Tobacco Control and Socioeconomic Inequalities in Adolescent Smoking in Europe

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Introduction: The strength of national tobacco control varies by country, but it is unclear how this relates to smoking in adolescents of high and low SES. This study examined the association between tobacco control policies and adolescent smoking and investigated the differences in this association between adolescents of high and low SES.

Methods: Data of 90,351 adolescents aged 15–16 years from 13 European countries were obtained from the 2003, 2007, and 2011 European Survey Project on Alcohol and other Drugs databases. Logistic regression analyses were performed in 2014 with a random intercept at the country level and with daily smoking as the outcome. The Tobacco Control Scale was the score for national tobacco control policy. SES was based on parental education.

Results: In all studied countries, except Portugal, adolescent smoking prevalence rates were highest among low-SES respondents. Stronger tobacco control policies were associated with lower smoking rates in all three survey waves (2003, OR=0.75, 95% CI=0.55, 1.01; 2007, OR=0.84, 95% CI=0.73, 0.98; 2011, OR=0.85, 95% CI=0.74, 0.98). The association was consistently stronger in high-SES than in low-SES individuals, but the difference was not statistically significant.

Conclusions: Countries with stronger tobacco control policies tend to have lower smoking rates. We are unable to demonstrate significant socioeconomic inequalities in the effect of tobacco control policies on adolescent smoking.

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Introduction

In some parts of Europe, nearly half of socioeconomic inequality in life expectancy is attributable to smoking.[1] Inequalities in adult smoking prevalence[2–4] find their origins in adolescence; smoking rates in adolescents of high SES are typically lower than in their low-SES peers.[5–7] The reduction of socioeconomic inequalities in adolescent smoking is an important strategy for reducing inequalities in life expectancy in the future.

Adolescent smoking remains a public health problem of considerable magnitude.[8] Across Europe, 15%–20% of those aged 13–15 years were smokers in 2006.[9] A decreasing trend in the prevalence of smoking has been observed, particularly in Western Europe.[6] However, inequalities in adolescent smoking in Europe persisted over the past two decades and may even have increased over time.[6,7]

Since the early 1990s, most European countries have developed national tobacco control policies. Most progress was made since the establishment of the WHO's Framework Convention on Tobacco Control in 2003.[10] Still, large differences in tobacco control between European countries remain.[11] Most of the national tobacco control policies in Europe were designed to target the general population[10] and not to decrease socioeconomic inequalities in smoking. However, decreasing socioeconomic inequalities may be a secondary effect of tobacco control if policies were more effective in lower than in higher socioeconomic groups.

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Previous studies show mixed evidence for the effects of tobacco control policies on socioeconomic inequalities in adolescent smoking.[12] The most consistent evidence is on tobacco pricing and taxation. Four of six studies on the effects of tobacco pricing on smoking inequalities showed that increases in tobacco price or tax reduce socioeconomic inequalities in adolescent smoking.[13–18] Studies on national smoke-free policies[19–21] and policy on advertising[13,22,23] showed mixed results, suggesting these policies have either a negative or a neutral impact on inequalities in adolescent smoking.

In real-world settings, policy measures are commonly introduced simultaneously; therefore, it is useful to study the effects of policy packages. Three studies assessed effects on inequalities in adolescent smoking using a policy package approach, with somewhat conflicting results. In Australia, a higher level of national funding for tobacco control was associated with lower smoking prevalence rates in low-SES groups, suggesting a negative equity impact (i.e., widening of inequalities).[24] In Finland, the introduction of the Tobacco Act in 1976 had a negative equity impact on men and a positive impact on women.[25] In the Netherlands, a policy package introduced in 2003 had a negative equity impact on smoking in both male and female adolescents.[26]

The aim of this study was to examine the association between tobacco control policies and adolescent smoking, and to investigate the differences in this association between adolescents of high and low SES. The study aimed to replicate the analyses in three survey waves of 2003, 2007, and 2011. The sample included 13 European countries, with information for each country on both the level of tobacco control and adolescent smoking prevalence.

