Med Assoc* Published Online First: 2000. doi:10.1001/jama.284.6.717

23 Fahy D, Trench B, Clancy L. Communicating Contentious Health Policy: Lessons From Ireland's Workplace Smoking Ban. *Health Promot Pract* Published Online First: 2012. doi:10.1177/1524839909341554

24 McNeill A, Lewis S, Quinn C, *et al.* Evaluation of the removal of point-of-sale tobacco displays in Ireland. *Tob Control* Published Online First: 2011. doi:10.1136/tc.2010.038141

25 Van Hurck MM, Nuyts PAW, Monshouwer K, *et al.* Impact of removing point-of-sale tobacco displays on smoking behaviour among adolescents in Europe: A quasi-experimental study. *Tob Control* Published Online First: 2019. doi:10.1136/tobaccocontrol-2018-054271

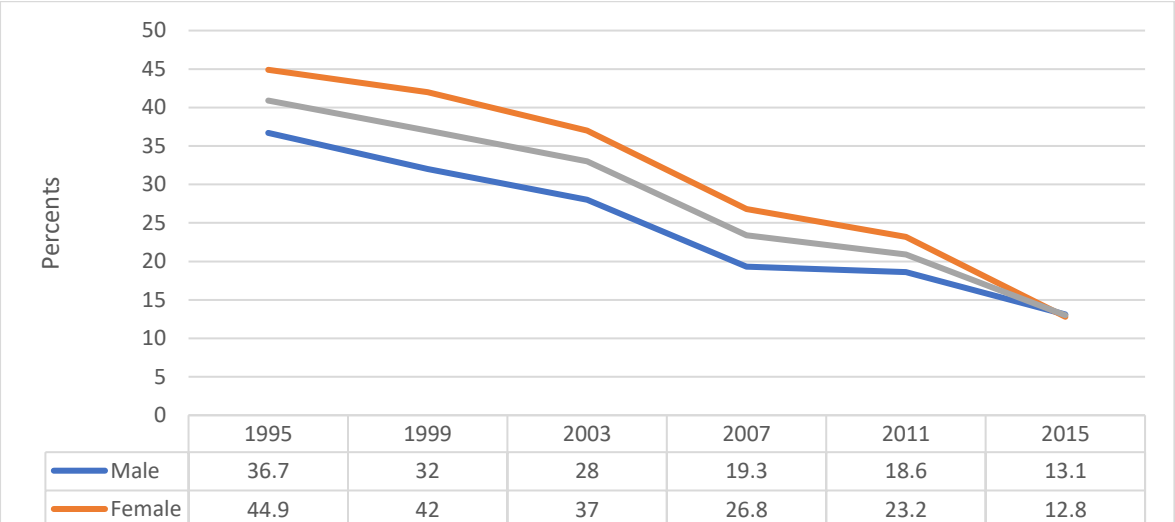
26 Edwards R, Ajmal A, Healey B, *et al.* Impact of removing point-of-sale

tobacco displays: Data from a New Zealand youth survey. *Tob Control* Published Online First: 2017. doi:10.1136/tobaccocontrol-2015-052764

27 Babineau K, Clancy L. Young people's perceptions of tobacco packaging: A comparison of EU Tobacco Products Directive & Ireland's Standardisation of Tobacco Act. *BMJ Open* Published Online First: 2015. doi:10.1136/bmjopen-2014-007352

