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Correlation between tobacco control policies and preterm births and low birth weight in Europe

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ABSTRACT

Objective: To assess the correlation between tobacco control policies— particularly smoking bans in work and public places—and the prevalence of preterm births and low birth weight in the European countries.

Methods: This is an ecological study and the unit of analysis set at the country level. Tobacco control data in Europe were obtained for the years 2010 and 2013 as measured by the Tobacco Control Scale (TCS), which reflects the level of implementation of tobacco control policies. Prevalence data for preterm births and low birth weight were obtained from two sources: the European Perinatal Health Report (EPHR), which provides data for 2010, and the Eurostat data, which includes the years 2013 and 2014. We analyzed the correlation between the TCS score and the prevalence of preterm birth and low birth weight in the European countries by means of Spearman (rsp) rank-correlation coefficients and their 95% confidence intervals (95%CI).

Results: The 2010 TCS was negatively correlated with the prevalence of preterm births before week 37 (rsp = −0.51; 95% CI: −0.77, −0.15; p = 0.006) and week 32 (rsp = −0.42; 95%CI: −0.73, −0.01; p = 0.030) and with the prevalence of the low birth weight (< 2500 g, (rsp = −0.42; 95% CI: −0.66, −0.09; p = 0.028) in European countries in 2010. We found a statistically significant inverse correlation between the level of restrictions on smoking in public places and the prevalence of low birth weight (< 2500 g rsp: −0.54; 95%CI: −0.72, −0.10; p = 0.017).

Conclusion: The level of smoke-free legislation in European countries correlates with lower preterm birth prevalence rates at the ecological level. Given the important negative effects of premature births for the public health system, these data support greater implementation of smoke-free policies and tend to support the implementation of tobacco control policies, but more research is needed.

1. Introduction

Preterm birth is the main cause of infant morbidity and mortality, with approximately 35% of infant deaths attributed to preterm birth; early births have also been implicated in a high percentage of long-term morbidity (Goldenberg et al., 2008; Blencowe et al., 2012; Howson et al., 2013; Shapiro-Mendoza et al., 2016). Preterm birth rates range from 5% to 18%, with wide variability among countries around the world (Blencowe et al., 2012; Kinney and Lawn, 2017). Despite advances in medical care in recent decades, the rate of preterm births has been increasing, even in developed countries (Blencowe et al., 2012; Kinney and Lawn, 2017).

Active smoking and SHS exposure during pregnancy are associated with several adverse effects during reproduction. Smoking during pregnancy has harmful effects on placenta and fetal growth (Mackay et al., 2012) and it has been implicated in several important

Abbreviations: TCS, Tobacco Control Scale; EPHR, European Perinatal Health Report; rsp, Spearman rank-correlation coefficients; 95%CI, 95% confidence intervals; SHS, secondhand smoke; CIs, confidence intervals; HDI, Human Development Index; GDP, gross domestic product; NICU, neonatal intensive care unit

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complications, including preterm labor (Nabet et al., 2005; Fantuzzi et al., 2007), intrauterine growth restriction, and low birth weight (Mackay et al., 2012). Moreover, there is a strong association between active smoking during pregnancy and preterm births, with a clear dose-response relationship (Simpson, 1957; Kyrklund-Blomberg and Cnattingius, 1998; Shah and Bracken, 2000; Ko et al., 2014). SHS exposure during pregnancy has also been associated with low birth weight and preterm births (Fantuzzi et al., 2007; Shah and Bracken, 2000; Misra and Nguyen, 1999; Windham et al., 1999; Leonardi-Bee et al., 2008; Crane et al., 2011; Wahabi et al., 2013; Jaakkola et al., 2001).