Methods

Data and Study Population

Data of 90,351 individuals from 13 European countries were derived from the 2003, 2007, and 2011 European Survey Project on Alcohol and other Drugs (ESPAD) survey waves. Access to the ESPAD data was obtained via the Trimbos Institute (Netherlands Institute of Mental Health and Addiction), responsible for ESPAD data collection in the Netherlands. The ESPAD study targeted students aged 15–16 years, randomly selected at the level of school classes. For more-detailed information on the ESPAD sampling procedure, see Hibell et al.[27] or www.espad.org. Data were collected in March and April, using class-administered questionnaires, under the supervision of a teacher or a research assistant. According to the Medical Ethical Committee of the Academic Medical Center, the Medical Research Involving Human Subjects Act did not apply to this study; therefore, official approval was not required.

Table 1 provides an overview of the number of respondents included per country, stratified by educational level of the parents. Nine countries participated in all survey waves; however, Lithuania

Table 1. Number of Adolescents in the Study Population by Country, Survey Year, and Parental Educational Level

	2003		2007		2011	
Country	**Low education**	**High education**	**Low education**	**High education**	**Low education**	**High education**
Austria	956	1,005	962	1,284		
Estonia	1,255	1,122	975	1,201	1,035	1,238
Finland	1,516	1,200	2,433	1,842	1,638	1,484
France	1,233	757	937	1,561	1,356	973
Germany	3,008	1,472	3,081	1,497	1,316	1,162
Ireland			1,119	954	1,025	1,055
Italy			3,756	5,265	1,830	2,734
Latvia	1,323	1,171	974	1,059	1,059	1,330
Lithuania			733	1,244	732	1,386
Netherlands	488	1,165	924	770	866	857
Portugal			1,404	1,432	974	845
Sweden	1,540	1,241	1,348	1,149	987	1,051
United Kingdom	907	954	827	1,085	787	502
N total	12,226	10,087	19,473	20,343	13,605	14,617

had missing information on parental educational level in 2003 and was therefore excluded in that survey year. Students with missing data on smoking or the educational level of both parents were excluded (17,670), resulting in a total population of 90,351.

Measures

All individual-level data were derived from the ESPAD database. Self-reported daily smoking was based on the following question: *How frequently have you smoked cigarettes during the last 30 days?* Daily smokers were defined as smoking at least one cigarette per day.

Socioeconomic status was based on the educational attainment of the parents, as an indicator of the SES of the family. Educational level of both parents was measured in five categories: primary school or less, some secondary school, secondary school completed, some college, and college degree or higher. The highest educational level between both parents was determined and used to define SES. SES was defined using rank scores of education, relative to the country of residence within the survey year, to make educational level comparable between countries. Rank scores were assigned per country and survey wave combination and then divided by the number of valid cases in the country of residence in the survey year. This resulted in a score between 0 and 1, respectively indicating the hypothetically lowest and highest SES in the individual's country and survey wave. The rank score had a mean value of 0.5 in all country–survey year combinations. Subsequently, the rank score was used as a continuous covariate in the regression analysis to determine the Relative Index of Inequality.[28,29] SES was included as dichotomous variable, with low-SES individuals having scores of <0.5 and high-SES individuals having scores of ≥ 0.5.

The strength of tobacco control policy in each country was expressed in a slightly adapted version of the Tobacco Control Scale (TCS), developed by Joossens and Raw.[11] The TCS scores tobacco price, smoke-free air laws, bans on advertising promotion and sponsorship, health warnings on tobacco product packaging, smoking-cessation treatment services, and spending on public information campaigns. The latter was excluded from the adapted version used in this paper because of a lack of information on campaign budgets, following the scale developed in the Pricing Policies And Control of Tobacco in Europe (PPACTE) project.[30] TCS scores were derived from the PPACTE reports for 2002, 2006, and 2010[30] (at $t-1$ for each survey year). For three countries (Latvia, Lithuania, and Estonia), TCS scores were derived from an internal report from the Lithuanian Tackling Socioeconomic Inequalities in Smoking project partner. TCS was measured on a scale of 0 to 100.

The smoking prevalence of each country among the population aged ≥ 15 years was derived from the Organisation for Economic Co-operation and Development database at $t-1$.[31,32] Smoking prevalence of the general population is viewed as a proxy of the social norm for smoking behavior in the country, as adult smoking influences adolescent smoking initiation.[33]

Statistical Analysis

The association between TCS and smoking was investigated using a logistic regression model with a random intercept at the country level. TCS was divided by ten to present the change in odds of smoking with a 10-point increase in TCS, because many countries showed a 10-point increase in TCS within 4 years.[30]

All analyses were stratified by survey wave. Combining data of all three survey waves resulted in unstable regression models, with unreliable outcomes. This was most likely due to a large variation between countries and between survey waves, which could not be modeled with observations of 13 countries.

