Smoking inequalities and tobacco control policies in Europe
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CHAPTER 11

The impact of age of tobacco sales legislation on adolescent smoking in Europe: A quasi-experimental study

Revisions submitted

Mirte AG Kuipers, Stephanie D Brandhof, Karin Monshouwer, Karien Stronks, Anton E Kunst. Impact of laws restricting the sale of tobacco to minors on adolescent smoking and perceived obtainability of cigarettes: an intervention-control pre-post study of 19 EU countries. *Addiction.*
ABSTRACT

**Aims** This study aimed at estimating the impact of introducing sales restriction laws by measuring changes in adolescent smoking prevalence and perceived obtainability of cigarettes over time in countries that had recently introduced sales restriction laws (intervention countries). These countries were compared to countries where such laws were already in force (control countries). The secondary aim was to test whether these trends differed between adolescents of higher and lower socioeconomic status (SES).

**Design** Repeated cross-sectional data were used in a quasi-experimental pre-post design. Intervention countries raised tobacco sales restrictions to 18 years in 2007, 2008 or 2009. Control countries had sales restrictions of 18 years since at least 2004.

**Setting** 19 European Union (EU) countries, in 2007 and 2011.

**Participants** Data of 97,245 15 and 16-year-old adolescents from the 2007 and 2011 European Survey Project on Alcohol and other Drugs (ESPAD) surveys.

**Measurements** Dependent variables were smoking status (weekly smoking vs. non-smoking or less than weekly smoking) and perceived obtainability of tobacco (easy vs. difficult). Key dependent variables were time (2007 or 2011), intervention exposure (intervention or control country) and their interaction (time*intervention). Covariates included gender, SES, the tobacco control scale (TCS), gross domestic product (GDP), and adult smoking prevalence.

**Findings** We did not find a significant difference in the change in smoking prevalence between intervention and control countries (odds ratio (OR): 1.07, 95% confidence interval (CI): 0.99-1.16). However, sales restrictions were associated with a significantly greater decrease in perceived ease of the obtainability of cigarettes in intervention countries (OR: 0.76, 95%CI: 0.70-0.81). No significant differential effects between high and low SES adolescents were found (OR: 0.99, 95%CI: 0.79-1.23).

**Conclusion** Laws prohibiting the sales of tobacco to minors in Europe were not associated with a reduction in adolescent smoking rates, but made the perceived obtainability of cigarettes somewhat more difficult, among youth of lower as well as higher socioeconomic position.
INTRODUCTION

The Third Action Plan for a Smoke-Free Europe was launched by the WHO in 1997. It stated that “by the year 2001, all countries of the European Region should have implemented legislation to restrict access to tobacco products for people under 18 years of age”. This target was a reaction to the alarmingly high smoking rates among European young people of over 30 percent, which even showed an increasing trend in many countries. During the 5 year period of the Third Action Plan, some countries introduced laws to restrict the legal age of tobacco sales to 18 years, but only a quarter of European countries had done so by 2002. In 2003, the WHO introduced the Framework Convention on Tobacco Control (FCTC) treaty which came into force in 2005, legally binding countries worldwide to take action against smoking. Article 16 addresses sales to and by minors and instructs countries to “adopt and implement effective legislative, executive, administrative or other measures to prohibit the sales of tobacco products by persons under the age set by domestic law, national law or eighteen”. In the years following the FCTC a second wave of European countries integrated sales restrictions into their policies.

As the majority of smokers initiated smoking before the age of 18 the restriction of tobacco sales to minors is important. If tobacco sales to those under 18 years of age can be effectively prevented, the likelihood of smoking initiation may be significantly reduced. Research on the effectiveness of sales restrictions has generated mixed conclusions. Studies from the USA, New Zealand and European countries showed that sales restrictions resulted in a reduction in adolescent smoking prevalence. However, other studies did not find sales restrictions to be effective. A lack of effect may be due to weak enforcement of sales restrictions or due to a shift from commercial to non-commercial sources of cigarettes, such as friends and family. Although the obtainability of cigarettes from commercial sources might decrease, the perceived obtainability from other sources has mostly been disregarded in previous studies. Contradictions in the existing literature call for additional research on the effectiveness of sales restrictions on smoking.