In the last decade, many countries have implemented tobacco control legislation—particularly smoking bans in work and public places—to protect non-smokers from SHS exposure. Similarly, numerous studies have assessed the impact of smoke-free policies and the benefits of such laws on the health of the population (International Agency for Research, 2017). However, those studies focused on adult populations; there is limited evidence on the impact of smoking legislation in pediatric populations (Dove et al., 2011; Jarvis et al., 2012; Been et al., 2015; Filippidis et al., 2017), particularly with regard to preterm births and birth weight (Been et al., 2015, 2014; Cox et al., 2013; Faber et al., 2008; Vicedo-Cabrera et al., 2016; Bakolis et al., 2016; Simón et al., 2017). According to a recent Cochrane review conducted to assess the impact of legislative smoking bans, the effect of such bans on perinatal outcomes (including preterm birth and low birth weight) cannot be determined based on the available evidence (Frazer et al., 2016).

In this context, we hypothesized that tobacco control policies should reduce tobacco consumption and SHS exposure during pregnancy and thereby also reduce preterm and low weight births after implementation of smoke-free legislation. Nevertheless, evidence on this topic in European countries is scant. Therefore, the objective of the present study was to evaluate the correlation between tobacco control policies—particularly smoking bans in work and public places—and the prevalence of preterm births and low birth weight in the European countries.

2. Methods

This is an ecological study with each country as the unit of analysis. Data was obtained from three different sources. We obtained tobacco control data (according to the Tobacco Control Scale; TCS see: http://www.tobaccocontrolscale.org/) in the European countries the years 2010 and 2013 (Joossens and Raw, 2011, 2014, 2006). The TCS provides a score for each country reflecting the level of implementation of tobacco control policies according to six cost-effective policies (Joossens and Raw, 2011, 2014, 2006).

Data on the prevalence of preterm births and low birth weight for the year 2010 were obtained from the European perinatal health report (EPHR) for 28 countries (Committee Euro-Peristat, 2017). The EPHR, published by Euro-peristat, was developed to establish a European perinatal health information system (Committee Euro-Peristat, 2017). We also obtained data on the prevalence of preterm birth and low birth weight in 2013 and 2014 for 14 countries, and in 2015 for 15 countries from the Eurostat. The Eurostat provides statistical information for European countries based on data collected from institutions in the different member countries (Eurostat. Database, 2015).

2.1. Variables

2.1.1. Tobacco control policies

We used data from the TCS (Joossens and Raw, 2011, 2014) to quantify the grade and effort of implementation of tobacco control policies in European countries. TCS is a systematic score system developed and drafted by a group of experts in 2006. It had supported from the European Commission and it can be used in more than 30 European countries, more specifically the TCS for 2010 was used in 30 European countries, and the TCS for 2013 was used in 34 European countries (Joossens and Raw, 2011, 2014). The six policies evaluated in the TCS are as follows (with scores shown in parentheses): 1) price increases through higher taxes on tobacco products (maximum 30 points); 2) bans/restrictions on smoking in public and workplaces (maximum 22 points); 3) better consumer information, including public information campaigns, media coverage and publicizing of research findings (maximum 15 points); 4) comprehensive bans on the advertising and promotion of all tobacco products, logos and brand names (maximum 13 points); 5) large, direct health-warning labels on cigarette boxes and other products (maximum 10 points); and 6) treatment to help dependent smokers to quit, including increased access to medications (maximum 10 points). The maximum TCS score is 100 points, indicating full implementation of all strategies.

2.1.2. Gestational age

We used two different sources to obtain the prevalence of preterm birth for 2010, 2013, 2014 and 2015. From the EPHR (Committee Euro-Peristat, 2017), we obtained the prevalence of preterm birth in the year 2010 for 28 European countries. Possible classifications are as follows: < 37 weeks gestational age, < 32 weeks gestational age or < 28 weeks gestational age.

From the EUROSTAT (Eurostat. Database, 2015), we obtained the prevalence of preterm birth for 14 European countries in 2013 and 2014, and for 15 European countries in 2015. In addition, we estimated the mean rate of preterm birth for 2013, 2014 and 2015 using the data extracted from the calculation of the intervals of gestational age ranges according to the number of births in each country in those years. We classified the data as follows: < 37 weeks gestational age, < 32 weeks gestational age, or < 28 weeks gestational age.