The regression models were gradually controlled for sex, SES, and adult smoking prevalence. Gross domestic product (GDP) was not included in the analysis, because controlling for GDP did not alter results. Results were presented for boys and girls separately because a previous study by Hublet and colleagues[9] found significant gender differences in the association between tobacco control policies and smoking.

Additionally, we performed three sensitivity analyses. The first analysis investigated whether results were similar when only the countries with data for all three survey waves were included. The data provided information for nine countries in 2003, compared with 13 and 12 countries in 2007 and 2011, respectively. The second analysis examined the associations between subscales of the TCS, as determined by Joossens and Raw,[11] and smoking rates. The third analysis investigated potential lag time in the effects of TCS by associating smoking with TCS scores in preceding years (e.g., smoking in 2003 was associated with TCS scores from 2001, 2000, and 1999).

All analyses were performed in 2014, with R, version 3.1.1, using the lme4 package.

Results

Table 2 presents smoking prevalence rates in all 13 countries. Overall, smoking was more prevalent among lower-SES respondents, and in earlier survey waves. Portugal was an exception, with a higher smoking prevalence among high-SES individuals. On average, Austria had the highest smoking rates. The lowest percentage of smokers was found in Sweden, followed by Ireland, Portugal, and the United Kingdom (UK).

The country-level characteristics of the study population are presented in Table 3. The minimum TCS score was 16 in Latvia in 2003. However, on average, Austria had the lowest TCS scores, with a mean of 32.3 over the 3 survey years. The highest score was 77 points for the UK in 2011. Overall, the UK had the highest TCS scores, followed by Ireland, Sweden, and Finland. Table 3 also shows that, on average, adult smoking rates were highest in Latvia and lowest in Sweden.

Table 4 shows the associations of covariates with smoking. The association between parental educational level and smoking was consistent over the three survey waves (Model 2), with higher-SES adolescents being less likely to smoke (e.g., 2003, OR=0.53, 95% CI=0.47, 0.60). Differences between sexes were larger in 2011 than in other survey years (2007, OR=1.00, 95% CI=0.95, 1.05; 2011, OR=1.12, 95% CI=1.05, 1.19). A higher adult

Table 2. Adolescent Smoking Prevalence in Percentages by Country, Survey Year, and Parental Educational Level

	2003		2007		2011	
Country	**Low education**	**High education**	**Low education**	**High education**	**Low education**	**High education**
Austria	34.7	32.6	32.0	29.8		
Estonia	28.3	25.7	19.7	15.7	20.8	14.1
Finland	28.2	18.3	19.8	16.2	20.5	16.6
France	23.8	18.6	20.8	17.4	23.8	20.9
Germany	38.1	28.9	25.8	16.9	20.3	15.1
Ireland			16.3	9.3	12.8	6.6
Italy			26.4	22.0	25.3	20.3
Latvia	27.7	25.4	29.7	26.3	29.7	25.9
Lithuania			21.0	19.0	25.8	18.3
Netherlands	25.0	18.2	21.2	13.0	17.8	14.2
Portugal			8.0	10.8	13.7	15.7
Sweden	10.3	8.5	10.9	7.0	12.4	8.5
United Kingdom	24.3	12.8	15.6	9.2	12.6	9.6
M±SD	26.7±7.8	21.0±7.7	20.6±6.9	16.4±6.8	19.6±5.9	15.5±5.5

Table 3. Country-Level Characteristics of the Study Population

	Tobacco Control Scale[a]			Adult smoking prevalence (in %)[b]		
Country	**2002**	**2006**	**2010**	**2003**	**2007**	**2011**
Austria	22	33	42	26	23	
Estonia	33	39	53	32	28	26
Finland	49	54	60	23	21	19
France	36	51	66	26	26	23
Germany	25	32	46	24	23	22
Ireland	34	67	78	27	29	23
Italy	36	55	59	24	23	23
Latvia	16	39	55	38	34	34
Lithuania	27	33	47	29	29	25
Netherlands	34	45	54	28	25	21
Portugal	29	41	53		19	19
Sweden	46	57	60	18	15	14
United Kingdom	42	65	77	26	22	20
M±SD	33±9.4	47±1.2	60±1.1	27±4.9	24±4.9	21±4.8

[a]Tobacco Control Scale (TCS) scores were derived from the PPACTE project report[30] and from the Lithuanian SILNE project partner (Klumbiene and colleagues, for Lithuania, Latvia, and Estonia).
[b]Adult smoking rates were derived from the OECD database.
OECD, Organization for Economic Cooperation and Development; PPACTE, Pricing Policies And Control of Tobacco in Europe; SILNE, Smoking Inequalities—Learning from Natural Experiments.