Evidence on differential effects of sales restrictions by socioeconomic status is inconsistent. Similar effects in adolescents of both high and low socioeconomic status (SES) have been found in some studies, while other studies found that sales restrictions to minors may be more effective in low SES adolescents. Millett et al. found that sales restrictions made the obtainability of cigarettes more difficult only in higher SES smokers. As a result, higher SES adolescents more often shifted from commercial to non-commercial sources of tobacco than low SES individuals did.
and decreases in smoking were similar for high and low SES adolescents\textsuperscript{11}. Socioeconomic differences in the effects of sales restrictions remain to be clarified.

As of 2015 there are still countries in the European region that do not have sales restrictions for all minors below the age of 18 (e.g. Belgium, Austria, Switzerland)\textsuperscript{30}. Also, there are more countries worldwide where tobacco sales to minors is insufficiently restricted\textsuperscript{30}. It is important to understand the effects of raising the legal age of tobacco sales to 18 years for those countries that still lack laws to restrain youth access to tobacco or that have a low legal sales age of 16 years.

The primary aim of this study was to estimate the impact of introducing sales restriction laws in the European setting, by making comparisons between countries that recently introduced youth tobacco access laws (intervention countries) and countries that had longer existing youth access laws (control countries). These countries will be compared with regards to changes over time in adolescent smoking prevalence and in perceived obtainability of cigarettes. The secondary aim was to test whether the impact of the laws, as estimated in these comparisons, differed between adolescents of higher and lower SES. This study on sales restrictions is among the first to compare a large number of countries. Moreover, the inclusion of a control group provides a means to control for secular trends and thus to strengthen the evidence. Furthermore the current study will not only estimate the effect of sales restriction in the general population of adolescents, but also its impact on socioeconomic inequalities in adolescent smoking.

**METHODS**

**Design**

This study has a quasi-experimental design utilising repeated cross-sectional data from 19 EU countries from the 2007 and 2011 European School Survey Project on Alcohol and Other Drugs (ESPAD) surveys. We distinguish intervention countries and control countries. Intervention countries introduced the 18 year age limit between 2007 and 2009 and control countries introduced a law restricting sales of tobacco to adults of 18+ years before 2004. Outcomes of interest were measured in a cross-sectional nationally representative surveys in 2007 and in 2011, yielding measurements before and after the introduction of sales restriction laws in intervention countries. Comparing intervention and control countries with regards to changes in outcomes provides an estimate of the effects of sales restriction laws on these outcomes in the European setting, over and above
secular trends.

**Data and study population**

Individual-level data of 117,977 adolescents were obtained from the 2007 and 2011 ESPAD surveys. The surveys were completed by 15- and 16-year-old adolescents in classrooms under the supervision of a teacher or research assistant. Samples were nationally representative, except in Germany where 7 out of 16 states were represented in the sample. More information on the sampling strategy and data collection is available from the ESPAD reports from 2007 and 2011\(^{31,32}\).

Data from 2007 and 2011 were available for 26 EU countries. We included 19 countries in this study (see Table 11.1). Italy, the Netherlands, Belgium and Austria were excluded for having sales restriction to minors below the age of 16 years, instead of 18 years throughout the study period. The sample size for these four countries combined was insufficient to create an alternative control group of countries with a 16+ sales age. Romania, Bulgaria and Croatia were excluded as these countries had joined the EU recently, and the state of national legislation is therefore less comparable to other EU countries.

From the 117,977 respondents in the included countries, 365 were excluded due to missing data on smoking status, resulting in the total study population of 117,612. For the analysis of perceived obtainability of cigarettes 19,076 individuals with missing data on obtainability were excluded, resulting in a study population of 98,536.