2.1.3. Birth weight

We obtained prevalence rates for low birth weight for the years 2010, 2013, 2014 and 2015 from two different sources, as follows: 1) From the EPHR (Committee Euro-Peristat, 2017), we obtained prevalence rates for babies weighing < 2500 g and < 1500 g in 2010 for 28 European countries. 2) From the EUROSTAT (Eurostat. Database, 2015), we obtained the prevalence of births with weights < 2500 g, < 2000 g, < 1500 g, and < 1000 g in 2013 and 2014 for 14 European countries and in 2015 for 15 European countries.

2.2. Statistical analysis

We analyzed the correlation between the TCS score in 2010 and the prevalence of preterm birth and low birth weight in European countries in the same year by means of Spearman rank-correlation coefficients (rsp). We also calculated 95% confidence intervals (CIs) for these values. In addition, we analyzed the correlation between each one of the six policies from TCS —particularly bans on smoking in workplaces and public places—and the prevalence of preterm births and low birth weight. We performed these same analyses for the TCS score in 2013 data to determine correlations with the prevalence of preterm birth and low birth weight in the years 2013, 2014 and 2015. Moreover, we performed a simple linear regression analysis between the TCS score or the public place bans score as the independent variable and the prevalence of preterm birth or low birth weight as the dependent variable to test for the statistically significant correlations. Finally, to study differences at socioeconomic level, we stratified the countries to perform the correlation according to countries above and below the median of high gross domestic product (GDP) per capita and human development index (HDI).

3. Results

Table 1 shows the data from the TCS and the public place bans policy for the years 2010 and 2013, with the available data on the prevalence of preterm births (< 37 weeks) and low birth weight births

Table 1
Data from TCS for 2010 & 2013 and prevalence of preterm and low birth weight for the years 2010, 2013, 2014 and 2015 for European countries.

Country	TCS 2010[a]		TCS 2013[a]		Preterm & LBW for 2010[b]		Preterm & LBW for 2013[c]		Preterm & LBW for 2014[c]		Preterm & LBW for 2015[c]	
	TCS	Public place bans	TCS	Public place bans	Less than 2500 g	Less than 37 weeks	Less than 2500 g	Less than 37 weeks	Less than 2500 g	Less than 37 weeks	Less than 2500 g	Less than 37 weeks
Austria	32	7	31	8	7.00%	8.50%	–	–	–	–	–	–
Belgium	50	13	47	13	7.30%	8.20%	–	–	–	–	–	–
Bulgaria	40	6	46	15			9.56%	6.45%	9.42%	7.09%	8.95%	6.77%
Cyprus	40	11	33	7	9.80%	10.50%	–	–	–	–	–	–
Czech Republic	34	7	34	9	7.50%	8.00%	8.02%	8.26%	7.68%	7.60%	7.64%	7.35%
Denmark	46	11	46	11	5.10%	6.40%	–	–	–	–	–	–
Estonia	43	12	43	12	4.10%	5.60%	–	–	–	–	–	–
Finland	52	17	55	17	4.30%		4.09%	5.58%	4.17%	5.77%	4.20%	5.70%
France	55	17	57	17	6.40%	6.60%	–	–	–	–	–	–
Germany	37	11	32	11	7.20%	8.50%	–	–	–	–	–	–
Greece	32	7	35	7	–	–	8.89%	11.12%	9.01%	11.41%	9.18%	11.24%
Hungary	34	6	48	13	8.50%	8.90%	8.64%	8.83%	8.61%	8.59%	8.40%	8.59%
Ireland	69	21	70	21	5.10%	5.70%	–	–	5.60%	6.30%	5.62%	6.38%
Italy	47	17	46	15	7.10%	7.40%	–	–	–	–	–	–
Latvia	44	14	41	14	4.80%	5.80%	–	–	–	–	–	–
Lithuania	41	12	35	12	4.70%	5.40%	4.58%	5.46%	4.25%	5.00%	4.12%	4.94%
Luxembourg	33	11	37	15	6.70%	8.10%	–	–	–	–	–	–
Malta	52	17	56	18	7.30%	7.10%	6.72%	5.46%	6.51%	6.70%	6.34%	6.80%
The Netherlands	46	13	47	13	6.20%	7.50%	–	–	–	–	–	–
Poland	43	11	43	11	5.70%	6.60%	5.96%	7.07%	5.92%	7.25%	5.78%	7.21%
Portugal	43	11	41	11	8.30%	7.60%	8.65%	7.82%	8.69%	7.72%	8.88%	7.99%
Romania	45	7	44	7	8.00%	8.20%	8.47%	8.51%	8.21%	8.30%	7.92%	8.32%
Slovakia	41	10	39	10	8.10%	7.10%	7.61%	6.16%	7.82%	6.10%	7.68%	6.04%
Slovenia	44	15	43	15	6.30%	7.20%	–	–	–	–	–	–
Spain	46	17	56	21	8.70%	15.50%	7.70%	6.34%	7.83%	6.47%	7.90%	6.41%
Sweden	51	15	48	15	4.40%	5.90%	–	–	–	–	–	–
United Kingdom	77	21	74	21	6.40%	7.10%	–	–	–	–	–	–
Iceland	61	17	66	17	3.30%	5.20%	–	–	–	–	–	–
Norway	62	17	61	17	4.90%	5.20%	–	–	–	–	–	–
Switzerland	48	11	45	11	6.50%	7.10%	6.57%	7.19%	–	–	6.45%	7.14%
Serbia	–	–	42	11	–	–	6.07%	6.69%	5.99%	6.49%	5.99%	6.51%