Table 4. Associations With Daily Smoking in Three Logistic Regression Models With Country-Level Random Intercept

	OR (95% CI)		
	Model 1	**Model 2**	**Model 3**
2003			
Tobacco Control Scale[a]	0.74 (0.60, 0.91)	0.74 (0.60, 0.92)	0.75 (0.55, 1.01)
Male sex	1.00 (0.94, 1.06)	1.01 (0.95, 1.07)	1.01 (0.95, 1.07)
Parental educational level[b]		0.53 (0.47, 0.60)	0.53 (0.47, 0.60)
% adult smokers			1.00 (0.94, 1.06)
2007			
Tobacco Control Scale[a]	0.81 (0.68, 0.97)	0.81 (0.68, 0.96)	0.84 (0.73, 0.98)
Male sex	0.99 (0.94, 1.04)	1.00 (0.95, 1.05)	1.00 (0.95, 1.05)
Parental educational level[b]		0.56 (0.51, 0.62)	0.56 (0.51, 0.62)
% adult smokers			1.04 (1.01, 1.08)
2011			
Tobacco Control Scale[a]	0.82 (0.67, 1.00)	0.82 (0.68, 0.98)	0.85 (0.74, 0.98)
Male sex	1.11 (1.04, 1.18)	1.12 (1.05, 1.19)	1.12 (1.05, 1.19)
Parental educational level[b]		0.54 (0.49, 0.61)	0.54 (0.49, 0.61)
% adult smokers			1.05 (1.02, 1.08)

[a]ORs for a 10-point increase in Tobacco Control Scale.
[b]Rank score of parental educational level, per country and survey year. Zero represents the lowest educational level, one represents the highest educational level.

smoking prevalence was associated with higher adolescent smoking rates.

Table 4 also presents the association between the TCS and smoking. In all three survey waves, TCS was inversely associated with smoking, meaning that countries with higher TCS scores had lower smoking prevalence rates (Model 3). Controlling for individual- as well as country-level characteristics slightly altered the estimates, but sex, parental education, and adult smoking did not seem to play an important role in the association between TCS and smoking.

Table 5 stratifies the results of Model 3 by sex. In 2007 and 2011, the association was somewhat stronger in male adolescents than in female adolescents, but not significantly according to the overlap in confidence intervals. Associations of smoking with sex and SES were similar for male and female adolescents.

Table 6 presents the association between TCS and smoking for high- and low-SES respondents in the total population and stratified by sex. Associations between TCS and smoking were consistently weaker in the low-SES group, but there were no significant differences between SES groups according to the large overlap in CIs. The same patterns were observed in Figure 1.

In the first sensitivity analysis, the key results were the same when only the countries with data for all three survey waves were included in the analysis (results not shown). Second, the associations between different subscales of the TCS and adolescent smoking showed similar inverse associations as in the presented analyses, although the variation in these subscale scores among the countries was often small, which resulted in large CIs. There was no substantial difference between SES groups and any of the subscales, including the relative price of cigarettes (results not shown). Third, there was no evidence for a lag time in the effect of tobacco control policies on adolescent smoking and inequalities in smoking (results not shown). The results presented in Table 6 were very similar when TCS scores for previous years were used.

Discussion

Key Results

In all studied countries, except Portugal, adolescent smoking prevalence rates were higher among low-SES respondents than their high-SES peers. Stronger national-level tobacco control policies were associated