In addition to the data available from the ESPAD surveys, a literature search was conducted on the ESPAD countries’ tobacco control policies. Scientific articles, reports, legal documents and news articles were consulted with the specific aim to map out the trends in sales restrictions from 1995 to 2011 for each country.

**Measures**

**Individual-level**

We assessed two outcome variables: weekly smoking and easy obtainability of cigarettes. Weekly smoking was measured with the question: ‘How frequently have you smoked cigarettes during the last 30 days?’. Participants who answered in the range from ‘less than 1 cigarette a day’ to ‘more than 20 cigarettes a day’ were defined as weekly smokers and participants who answered ‘none’ or ‘less than 1 cigarette a week’ were labelled non-smokers.
Easy obtainability of cigarettes was assessed with the question: “How difficult do you think it would be for you to get cigarettes, if you wanted?”. Participants could reply: ‘impossible’, ‘very difficult’, ‘fairly difficult’, ‘fairly easy’, ‘very easy’ or ‘don’t know’. Answers ranging from ‘impossible’ to ‘fairly easy’ were coded 0, and answers indicating obtainability as very easy were coded 1. ‘Don’t know’ responds were regarded as missing values. In a sensitivity analysis we coded both ‘very easy’ and ‘fairly easy’ as 1.

Socioeconomic status (SES) of the participants was defined with reference to the parent with the highest attained educational level (either the mother or the father). Parental education was assessed for both parents with the question: “What is the highest level of schooling your father/mother completed?”. Possible answers were: ‘completed primary school or less’, ‘some secondary school’, ‘completed secondary school or less’, ‘some college or university’, ‘completed college or university’ and ‘don’t know’ or ‘does not apply’. Categories ‘don’t know’ and ‘does not apply’ were considered missing. In order to construct a measure of ‘relative SES’ that is comparable across Europe, parental educational level was ranked in each country. Each educational category was assigned the mean rank which ranged between 0 and 1 and which was defined as the cumulative proportion of the category in the total population in the country. A value of 0 represents the hypothetical person with the lowest SES in the country, and 1 represents the highest SES in the country. Data on SES were missing for 20,367 individuals, of which 9,096 were missing because parental educational level was not measured in the 2007 survey of Cyprus and the 2011 survey of Germany. Individuals with missing information on parental educational level were assigned the mean SES score (0.5 in all countries). A sensitivity analysis in which all individuals with missing data on SES were excluded resulted in findings very similar to those reported in this paper.

Gender was defined as female (coded as 0) or male (coded as 1). Time represented the year that the survey was conducted, in 2007 (coded as 0) or 2011 (coded as 1).

Country-level

Countries were distinguished as either ‘intervention’ or ‘control’ countries (see Table 11.1). Intervention countries were countries that had increased their age limit between 2007 and 2011. Control countries were countries
that had stable sales restrictions at 18 years of age before at least 2004.

The Tobacco Control Scale (TCS) scores from 2007 and 2010\textsuperscript{35,36} for each country were assigned to individuals in the surveys of 2007 and 2011, respectively. TCS was included to take differences in the development of tobacco control policies between intervention and control countries into account. Scores were converted according to the 2013 TCS scoring procedure, to allow for comparisons between 2007 and 2010\textsuperscript{37}. TCS scores from 2007 were assumed to apply to 2007, and TCS scores from 2010 to 2011.

Gross Domestic Product (GDP) per capita in 2007 and 2011 was derived from the World Bank development indicators\textsuperscript{38}.

Adult smoking prevalence rates from 2006 and 2012 were available through the Eurobarometer\textsuperscript{37}. These rates were assigned to each country for 2007 and 2011, to represent the smoking prevalence among adults, and the social norm regarding smoking, in the participating countries.