Data of the prevalence of preterm (less than 37 weeks) or low birth weight (less than 2500 g) is expressed as a percentage with two decimals. TCS: Tobacco Control Scale (maximum 100 points) quantifies the full implementation of tobacco control policies at country level and collects information about of the six most cost-effective tobacco control policies (Price, Public places bans, Public information campaign spending, Advertising bans, Health warnings, and Treatment); Public place bans: bans/restrictions on smoking in public and work places (maximum 22 points); LBW: Low birth weight.

[a] Data extracted from TCS for 2010 and 2013.

[b] Data extracted from EPHR (European Perinatal Health Report) for 2010.

[c] Data extracted from EUROSTAT for 2013, 2014 and 2015.

(< 2500 g) for European countries with data available for the years 2010, 2013, 2014 and 2015.

Table 2 shows the correlations between the TCS and the prevalence of preterm births and low birth weight. As that table shows, the TCS in 2010 were negatively correlated with the prevalence of preterm births (< 37 weeks and < 32 weeks) in European countries in 2010 (rsp = −0.51; 95% CI: −0.77, 0.15; p = 0.006; rsp = −0.42; 95% CI: −0.73, 0.01; p = 0.03). Similarly, a statistically significant correlation was found between the level of restrictions on smoking in public places in 2010 and the prevalence of preterm births (year 2010) before week 37 (Table 2). We observed similar correlation patterns between the other five tobacco control policies (price, public information campaigns, advertising bans, health warnings, and treatment) and the prevalence of preterm births, but only the level of advertising bans for preterm birth before week 37 (rsp = −0.53; 95%CI: −0.81, −0.10) and before week 32 (rsp = −0.41; 95%CI: −0.69, −0.05) and the price for preterm birth before week 37 (rsp = −0.47; 95%CI: −0.72, −0.13) and before week 28 (rsp = −0.54; 95%CI: −0.81, −0.23) showed a statistically significant correlation.