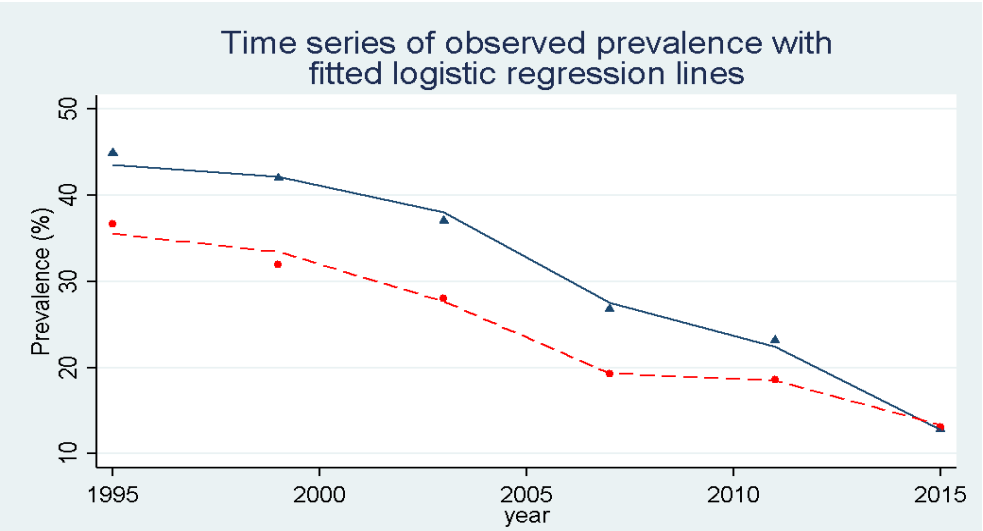
28 Evans D, Farrell AO HP. Roll Your own Cigarettes in Ireland Key Patterns and Trends Roll Your Own Cigarettes in Ireland. Dublin: 2017. https://www.drugsandalcohol.ie/27372/1/Roll-Your-Own-Report-2017.pdf