Statistical analysis

We conducted multilevel logistic regression analyses including two levels: the individual-level at level 1 and the country-level at level 2. We included a random intercept at the country-level to account for country-level clustering. Outcome variables were weekly smoking and easy obtainability of cigarettes. The basic model included intervention, time and interaction between the two (i.e. time*intervention). This basic model estimates the change in the outcome over time and tests the difference in this change between intervention and control countries. In Model 1 we controlled for gender, and in the analysis for obtainability also for weekly smoking, as smokers perceive tobacco to be much more easy to obtain than non-smokers. In Model 2 SES was added, in Model 3 GDP was added, in Model 4 adult smoking prevalence was added and in Model 5 the TCS was added. With these stepwise models we were able to control for changes in the population and changes in country characteristics over time. A three-way interaction was performed to test differential effects by SES (time*intervention*SES).

Three sensitivity analyses were undertaken. First, daily smoking and ever smoking were used as two alternative outcome variables and results were compared with results for weekly smoking. Second, we tested whether results were robust to the use of a less strict cut-off for tobacco obtainability. Third, we tested whether the effects on tobacco obtainability differed between smokers and non-smokers, by adding to the regression model the term time*intervention*smoking.
Analyses were performed in Stata version 14.0.

Table 11.1: Characteristics of the included countries.

<table>
<thead>
<tr>
<th>Intervention countries</th>
<th>Respondents (N)</th>
<th>Weekly smoking prevalence (%)</th>
<th>Easy obtainability cigarettes (%)</th>
<th>Sales restriction 18 years since</th>
<th>Newly introduced or increased age limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>871</td>
<td>2,165</td>
<td>25.0</td>
<td>20.8</td>
<td>2008 Increased</td>
</tr>
<tr>
<td>France</td>
<td>2,909</td>
<td>2,560</td>
<td>22.3</td>
<td>17.4</td>
<td>2009 Increased</td>
</tr>
<tr>
<td>Germany</td>
<td>5,011</td>
<td>2,794</td>
<td>26.2</td>
<td>17.4</td>
<td>2007 Increased</td>
</tr>
<tr>
<td>Greece</td>
<td>3,057</td>
<td>5,883</td>
<td>16.3</td>
<td>20.7</td>
<td>2007 New</td>
</tr>
<tr>
<td>Portugal</td>
<td>3,137</td>
<td>1,962</td>
<td>12.4</td>
<td>19.1</td>
<td>2008 Increased</td>
</tr>
<tr>
<td>Slovenia</td>
<td>3,082</td>
<td>3,180</td>
<td>23.7</td>
<td>23.4</td>
<td>2007 New</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2,174</td>
<td>1,703</td>
<td>16.0</td>
<td>15.9</td>
<td>2007 New</td>
</tr>
<tr>
<td>Total</td>
<td>20,241</td>
<td>20,247</td>
<td>20.3</td>
<td>20.1</td>
<td>–</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Control countries</th>
<th>Respondents (N)</th>
<th>Weekly smoking prevalence (%)</th>
<th>Easy obtainability cigarettes (%)</th>
<th>Sales restriction 18 years since</th>
<th>Newly introduced or increased age limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyprus</td>
<td>6,302</td>
<td>4,214</td>
<td>18.4</td>
<td>18.2</td>
<td>2002 New</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>3,898</td>
<td>3,909</td>
<td>34.8</td>
<td>35.0</td>
<td>1999 Increased</td>
</tr>
<tr>
<td>Estonia</td>
<td>2,356</td>
<td>2,455</td>
<td>21.8</td>
<td>21.3</td>
<td>2000 New</td>
</tr>
<tr>
<td>Finland</td>
<td>4,974</td>
<td>3,736</td>
<td>22.5</td>
<td>24.4</td>
<td>1995 Increased</td>
</tr>
<tr>
<td>Hungary</td>
<td>2,797</td>
<td>3,047</td>
<td>26.8</td>
<td>27.3</td>
<td>1999 New</td>
</tr>
<tr>
<td>Ireland</td>
<td>2,216</td>
<td>2,205</td>
<td>17.2</td>
<td>13.2</td>
<td>2002 New</td>
</tr>
<tr>
<td>Latvia</td>
<td>2,269</td>
<td>2,620</td>
<td>32.8</td>
<td>33.0</td>
<td>1999 New</td>
</tr>
<tr>
<td>Lithuania</td>
<td>2,400</td>
<td>2,471</td>
<td>25.1</td>
<td>27.1</td>
<td>1995 New</td>
</tr>
<tr>
<td>Malta</td>
<td>3,658</td>
<td>3,373</td>
<td>17.1</td>
<td>13.5</td>
<td>2004 Increased</td>
</tr>
<tr>
<td>Poland</td>
<td>2,109</td>
<td>5,928</td>
<td>14.6</td>
<td>20.8</td>
<td>1995 New</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>2,467</td>
<td>1,995</td>
<td>28.9</td>
<td>28.8</td>
<td>1999 New</td>
</tr>
<tr>
<td>Sweden</td>
<td>3,166</td>
<td>2,559</td>
<td>13.3</td>
<td>14.5</td>
<td>1997 Increased</td>
</tr>
<tr>
<td>Total</td>
<td>38,612</td>
<td>38,512</td>
<td>22.8</td>
<td>23.1</td>
<td>–</td>
</tr>
</tbody>
</table>