There was a statistically significant negative correlation between TCS in 2010 and the prevalence of low birth weight (< 2500 g) in European countries in 2010 (rsp = −0.42; 95% CI: −0.66, −0.09; p = 0.028). We also observed a significant inverse correlation between the level of restrictions on smoking in public places and the prevalence of low birth weight (< 2500 g) (rsp = −0.54; 95% CI: −0.72, −0.10; p = 0.017) (Table 2). All five of the other tobacco control policies (price, public information campaigns, advertising bans, health warnings, and treatment) correlated with the prevalence of low birth weight in 2010 (data not shown), but the statistically significant correlations were for the prevalence of births < 2500 g and the level of advertising bans (rsp = −0.50; 95%CI: −0.76, −0.07), the public information campaign (rsp = −0.41; 95%CI: −0.68, −0.05); and for the prevalence of births < 1500 g were the level of advertising bans (rsp = −0.38; 95%CI: −0.68, −0.03) and price (rsp = −0.29; 95%CI: −0.68, −0.01). Similar negative correlations were found among countries when stratifying according to GPD per capita and HDI median, with a higher correlation among countries with the GPD per capita and HDI over the median.

The TCS in 2013 was negatively correlated with the prevalence of preterm births and low birth weight in 2013, 2014 and 2015, although these associations were not statistically significant (Table 2). There was a significant negative correlation between the level of public place smoking bans in 2013 and the prevalence of preterm births before week 37 and week 32 in 2013, before week 32 in 2014 and before week 37 in 2015 (Table 2). The level of public information campaigns in 2013 was significantly negatively correlated with the prevalence of preterm births before week 32 in 2014 (rsp = −0.56; 95%CI: −0.83, −0.13, and with the prevalence of birth < 1500 g and < 1000 g respectively (rsp = −0.62; 95%CI: −0.86, −0.28) (rsp = −0.56; 95%CI: −0.83, −0.11).

The simple linear regression analysis of the statistically significant correlations between the TCS score or the public place bans score as the independent variable and the prevalence of preterm birth or low birth

Table 2
Spearman correlation coefficients (r_{sp}) and thir 95% confidence intervals (95%CI) between TCS and public place bans (2010 and 2013) and prevalence of birth weight and preterm births (2010, 2013, 2014 and 2015) in Europe.

	TCS from 2010 and data of prevalence from 2010[a]		TCS from 2013 and data of prevalence from 2013[b]		TCS from 2013 and data of prevalence from 2014[c]		TCS from 2013 and data of prevalence from 2015[d]	
	TCS	Public place bans	TCS	Public place bans	TCS	Public place bans	TCS	Public place bans
Terms of birth								
Less than 37 weeks (%)	−0.51 (−0.77, −0.15)	−0.47 (−0.76, −0.13)	−0.31 (−0.82, 0.34)	−0.64 (−0.95, −0.09)	−0.21 (−0.75, 0.39)	−0.52 (−0.89, −0.02)	−0.22 (−0.75, 0.39)	−0.53 (−0.88, 0.00)
p-value	0.006	0.013	0.283	0.014	0.468	0.056	0.423	0.040
Less than 32 weeks (%)	−0.42 (−0.73, −0.01)	−0.34 (−0.69, 0.084)	−0.46 (−0.85, 0.22)	−0.69 (−0.92, −0.19)	−0.30 (−0.73, 0.29)	−0.62 (−0.90, −0.15)	−0.03 (−0.54, 0.57)	−0.21 (−0.71, 0.33)
p-value	0.030	0.082	0.101	0.007	0.302	0.019	0.922	0.452
Less than 28 weeks (%)	−0.39 (−0.72, 0.03)	−0.26 (−0.64, 0.21)	−0.03 (−0.59, 0.58)	−0.01 (−0.65, 0.57)	−0.10 (−0.60, 0.48)	−0.14 (−0.68, 0.44)	0.14 (−0.40, 0.58)	0.07 (−0.50, 0.64)
p-value	0.052	0.207	0.923	0.970	0.727	0.623	0.624	0.808
Birth weight								
Less than 2500 g (%)	−0.42 (−0.66, −0.09)	−0.54 (−0.72, −0.10)	−0.09 (−0.61, 0.52)	−0.26 (−0.76, 0.29)	−0.16 (−0.67, 0.43)	−0.33 (−0.75, 0.22)	−0.16 (−0.67, 0.42)	−0.36 (−0.76, 0.17)
p-value	0.028	0.017	0.753	0.373	0.583	0.253	0.567	0.191
Less than 2000 g (%)	–	–	−0.29 (−0.77, 0.34)	−0.45 (−0.84, 0.11)	−0.34 (−0.80, 0.30)	−0.42 (−0.76, 0.10)	−0.25 (−0.72, 0.36)	−0.34 (−0.71, 0.14)
p-value	–	–	0.313	0.109	0.232	0.134	0.375	0.208
Less than 1500 g (%)	−0.37 (−0.72, 0.03)	−0.33 (−0.64, 0.06)	−0.24 (−0.74, 0.51)	−0.39 (−0.77, 0.22)	−0.38 (−0.84, 0.25)	−0.45 (−0.85, 0.10)	−0.17 (−0.68, 0.44)	−0.22 (−0.68, 0.28)
p-value	0.050	0.088	0.408	0.169	0.182	0.103	0.542	0.426
Less than 1000 g (%)	–	–	−0.09 (−0.73, 0.47)	−0.18 (−0.68, 0.47)	−0.31 (−0.63, 0.27)	−0.23 (−0.68, 0.47)	−0.23 (−0.76, 0.34)	−0.37 (0.78, 0.15)
p-value	–	–	0.750	0.539	0.276	0.434	0.407	0.170