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



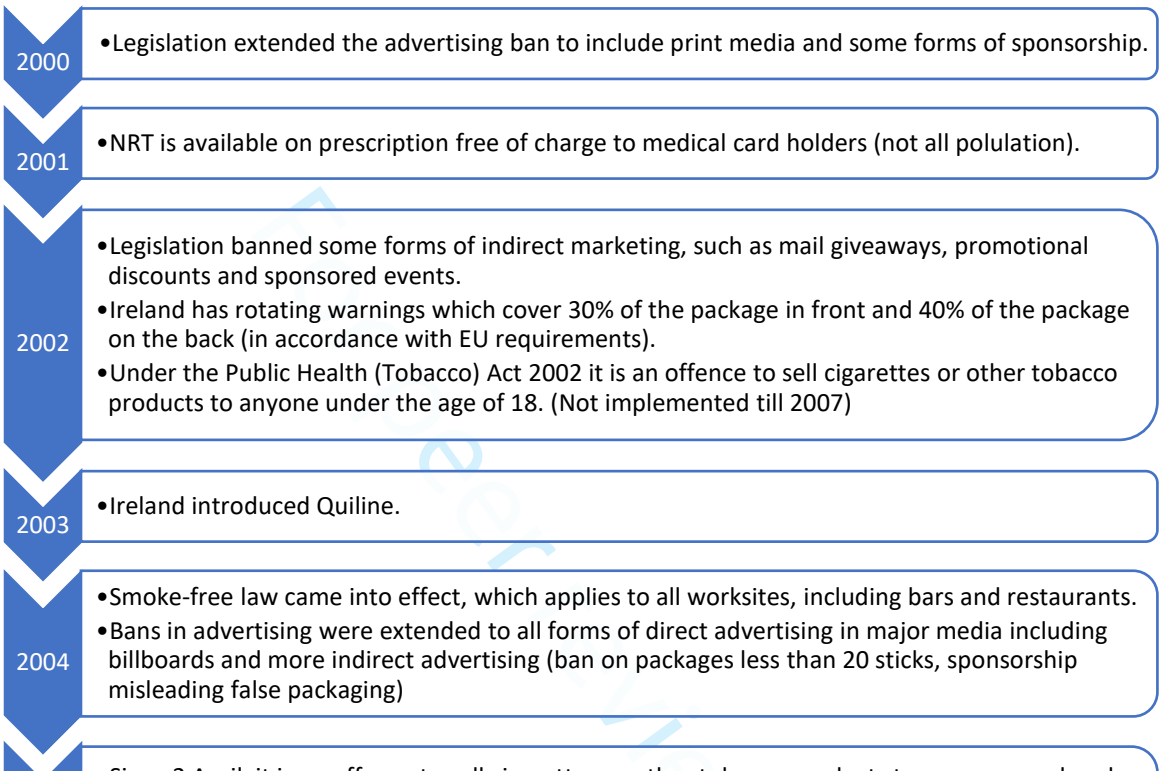

| | 1995 | 1999 | 2003 | 2007 | 2011 | 2015 |
|---|---|---|---|---|---|---|
| Male | 36.7 | 32 | 28 | 19.3 | 18.6 | 13.1 |
| Female | 44.9 | 42 | 37 | 26.8 | 23.2 | 12.8 |
| Total | 40.9 | 37 | 33 | 23.4 | 20.9 | 13 |

**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

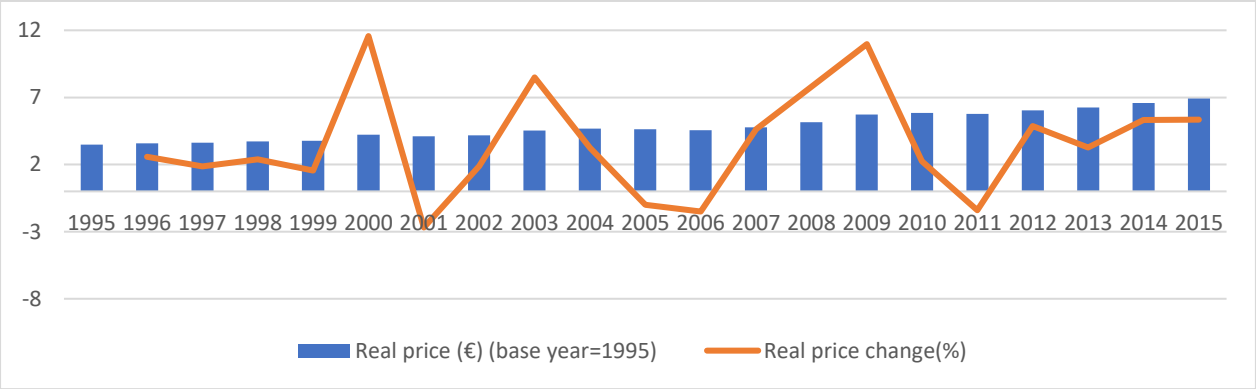
## Timeline of Tobacco Control Policies/ Interventions in Ireland, 2000 -2016