a Indicates whether countries newly introduced the age limit of 18 years, or increased it from 16 to 18 years.

b The timing of surveys administration varied between countries, but was before the age limit of 18 years was introduced in all included countries.

c Prevalence rates reported by total were based on country-level prevalence rates, so that differences in sample size between countries were taken into account.

d Uncertainty about exact adoption date of age restriction, earliest confirmed year of restrictions’ existence.

RESULTS

Table 11.1 presents the characteristics of the included countries. On average, there was very little change in smoking prevalence rates between 2007 and 2011, in both intervention and control countries. There was a decrease in the perceived obtainability of cigarettes in intervention countries, with 61% perceiving obtainability as easy in 2007 and 51.6% in 2011. In control countries, there was no substantial decrease in obtainability.

Table 11.2 shows the results of the multilevel logistic regression analysis
with weekly smoking as the outcome variable. Weekly smoking was more prevalent in males than in females, and in lower SES than in higher SES individuals. Smoking prevalence did not differ between intervention and control countries in 2007. We also did not find a significantly larger change in smoking over time in intervention countries than in control countries (Model 5 OR: 1.00, 95%CI: 0.93-1.07). Sensitivity analyses showed that the change over time in intervention countries compared to control countries was similar for daily smoking (Model 5 OR: 1.00, 95%CI: 0.93-1.07) and ever smoking (Model 5 OR: 0.95, 95%CI: 0.89-1.01, results not shown in table).

Table 11.3 presents the results for obtainability of cigarettes. The odds of perceiving obtainability as easy were higher in males, smokers, and high SES individuals. Before the introduction of sales restrictions, adolescents in intervention countries perceived cigarettes to be significantly easier to obtain than in control countries in 2007. There was a significant decrease in obtainability in control countries between 2007 and 2011, but the decrease was significantly larger in intervention countries (Model 5 OR: 0.75, 95%CI: 0.70-0.80). The results were consistent over the five models; the observed decrease in obtainability was not caused by a change in the survey's demographic composition or a change in the country characteristics that were included. Sensitivity analyses in which obtainability was measured with a less strict cut-off point, we found as well that the decrease in obtainability was significantly larger in intervention countries (Model 5 OR: 0.73, 95%CI: 0.67-0.80, results not presented in table). Further stratification by smoking status showed no evidence for an interaction. Thus, the larger decrease in obtainability for intervention countries compared to control countries occurred in smokers as well as non-smokers ($p$ for three-way interaction: 0.730, results not presented in table).

Table 11.4 displays the changes in smoking and obtainability over time in both intervention and control countries, stratified by SES. In control and intervention countries, and also in high and low SES, we found no change in smoking prevalence, and a significant decrease in obtainability. Results for the differences in change over time between control and intervention countries were also very similar for high and low SES. There was no significant three-way interaction for either of the outcomes.
Table 11.2: Logistic regression models for weekly smoking.