There is no data available from the source (EPHR) for birth weight < 2000 g or birth weight < 1000 g.

TCS: Tobacco Control Scale (maximum 100 points) quantifies the full implementation of tobacco control policies at country level and collects information about of the six most cost-effective tobacco control policies (Price, Public places bans, Public information campaign spending, Advertising bans, Health warnings, and Treatment); Public place bans: bans/restrictions on smoking in public and work places (maximum 22 points).

[a] Data from 28 countries (Austria, Belgium, Cyprus, Czech-Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom.) obtained of the European perinatal health report (EPHR).

[b] Data from 14 countries (Bulgaria, Czech Republic, Finland, Greece, Hungary, Lithuania, Malta, Poland, Portugal, Romania, Slovakia, Spain, Switzerland, Serbia) obtained of the EUROSTAT.

[c] Data from 14 countries (Bulgaria, Czech Republic, Finland, Greece, Hungary, Ireland Lithuania, Malta, Poland, Portugal, Romania, Slovakia, Spain, Serbia) obtained of the EUROSTAT.

[d] Data from 15 countries (Bulgaria, Czech Republic, Finland, Greece, Hungary, Ireland, Lithuania, Malta, Poland, Portugal, Romania, Slovakia, Spain, Switzerland, Serbia) obtained of the EUROSTAT.

weight as the dependent variable show a decrease in the prevalence according to the increase of TCS (negative beta coefficient). However, we have only obtained statistically significant correlations in the coefficient with the public place bans score (data not shown). For the year with the most data (2010), the increase of one point in the public place bans score is estimated to produce a decrease of 1.6 for 1000 in births with low birth weight (less than 2500 g). For data from 2013, 2014, and 2015 the beta coefficient of the regression with statistically significant correlations were similar to that observed in 2010 with the beta coefficient statistically significant in preterm births with less than 37 weeks and with less than 32 weeks (data not shown).