Table 5. Associations With Daily Smoking, Stratified by Sex

	OR (95% CI)[a]	
	Males	**Females**
2003		
Tobacco Control Scale[b]	0.75 (0.54, 1.05)	0.74 (0.56, 0.97)
Parental educational level[c]	0.56 (0.47, 0.66)	0.50 (0.42, 0.58)
% adult smokers	1.04 (0.97, 1.11)	0.97 (0.92, 1.02)
2007		
Tobacco Control Scale[b]	0.76 (0.65, 0.88)	0.92 (0.77, 1.09)
Parental educational level[c]	0.62 (0.54, 0.71)	0.51 (0.45, 0.58)
% adult smokers	1.06 (1.02, 1.09)	1.03 (0.99, 1.07)
2011		
Tobacco Control Scale[b]	0.80 (0.69, 0.92)	0.92 (0.79, 1.06)
Parental educational level[c]	0.53 (0.45, 0.62)	0.56 (0.48, 0.66)
% adult smokers	1.06 (1.03, 1.09)	1.04 (1.01, 1.07)

[a]ORs were controlled for presented covariates.
[b]ORs for a 10-point increase in Tobacco Control Scale.
[c]Rank score of parental educational level, per country and survey year. Zero represents the lowest educational level, one represents the highest educational level.

with lower odds of daily smoking. Weak evidence was found for stronger associations in male than in female adolescents and stronger associations in high-SES male than low-SES male adolescents. However, according to the overlap in CIs, these differences were not statistically significant.

Table 6. Association Between the Tobacco Control Scale and Daily Smoking by Parental Educational Level and Sex

	OR (95% CI)[a]	
	Low parental education	**High parental education**
General population		
2003	0.80 (0.59, 1.08)	0.70 (0.53, 0.92)
2007	0.90 (0.77, 1.05)	0.80 (0.68, 0.94)
2011	0.87 (0.77, 0.98)	0.81 (0.68, 0.97)
Males		
2003	0.81 (0.56, 1.18)	0.69 (0.51, 0.94)
2007	0.78 (0.65, 0.94)	0.75 (0.63, 0.89)
2011	0.79 (0.69, 0.90)	0.79 (0.65, 0.95)
Females		
2003	0.78 (0.59, 1.03)	0.70 (0.57, 0.88)
2007	0.99 (0.81, 1.20)	0.85 (0.71, 1.03)
2011	0.95 (0.82, 1.09)	0.85 (0.70, 1.04)

[a]ORs were controlled for adult smoking prevalence and represent the odds of smoking with a 10-point increase in Tobacco Control Scale.

Potential Limitations

The data were derived from self-completed surveys, providing information on self-reported smoking behavior. When using self-reported data,[34,35] smoking behavior may be under-reported owing to socially desirable answering of questions. Children of more highly educated parents may be more likely to be aware of the negative consequences of smoking,[18] and social desirability may therefore have played a larger role among high-SES respondents. If so, this would have caused an overestimation of the differences in smoking between high- and low-SES respondents. Similarly, social desirability may have had a stronger effect in the countries where smoking is less normal.[36] If social desirability is associated with the country's TCS score, this may have resulted in an overestimation of the associations between smoking and TCS as observed in this study.

The TCS used in the current study contains five domains of tobacco control, including smoking-cessation support, for example. Not all of these domains may be as likely to affect adolescent smoking. Moreover, the laws restricting the sale of tobacco to young people may be an important policy component,[37,38] but this component was not covered by the TCS.[11] Similarly, spending on public information campaigns, which may have positive effects among adolescents, could not be included in our study because of lack of detailed information for all countries in all years.[39] If it would have been possible to construct a measure summarizing all policies relevant to youth smoking, stronger associations may have been observed in the current study.