<table>
<thead>
<tr>
<th>Weekly smoking (N= 117,612)</th>
<th>Odds ratio (95% Confidence interval)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
</tr>
<tr>
<td>Prevalence in intervention countries compared to control countries in 2007</td>
<td>0.85 (0.62-1.18)</td>
</tr>
<tr>
<td>Change over time within control countries</td>
<td>1.02 (0.99-1.06)</td>
</tr>
<tr>
<td>Change over time in intervention countries compared to control countries</td>
<td>0.99 (0.93-1.05)</td>
</tr>
<tr>
<td>Male gender</td>
<td>1.08 (1.05-1.11)</td>
</tr>
<tr>
<td>High SES</td>
<td>0.61 (0.57-0.64)</td>
</tr>
<tr>
<td>GDP per capita (per 10,000 dollars)</td>
<td>1.01 (0.93-1.09)</td>
</tr>
<tr>
<td>Adult smoking prevalence (per 10%)</td>
<td>0.98 (0.92-1.05)</td>
</tr>
<tr>
<td>TCS (per 10 points)c</td>
<td>0.98 (0.92-1.05)</td>
</tr>
</tbody>
</table>

* Models include: Model 1: intervention (defines intervention/control country), time, intervention*time and gender, Model 2: Model 1 + SES, Model 3: Model 2 + GDP, Model 4: Model 3 + adult smoking prevalence, Model 5: Model 4 + TCS.

b Intraclass correlation coefficient (ICC) Model 5 = 6.02% (95%CI: 2.71-12.81).

c OR for the odds of weekly smoking with a 10 point increase in TCS score.
### Table 11.3: Logistic regression models for easy obtainability of cigarettes.

<table>
<thead>
<tr>
<th>Easy obtainability of cigarettes</th>
<th>Odds ratio (95% Confidence interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
</tr>
<tr>
<td>Prevalence in intervention countries compared to control countries in 2007</td>
<td>1.47 (1.13-1.93)</td>
</tr>
<tr>
<td>Change over time within control countries</td>
<td>0.91 (0.88-0.94)</td>
</tr>
<tr>
<td>Change over time in intervention countries compared to control countries</td>
<td>0.74 (0.70-0.78)</td>
</tr>
<tr>
<td>Male gender</td>
<td>1.32 (1.29-1.36)</td>
</tr>
<tr>
<td>Weekly smoking</td>
<td>2.76 (2.67-2.84)</td>
</tr>
<tr>
<td>High SES</td>
<td>1.18 (1.12-1.25)</td>
</tr>
<tr>
<td>GDP per capita (per 10,000 dollars)</td>
<td>1.02 (0.96-1.08)</td>
</tr>
<tr>
<td>Adult smoking prevalence (per 10%)</td>
<td>1.00 (0.92-1.08)</td>
</tr>
<tr>
<td>TCS (per 10 points)</td>
<td>0.99 (0.93-1.05)</td>
</tr>
</tbody>
</table>

* Models include: Model 1: intervention (defines intervention/control country), time, intervention*time, gender and weekly smoking, Model 2: Model 1 + SES, Model 3: Model 2 + GDP, Model 4: Model 3 + adult smoking prevalence, Model 5: Model 4 + TCS.

** Intraclass correlation coefficient (ICC) Model 5 = 2.31% (95% CI: 1.09-4.79).**

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Youth tobacco access laws
Table 11.4: Change over time in weekly smoking and obtainability of cigarettes by SES.