4. Discussion

We found that, at an ecological level, several indicators of the level of tobacco control policies implemented in European countries (as the level of restrictions on smoking in public places, the level of advertising bans, the price or the level of public information campaigns) are inversely related to perinatal outcomes, particularly preterm births. This is the first study to investigate this important pediatric outcome across European countries, as previous studies were conducted only in a single country. The results of this study are consistent with previous individual studies that assessed the impact of smoke-free legislation in perinatal outcomes (Mackay et al., 2012; Fantuzzi et al., 2007; Crane et al., 2011; Jaakkola et al., 2001; Cox et al., 2013; Been et al., 2014; Faber et al., 2017; Vicedo-Cabrera et al., 2016; Bakolis et al., 2016; Simón et al., 2017; El-Mohandes et al., 2010; Bharadwaj et al., 2012).

A published study conducted in Switzerland showed a dose-response relationship between the level of smoking bans and preterm births, with a decline in early-term births (infants born at 37 and 38 weeks of gestation) (Vicedo-Cabrera et al., 2016). A meta-analysis of 11 studies (Been et al., 2014) assessed the impact of smoke-free legislation on perinatal and child health, finding that preterm births and hospital attendance for asthma decreased substantially after implementation of smoke-free legislation. Recently the same working group has updated the meta-analysis (Faber et al., 2017) including 35 studies to examine the effect of smoke-free legislation on perinatal and child health; this study shows that the implementation of smoke-free legislation is associated with significant reductions in the rates of preterm births (Faber et al., 2017). Another meta-analysis (Shah and Bracken, 2000) quantified the relationship between smoking during pregnancy and preterm delivery, finding a positive association between these two factors and a consistent dose-response relationship. The results of our study are in line with the aforementioned meta-analyses: we found a negative correlation between TCS and preterm births, particularly with smoking restriction in public and workplaces.

It is important to highlight the findings of the most recent Cochrane review (published in February 2016), which showed inconclusive results for the effect of legislative smoking bans on reducing preterm births and low birth weight (Frazer et al., 2016). In our study, although we found correlations between TCS and the prevalence of low birth weight, these were only statistically significant with the prevalence of birth weight less than 2500 g in 2010. For this reason, more studies are needed to confirm the real impact of tobacco control policies in perinatal outcomes. Furthermore, it would be highly recommended to analyse the impact of TCS in perinatal outcomes in countries all over the world because the TCS quantify the implementation of tobacco control policies at country level based on 6 policies described by the World Bank (Joossens and Raw, 2011, 2014, 2006). However, the TCS is the result of a survey of tobacco activity carried out in European countries and the survey was distributed through the correspondents of European Network for Smoking and Tobacco Prevention (ENSP) who had agreed to fill in their country data (European Cancer Leagues and Institut Català d'Oncologia, 2017).

Our results are consistent with other studies that have found that smoking bans are associated with reductions in the risk of preterm birth (Mackay et al., 2012; Cox et al., 2013; Bakolis et al., 2016; Simón et al., 2017; Bharadwaj et al., 2012). Specifically, we found that the prevalence of preterm births (before 37 weeks and 32 weeks) decreases with a higher TCS in public place smoking bans. Our hypothesis with the correlations for preterm births is that a larger sample size in 2013, 2014 and 2015 would show similar results. However, we did not find associations. A study conducted in Belgium reported similar results: the rate of preterm births in that country decreased after the implementation of various types of smoking bans, in particular workplace smoking prohibitions but also, to a lesser extent, smoking bans in restaurants and bars serving food (Cox et al., 2013). Following this trend, two studies have recently been published showing in two different European countries a decline in the rates of preterm and low birth weight after the introduction of smoking legislation (Bakolis et al., 2016; Simón et al., 2017). Smoking restrictions in public and workplaces, without assigning less importance to the other five policies from TCS, are especially relevant in this case, because it is a direct way of reducing SHS exposure in pregnant women and their children, reducing the risk of preterm delivery.