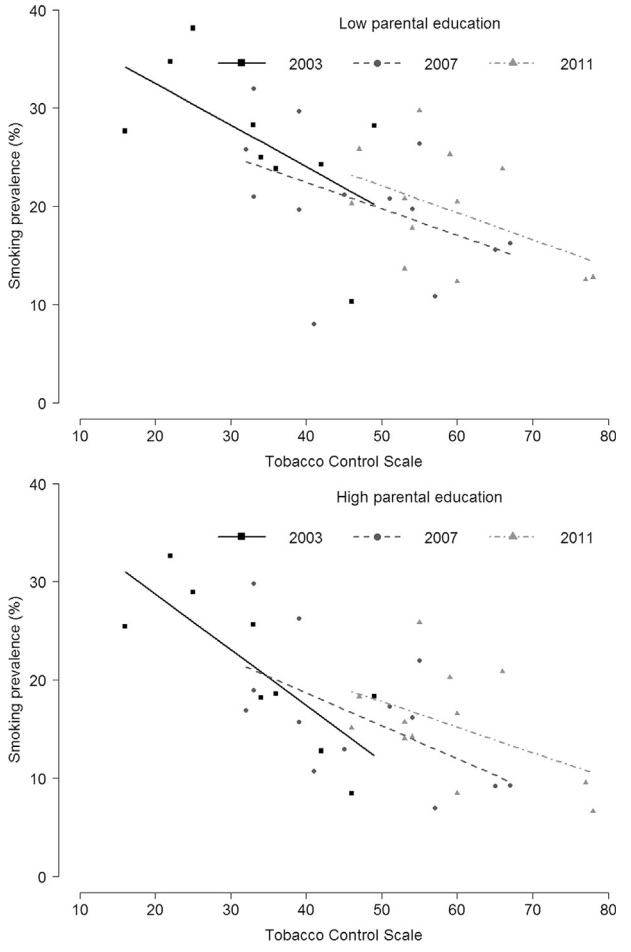

Figure 1. The association between the Tobacco Control Scale and smoking prevalence stratified by parental educational level.

The use of cross-sectional data does not resolve questions that may be asked regarding the causality of the observed association. In our study, reverse causation may have occurred if lower smoking rates in a country lead to stronger national tobacco control policies. Such a process may have occurred if low smoking prevalence rates enhance the societal pressure to, and support for, politicians' decisions in tobacco control strategies.[40] However, as adolescent smoking was related to TCS scores of up to 3 years previous to the same extent as with TCS in the year before, we consider it plausible that tobacco control policies lead to a decrease in adolescent smoking rather than the other way around.

In this study, daily smoking was used as the outcome measure. Other studies on adolescent smoking often used regular or weekly smoking because adolescents more often than adults have a non-daily smoking frequency. However, a previous study by Hublet et al.[9] examined the association between regular smoking and tobacco control policies, and found similar inverse associations as shown in the current study.

Explaining Results

In 2003, Austria and Germany had low TCS scores and very high smoking rates. TCS subscores were especially low on smoke-free policies and advertising bans, but relatively high on price policies.[30] In later years, price had a smaller share in the total TCS scores of these countries, but smoking rates dropped considerably. Although an analysis of all countries of the subscore of price did not show very different associations than the total TCS score, this finding may suggest that price had a less important role in tobacco control than the other TCS components.

Consistently stronger associations were found for high-SES individuals, even though the differences could not be demonstrated with statistical significance. These results suggest that high-SES adolescents have benefited more from tobacco control policies than their low-SES peers. Given the limited number of previous studies on equity impact of tobacco control in young people, it is difficult to identify the policies that may have caused this possible differential effect.[12] TCS scores accounted for a large part of the of the price policy subscore. Yet, a positive equity impact was mostly found for price policies,[12,41] which cannot explain the equity-neutral or negative findings of this study. By contrast, smoke-free policies have a mostly negative equity impact on young people.[12] As TCS scores on smoke-free policies were relatively high,[30] these policies may have contributed to a negative equity impact.

Adult smoking prevalence was a predictor of adolescent smoking. An increase in adult smoking prevalence of 10% would lead to an increase in adolescent smoking prevalence of 63% (derived from the OR of 1.05). Adult smoking was more predictive in male than in female adolescents, in all three survey waves. This finding is consistent with the strong association between parental smoking and adolescent smoking in previous studies.[33] Also, it provides support for the importance of reducing smoking in the general population in order to positively change the social norm and prevent young people from taking up smoking.

This study shows that Portugal was exceptional in its higher smoking rate in high-SES adolescents, compared with low-SES peers. Other studies on adolescent smoking in other European countries found that smoking was more prevalent in low-SES groups,[42] but a higher smoking rates in high-SES adults in Portugal has been described previously.[2] Portugal is likely to be in an earlier stage of the tobacco epidemic, in which smoking in women and in high-SES individuals is still relatively high and may even increase.[43] Therefore, Portugal may still develop smoking inequalities similar to other European countries, and tobacco control policies that are effective in low-SES groups may be crucial in preventing large inequalities in the future.

Conclusions

Countries with a stronger tobacco control policy tend to have lower smoking rates. We are unable to demonstrate significant socioeconomic inequalities in the effect of tobacco control policies on adolescent smoking. As smoking inequalities persist in European adolescents, there is a need to identify and implement tobacco control strategies that are more effective among low-SES youth in order to narrow inequalities in smoking in the future.

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