<table>
<thead>
<tr>
<th>Weekly smoking</th>
<th>Odds ratio (95% Confidence interval)</th>
<th>Intervention countries compared to control countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Change over time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intervention countries</td>
<td>Control countries</td>
</tr>
<tr>
<td>Total population</td>
<td>1.03 (0.97-1.09)</td>
<td>1.03 (0.99-1.07)</td>
</tr>
<tr>
<td>Low SES</td>
<td>0.97 (0.86-1.08)</td>
<td>1.07 (0.99-1.15)</td>
</tr>
<tr>
<td>High SES</td>
<td>1.10 (0.98-1.24)</td>
<td>0.99 (0.91-1.07)</td>
</tr>
<tr>
<td>High SES compared to low SES</td>
<td>1.23 (0.96-1.57)</td>
<td></td>
</tr>
<tr>
<td>Easy obtainability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total population</td>
<td>0.68 (0.64-0.72)</td>
<td>0.91 (0.88-0.94)</td>
</tr>
<tr>
<td>Low SES</td>
<td>0.69 (0.62-0.77)</td>
<td>0.90 (0.84-0.97)</td>
</tr>
<tr>
<td>High SES</td>
<td>0.71 (0.64-0.79)</td>
<td>0.94 (0.87-1.01)</td>
</tr>
<tr>
<td>High SES compared to low SES</td>
<td>1.01 (0.81-1.25)</td>
<td></td>
</tr>
</tbody>
</table>

*a* Controlled for gender, GDP, adult smoking prevalence and TCS and additionally for SES in the total population.

*b* Three-way interaction: time*intervention*SES

DISCUSSION

Key findings

We did not find a significantly larger decrease in smoking in countries that have introduced sales restrictions for minor below 18 years of age in the studied period, compared to countries that had introduced these restrictions earlier. However, sales restrictions were associated with a significantly stronger decrease in perceived ease of the obtainability of cigarettes. The results were similar for adolescents of high and low socioeconomic status; no significant differential effects were found.

Potential limitations

As outcome measures were self-reported, socially desirable answers could have caused an underestimation of smoking prevalence. However, self-reported data on smoking has been shown to provide valid estimates of youth smoking prevalence. Furthermore, surveys conducted in school based settings have resulted in higher prevalence rates than surveys conducted at home. Finally, our results may be also less prone to reporting bias because we studied changes over time. Survey methods were consistent over time and were the same across countries.

Two aspects of sales restriction laws were not taken into account. Firstly, we did not have information on the degree of enforcement. This information would not influence the results directly, as we aimed to measure whether real-life introductions of sales restrictions, with all their imperfections, affected smoking and tobacco obtainment. Yet, information on enforcement
could have been helpful in understanding the results. Weak enforcement of sales restriction laws could explain the absence of an association between sales restriction laws and smoking prevalence in our study. However, the strong reduction that we found in the perceived obtainability of cigarettes suggests that adolescents perceived the sales restrictions to be well enforced. Secondly, in the analysis we were not able to distinguish between intervention countries that increased the age limit from 16 to 18 years and those without an existing law in place before 2007 (see Table 11.1). There is evidence for the effectiveness of both increasing the age from 16 to 18 and introducing an age limit. Therefore, it is likely that similar results would have been found in a sample of countries all applying the same strategy.

SES was measured according to parental educational level. While parental educational level has been shown to be related to adolescent smoking prevalence, other measures of SES might have led to different results. SES indicators related to the adolescent’s own educational achievements, such as the educational track or academic performance, may be stronger predictors of smoking onset than parental education level or other familial measures.

**Interpretation of results**

We found a significant decrease in easy obtainability of cigarettes, but not of weekly smoking prevalence after the introduction of sales restriction laws. This finding seems at odds with the observation that perceived difficulty of obtaining cigarettes is generally associated with lower smoking rates. This discrepancy may be due to the limited time after the implementation of sales restrictions of a maximum of four years in the intervention countries, which may be too short a period to detect an effect on the smoking initiation of adolescents. However, adolescents of 16 years old in 2011 were 12 years old at the time the sales ban was introduced (if introduced in 2007), and at that age it is unlikely that they had already initiated smoking. The time aspect might still play a role, as the de-normalising function of a sales restriction might take more than four years to take full effect. Alternatively, smoking may not have decreased because adolescents often shift from commercial to family or peer sources of tobacco, or they ask strangers to buy tobacco for them (proxy sales), thereby undermining access restrictions. Although in the current study the perceived ease of access decreased, around half of the respondents in 2011 still thought that it would be easy to obtain cigarettes. If at least one source of tobacco (commercial or non-commercial) remains accessible, smoking may still be initiated and maintained.

The effect of sales restrictions on smoking has been suggested to differ
between adolescents who start experimenting with smoking and those who transition into regular smoking\textsuperscript{24}. Sales restrictions may have a stronger effect on experimenting with tobacco than on regular smoking, because inexperienced smokers have not developed strategies to undermine sales restrictions and may be less willing to violate the law\textsuperscript{24}. On the other hand, regular smokers are more likely to obtain their cigarettes from commercial sources\textsuperscript{49} and may therefore be more strongly affected by the restriction on tobacco sales from these sources. In a sensitivity analysis we found very similar results for daily smoking, weekly smoking and ever smoking outcomes and we could therefore not support either hypothesis on differential effects by smoking frequency.

The effect of sales restrictions on smoking was similar for adolescents with both higher and lower educated parents. This is in line with findings from previous studies\textsuperscript{11,26}. A pre-post evaluation of the UK’s raise of the legal age from 16 to 18 years\textsuperscript{11} found a decrease in smoking that was similar for those eligible for free school meals and other students. A study from the US showed that stores in deprived and affluent areas were similarly likely to comply to the sales restriction law\textsuperscript{26}. However, two other US studies found that retailer compliance with sales restriction laws was higher in communities with a higher poverty rate\textsuperscript{27} and that enforcement efforts were more effective in adolescents of low SES\textsuperscript{28}. Such a possible ‘equity positive impact’\textsuperscript{25} may result from high SES adolescents, compared to those with low SES, being more likely to switch from commercial to social sources of tobacco\textsuperscript{11}. Our measure of perceived obtainability includes commercial as well as non-commercial sources. Therefore, in our case, a more difficult commercial obtainability in high SES adolescents might be counteracted by a stronger shift to non-commercial tobacco in this group\textsuperscript{11}. If so, the net effect on perceived obtainability could be equal among SES groups.

As the results of our current study on the 18 years ban suggests that the effect on tobacco obtainability was modest, further steps to limit youth tobacco access may be necessary. First, strengthening the enforcement of sales restrictions is crucial to further reduce the obtainability of tobacco, and enhancing the protective effect of such restrictions on smoking initiation\textsuperscript{21,22,24,50}. Second, countries may consider a further increase of the legal sales age in Europe to 21 years. There are multiple reasons why an age limit of 21 years could be more effective than one of 18 years\textsuperscript{51}. First, although many young people are likely to initiate smoking before they are 18, a relatively large group of young people start smoking during their transition to college or working life\textsuperscript{52}. Second, as de-normalisation of smoking is expected to be stronger in those who are further below the legal age limit\textsuperscript{51}, an age limit of 21 years would have stronger effect on de-normalisation in those around the age of 16 than with an age limit of 16 or
18 years. Third, as young people in the age of 19 to 21 are often the group who buy cigarettes for those under 18 years, increasing the legal sales age to 21 will constrain this social source of cigarettes for the under-18-year-olds\textsuperscript{53,54}. There is some evidence from the US indicating that a raise in the legal sales age to 21 years would decrease adolescent smoking\textsuperscript{51,53,55,56}, but future studies will need to identify potential effects in the European setting.

**Conclusions**

Laws restricting the sales of tobacco to minors made the perceived obtainability of cigarettes a bit more difficult, but did not lead to lower smoking rates within four years. This study adds to the evidence suggesting that sales restrictions to minors below the age of 18 do not reduce adolescent smoking in the short term. In the long run, however, the ban may serve the purpose of de-normalising smoking by making tobacco less available to the age group in which smoking uptake is most likely.

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