We observed a negative correlation between TCS and the prevalence of low birth weight in 2010, and between the level of restriction of smoking in public places and low birth weight in the same year. Although results were only statistically significant for the year 2010, other studies have found a significant association between these variables. Our hypothesis, as for preterm births, is that a larger sample size in 2013, 2014 and 2015 would show similar results, however, we have not been able to demonstrate it. A study carried out in Norway in 2004 found that the extension of smoking restrictions to bars and restaurants had a large effect on birth weight (Bharadwaj et al., 2012). Similarly, when legislation was introduced in Scotland in 2006 to prohibit smoking in public spaces, this resulted in a statistically significant reduction in low birth weight (Mackay et al., 2012). In addition, other studies have reported a statistically significant reduction in the incidence of small for gestational age births after the introduction of anti-smoking policies (Mackay et al., 2012; Kabir et al., 2013).

We have chosen to focus our study on preterm births because this is the second leading cause of death in children under age 5 and prematurity also increases the risk of death due to other causes (Blencowe et al., 2012; Liu et al., 2012). Although the proportion of deaths due to preterm birth is reported to be lower in low-income countries than in high-income countries, the cause-specific rates are much higher in low- and middle-income countries than in high-income countries (high gross domestic product (GDP) per capita), resulting in a major survival gap for preterm depending on which country they are born in. Most preterm infants from 28 to 32 weeks need special care at birth, and in cases of preterm infants with less than 28 weeks of age they need a neonatal intensive care unit (NICU) to survive and adequate NICUs are not available in many low- or middle-income countries. In this sense, we observed negative correlation among countries with high GPD per capita or HDI, with a higher correlation among the countries with a GPD per capita or HDI over the median (data not shown).

The main limitation of our study is the ecological design, which does not allow us to extrapolate the associations found at the country level to individuals. Similarly, the study design does not permit adjustments for potential individual confounders such as the age of the mother, the smoking status during the pregnancy of the mother and other family members, the socioeconomic status of the family, or the use of assisted reproductive technology. These variables could be a confounder or mediates between tobacco control policies and perinatal outcomes. Nevertheless, our results are in line with previous studies conducted at the individual level (Mackay et al., 2012; Cox et al., 2013; Vicedo-Cabrera et al., 2016; Bharadwaj et al., 2012; Kabir et al., 2013). Another potential limitation is the 2013, 2014 and 2015 prevalence data for preterm births and birth weights provided by Eurostat are only available for a limited number of countries. For this reason, the statistical power in the estimations of correlation significance could be

low. In addition, the data of the EPHR are from 2010 because there are no more updated published data. However, the correlations between TCS and prevalence in the countries with available data for 2013, 2014 and 2015 are consistent with the comparison conducted using data from 2010, which included a much greater number of countries. An important strength of this study is that we performed three comparisons of two different TCS for four different years. This is a strength because we found consistent results in terms of the observed correlations. Moreover, the time interval between the TCS (2013 data) and the Eurostat data (2014 and 2015) provides an optimal time frame (1 year and 2 years respectively) to observe the potential effects of tobacco control policies on preterm and weight to birth.

Preterm births, even late preterm, are associated with clinical complications (Raju, 2012). Moreover, preterm births can have lifelong effects on children and, consequently, a high economic cost for governments (Blencowe et al., 2012; Liu et al., 2012). For many years, a variety of preventive measures have been implemented to reduce the prevalence of prematurity; unfortunately, these efforts have been largely unsuccessful (Blencowe et al., 2012; Liu et al., 2012). The implementation of smoke-free laws, as our data show, has the potential to yield considerable public health benefits. In conclusion, our study shows that the level of smoke-free legislation among European countries is correlated with a decrease in the prevalence of preterm birth at the ecological level. These findings suggest greater implementation of tobacco control policies with European countries and worldwide.

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Contributors' statements

Jose M. Martínez-Sanchez: conceptualized and designed the study, coordinated and supervised data collection, critically reviewed the manuscript, and approved the final manuscript as submitted. He is the principal investigator.

Ana Díez-Izquierdo: collected the data and prepared the database, drafted the initial manuscript and approved the final manuscript as submitted.

Cristina Lidón-Moyano: analyzed the data and critically reviewed the manuscript, and approved the final manuscript as submitted.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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