**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 | 3.35 | 3.36 | 3.38 | 3.39 | 4.1 | 4.48 | 4.49 | 5.2 | 5.58 | 6.2 | 6.3 | 6.4 | 7.0 | 7.9 | 8.4 | 8.5 | 8.6 | 9.1 | 9.5 | 10.00 | 10.05 |
| CPI (year 1995=100) | 100 | 102 | 103 | 106 | 107 | 113 | 119 | 124 | 129 | 131 | 135 | 140 | 147 | 153 | 146 | 145 | 148 | 151 | 152 | 152 | 151 |
| Real price (base year=1995) | 3.35 | 3.36 | 3.36 | 3.37 | 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 | 6.6 | 6.9 |
| Real price change (%) | | 2.6 | 1.9 | 2.4 | 1.6 | 11.6 | -2.7 | 1.9 | 8.5 | 3.2 | -1.0 | -1.5 | 4.6 | 7.8 | 11.0 | 2.2 | -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*** | 0.75*** | 0.54*** | 0.64*** | 0.63*** | 0.78** | 0.53*** | 0.64*** |
| | (0.02) | (0.05) | (0.04) | (0.03) | (0.06) | (0.06) | (0.04) | (0.07) |
| Workplace ban | | 0.72** | | | 0.76* | 0.70** | | 0.75* |
| | | (0.08) | | | (0.09) | (0.09) | | (0.10) |
| POS ban | | | 1.57** | | 1.48* | | 1.59** | 1.47* |
| | | | (0.23) | | (0.23) | | (0.24) | (0.23) |
| Graphic images | | | | 1.09 | | 0.90 | 1.12 | 0.96 |
| | | | | (0.16) | | (0.15) | (0.17) | (0.16) |
| Constant | 2.39*** | 1.43 | 4.83*** | 2.55*** | 2.83** | 1.24 | 5.36*** | 2.66* |
| | (0.36) | (0.34) | (1.34) | (0.48) | (1.01) | (0.39) | (1.64) | (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<0.001, ** p<0.01, * p<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*** | 0.65*** | 0.52*** | 0.61*** | 0.58*** | 0.75*** | 0.54*** | 0.68*** |
| | (0.02) | (0.04) | (0.03) | (0.02) | (0.05) | (0.06) | (0.04) | (0.07) |
| Workplace ban | | 0.79* | | | 0.83 | 0.70** | | 0.73** |
| | | (0.08) | | | (0.09) | (0.08) | | (0.09) |
| POS ban | | | 1.36* | | 1.27 | | 1.35* | 1.20 |
| | | | (0.18) | | (0.18) | | (0.18) | (0.17) |
| Graphic images | | | | 0.80 | | 0.65** | 0.81 | 0.67* |
| | | | | (0.12) | | (0.10) | (0.12) | (0.11) |
| Constant | 5.24*** | 3.58*** | 8.46*** | 4.48*** | 5.65*** | 2.13** | 7.22*** | 3.11** |
| | (0.74) | (0.77) | (2.12) | (0.78) | (1.92) | (0.61) | (1.97) | (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<0.001, ** p<0.01, * p<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 sectionalreporting guidelines, and cite them as:

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

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

| | | | |
|---|---|---|---|
| | | recruitment, exposure, follow-up, and data collection | |
| Eligibility criteria | #6a | Give the eligibility criteria, and the sources and methods of selection of participants. | 4 |
| | #7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 5 |
| Data sources / measurement | #8 | For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable. | 4 |
| Bias | #9 | Describe any efforts to address potential sources of bias | 4-5 |
| Study size | #10 | Explain how the study size was arrived at | 4 |
| Quantitative variables | #11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why | 4 |
| Statistical methods | #12a | Describe all statistical methods, including those used to control for confounding | 4 |
| Statistical methods | #12b | Describe any methods used to examine subgroups and interactions | 4 |
| Statistical methods | #12c | Explain how missing data were addressed | 4 |
| Statistical methods | #12d | If applicable, describe analytical methods taking account of sampling strategy | 4 |
| Statistical methods | #12e | Describe any sensitivity analyses | 4 |
| **Results** | | | |
| Participants | #13a | Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable. | 4 |
| Participants | #13b | Give reasons for non-participation at each stage | 4 |
| Participants | #13c | Consider use of a flow diagram | na |

| | | | |
|---|---|---|---|
| Descriptive data | #14a | 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 |
| Descriptive data | #14b | Indicate number of participants with missing data for each variable of interest | 4 |
| Outcome data | #15 | Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable. | 5 |
| Main results | #16a | 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 |
| Main results | #16b | Report category boundaries when continuous variables were categorized | 5 |
| Main results | #16c | If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 5 |
| Other analyses | #17 | Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses | 5 |
| **Discussion** | | | |
| Key results | #18 | Summarise key results with reference to study objectives | 6 |
| Limitations | #19 | 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 |
| Interpretation | #20 | Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence. | 7 |
| Generalisability | #21 | Discuss the generalisability (external validity) of the study results | 7 |
| **Other Information** | | | |
| Funding | #22 | 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 |


This checklist was completed on 27. June 2019 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai