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Secondhand Smoke Exposure and Other Signs of Tobacco Consumption at Outdoor Entrances of Primary Schools in Eleven European Countries

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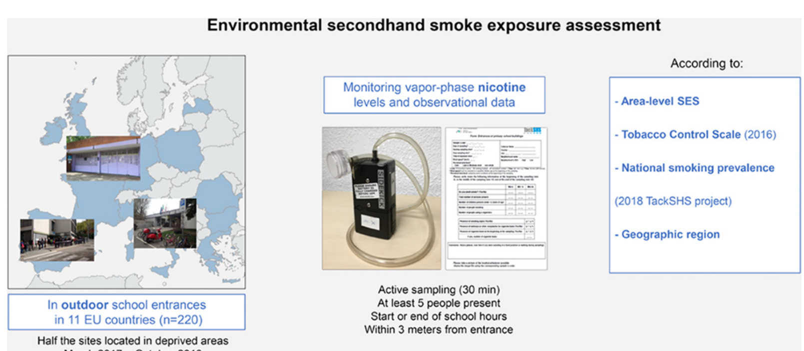
HIGHLIGHTS

- We monitored nicotine and tobacco signs in outdoor school entrances across EU.
- 46% of the entrances had SHS presence, 43% had smokers, and 75% cigarette butts.
- SHS exposure was higher in countries with lower scores on the TCS.
- SHS exposure varied according to the national smoking prevalence and EU region.
- Smokers were found more frequently at school entrances in areas with lower SES.

GRAPHICAL ABSTRACT



Abbreviations: SHS, secondhand smoke; SES, socioeconomic status; TCS, Tobacco Control Scale; IQR, Interquartile range; LOQ, limit of quantification; UN, United Nations.

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A B S T R A C T

Introduction: Although smoking restrictions at child-related settings are progressively being adopted, school outdoor entrances are neglected in most smoke-free policies across Europe.
Objectives: To describe secondhand smoke (SHS) exposure and tobacco-related signs in outdoor entrances of primary schools in Europe according to area-level socioeconomic status (SES), smoke-free policy, national smoking prevalence, and geographical region.
Methods: In this cross-sectional study we monitored vapor-phase nicotine concentrations at 220 school outdoor entrances in 11 European countries (March 2017–October 2018). To account for nicotine presence, we used the laboratory's limit of quantification of 0.06 μg/m^3 as point threshold. We also recorded the presence of smell of smoke, people smoking, cigarette butts, and ashtrays. Half of the schools were in deprived areas. We grouped countries according to their Tobacco Control Scale (TCS) score, smoking prevalence (2017–2018), and United Nations M49 geographical region.
Results: There were detectable levels of nicotine in 45.9% of the outdoor entrances, in 29.1% smell of smoke, in 43.2% people smoking, in 75.0% discarded butts, and in 14.6% ashtrays. Median nicotine concentration was below the laboratory's limit of quantification <0.06 μg/m^3 (Interquartile range:<0.06–0.119). We found higher SHS levels in countries with lower TCS scores, higher national smoking prevalence, and in the Southern and Eastern European regions. People smoking were more common in schools from lower area-level SES and in countries with lower TCS scores ($p<0.05$).
Conclusions: Smoking at school outdoor entrances is a source of SHS exposure in Europe. These findings support the extension of smoking bans with a clear perimeter to the outdoor entrances of schools.

1. Introduction

Secondhand tobacco smoke (SHS) exposure is a major public health hazard. SHS has been cataloged as a human carcinogen, which is composed of a large number of known carcinogens, teratogens, irritants, toxicants, and mutagens (IARC, 2004). Inhaling SHS has been proven to cause cancer, cardiovascular and respiratory disease in nonsmoking adults and to increase the risk for middle ear infections and respiratory disorders, among others, in children (U.S. Department of Health and Human Services, 2006; Carreras et al., 2018).

Previous studies have shown that SHS exposure at outdoor locations can be considerable and on some occasions close to the levels of indoor SHS concentrations (CARB California Air Resources Board, 2005; Sureda et al., 2013). A few studies have measured SHS exposure at the outdoor entrances of public buildings (Kaufman et al., 2011; Sureda et al., 2012). Kaufman et al. (2011) found outdoor respirable particulate matter ($PM_{2.5}$ μm or less) concentrations to be significantly higher than background levels when smoking took place, and $PM_{2.5}$ levels to be increasing with the number of active cigarettes. Sureda et al. (2012) simultaneously measured $PM_{2.5}$ concentrations around outdoor entrances and the immediate indoor halls of public administration buildings, libraries, educational venues, public transport buildings, and healthcare centers. When smoking was present at outdoor entrances, $PM_{2.5}$ levels in indoor halls were comparable to $PM_{2.5}$ concentrations outdoors, suggesting that SHS drifts from outdoor entrances to adjacent indoor spaces where smoking inside is forbidden.

Outdoor school entrances might be as relevant as school grounds in the implementation and promotion of healthy lifestyles (Moncada et al., 2011). Schools, and thereby, outdoor school entrances are locations dedicated to children, for whom attendance is compulsory. Tobacco presence in outdoor entrances beyond the school grounds can pose direct and indirect health risks for children. Outdoor school entrances tend to be crowded delimited areas with high presence of children during school starting and ending hours. Although exposure periods at school entrances are usually transient, children might be exposed daily over the school years, facing short but cumulative exposures to SHS, as it has been suggested for this type of location (Kaufman et al., 2010, 2011). Also, children observing smoking at school entrances are exposed to pro-smoking cues within a learning environment, which might influence their attitudes and beliefs regarding tobacco use. For instance, reporting encountering teachers smoking at outdoor school premises predicted adolescent daily smoking and heavy smoking behavior (Poulsen et al., 2002). Moreover, the existence of smoking restrictions at school influenced adolescents' support for smoke-free policies in other public places, beyond their smoking status or their expectations to smoke (Lazuras et al., 2011).

Children's physiological characteristics (i.e., higher breathing rates, immature immune and respiratory systems) increase their risk of harm from environmental exposures (Öberg et al., 2010). Besides, children are particularly vulnerable to SHS exposure, as they lack control over their social and physical environment (US Environmental Protection Agency, 1992). Although progress has been made over time, SHS exposure at an early age remains an unresolved public health problem with evident social inequalities (Moore et al., 2012; Jarvis and Feyerabend, 2015; Kuntz and Lampert, 2016). Lower parental socioeconomic status (SES) has been related to higher children's SHS exposure, measured using both biomarkers (Moore et al., 2012; Jarvis and Feyerabend, 2015; Aurrekoetxea et al., 2016) and surveys (Kuntz and Lampert, 2016; López et al., 2018). Moreover, parental smoking behavior is more prevalent among lower SES groups (Moore et al., 2012; Aurrekoetxea et al., 2016; Kuntz and Lampert, 2016).

The outdoor area at school entrances is often "on-street" or other public space and is thus rarely considered part of school premises in terms of smoke-free policies and rules. When enacting smoking bans at educational venues, these spaces are not regulated or regulation in Europe is ambiguous, not establishing a clear perimeter where smoking is banned. SHS levels at outdoor school entrances have never been measured at a European level with an environmental marker and, as far as we know, no previous study has assessed potential country-specific differences in SHS exposure at this setting. For these reasons, we sought to describe SHS levels and tobacco-related signs in outdoor entrances of schools in 11 European countries according to area-level SES, smoke-free policy, national smoking prevalence (2017–2018), and geographical region.

2. Methods

2.1. Study design

This was a cross-sectional study within the Horizon 2020 funded project TackSHS (Fernández et al., 2020). We monitored vapor-phase nicotine, as an objective and specific environmental marker of SHS exposure, at entrances of primary school buildings in 11 European countries. We selected densely populated urban areas in Bulgaria (Sofia), France (Paris), Germany (Mannheim, Heidelberg), Greece (Aigaleo, Alimos, Athens, Glyfada, Kifisia), Ireland (Dublin), Italy (Milano, Varese), Poland (Warsaw), Portugal (Braga), Romania (Bucharest), Spain (Barcelona), and the United Kingdom (Edinburgh) to conduct an environmental SHS exposure assessment. On-site nicotine levels were assessed in a convenience sample of 20 different school entrances per country, a total of 220 measurements, from March 2017 to October 2018. This study was designed to evaluate SHS exposure according to SES, for this reason, half of the schools visited were located in the most deprived neighborhoods (below the 20th percentile of the local SES distribution) and the other half in the most affluent neighborhoods (above the 80th percentile of the local SES distribution). Neighborhood SES was established using ecological synthetic deprivation indexes in each city (Stadt Mannheim, 2009; Caranci et al., 2010; Stadt Heidelberg, 2011; Scottish Government, 2016; Pobal Deprivation Index, 2017; Ribeiro et al., 2017; Ajuntament de Barcelona, 2017). When synthetic indexes were not available, this was the case for Bulgaria, France, Greece, Poland, and Romania, other socio-economic indicators were used, such as the cost of housing by square meter or the rate of poverty by district, among others. Nicotine measurements were conducted exclusively when there was a minimum of five people (adults and/or children) present at the school entrance at the beginning of the measurement. Fieldwork took place during weekdays and before the start or after the end of school hours, in the pursuit of gathering the maximum number of people at school entrances.

2.2. Airborne nicotine measurements

We used portable samplers that specifically collected airborne nicotine. The samplers consisted of a 37-mm diameter plastic cassette containing a filter treated with sodium bisulfate. We connected the plastic cassettes to air pumps (Sidekick, SKC Ltd., Dorset, UK) to control the volume of air actively passing through the filter. The airflow rate was set at 3 l/min and air pumps were calibrated, before and after taking nicotine measurements, with calibrator Defender 510M (Mesa Labs, Lakewood, CO, USA). We took nicotine measurements for 30 min and at a maximum distance of three meters from the school main entryway. This technique for outdoor airborne nicotine sampling has already been described in the literature (Hammond et al., 1987) and used in previous research (Fu et al., 2016; Sureda et al., 2018). To avoid drawing attention and altering the behavior of those present at the setting, we kept the air pumps hidden in backpacks. To prevent filter contamination, sampler assembly and filter removal were done in a tobacco-free environment. Nicotine filters were analyzed in the Agència de Salut Pública de Barcelona laboratory. Nicotine concentrations were determined by mass-spectrometry gas-chromatography. Along with the 20 filters sampled, every country sent additional blank filters to determine blank-corrected nicotine concentrations. For every 20 nicotine samples, one blank filter that had not been exposed and a fortified sample used as quality control were analyzed. To quantify the time-weighted average nicotine concentration (in $\mu g/m^3$), the amount of nicotine extracted from each filter was divided by the volume of air sampled (estimated flow rate times the minutes the filter had been exposed). Nicotine concentration was assessed as a continuous variable. To account for nicotine presence, we used the laboratory's limit of quantification (LOQ) of 0.06 $\mu g/m^3$ as a reference.

2.3. Observational data

During sampling, a form was also filled out by researchers. We recorded the presence of smell of tobacco smoke and ashtrays or similar receptacles, and the number of people smoking and discarded cigarette butts at school entrances (López et al., 2012a; López et al., 2012b). This information was noted at a form over the course of every measurement session at the beginning of sampling, after 15 min, and at the end (30 min). We considered there was smell of smoke or people smoking when we noticed any of these tobacco-related variables in at least one of the three time points. All researchers were trained before fieldwork by the coordinating center, and guidance was provided in a sampling protocol.

2.4. Contextual variables

Data from different sources were used to group the countries in our study. According to the United Nation's geographical regions (M49) for Europe (United Nations, 1999), the countries were classified into four regions: Northern Europe, Southern Europe, Western Europe, and Eastern Europe. We also grouped countries based on their overall score in the 2016 Tobacco Control Scale (TCS), a ranking on tobacco control activity across 35 European countries. The TCS is based on a scoring system, with up to 100 points, that measures the adoption at a national level of six tobacco control policies: price (30 points), smoke-free public places (22 points), spending in public information campaigns (15 points), comprehensive advertising bans (13 points), health warnings (10 points), and cessation support (10 points) (Joossens and Raw, 2016). In line with the TCS report, countries with less than half the overall score were allocated in one group and countries with 50 or more points in another. We also assessed the national smoking prevalence in each country, which was obtained from a different study conducted within the framework of the TackSHS project (Fernández et al., 2020; Gallus et al., 2020). The national smoking prevalence was estimated through a face-to-face survey in a representative sample aged 15 years and above during 2017–2018. Participants were considered smokers if they reported smoking at the time and had smoked at least 100 cigarettes, including hand-rolled cigarettes. A median smoking prevalence among the 11 countries in this study was calculated. Countries were grouped into two categories: those with smoking prevalence above/equal to the median or below the median.

2.5. Statistical analyses

Our data on nicotine concentrations were left bounded by the laboratory's LOQ. Samples with concentrations below the LOQ of 0.06 $\mu g/m^3$ were assigned half of this value. We provided the median and interquartile range (IQR) to describe nicotine concentration overall and by country, SES, geographical region, smoke-free policies, national smoking prevalence, and tobacco-related observational variables. Nicotine concentrations were compared using non-parametric Mann-Whitney U or Kruskal Wallis tests, as appropriate. We used raw frequencies and percentages to describe nicotine presence and tobacco-related observational data overall and by country, SES, geographical regions, smoke-free policies, and smoking prevalence. Differences in nicotine presence and tobacco-related observational variables were assessed using the Chi-squared test. All analyses were performed with the statistical package Stata 15.

2.6. Ethical issues

The TackSHS project was approved by the Clinical Research Ethics Committee of the Bellvitge University Hospital (PR341/15) and this study was approved by each country's local Ethics Committees. The study protocol was registered in ClinicalTrials.gov (ID: NCT03150186).

3. Results

Table 1 displays the median airborne nicotine concentration and nicotine presence from 220 school outdoor entrances in 11 European countries. In total, median nicotine concentrations did not exceed the laboratory's LOQ of 0.06 $\mu g/m^3$, while nicotine presence was found in 45.9% of the sites visited. Among countries, Romania (0.831 $\mu g/m^3$ IQR: 0.262–2.464), Bulgaria (0.178 $\mu g/m^3$ IQR: $<$0.06–0.346), Greece (0.118 $\mu g/m^3$ IQR: 0.077–0.200) and Italy (0.068 $\mu g/m^3$ IQR:

Table 1
Airborne nicotine concentration (μg/m^3) in outdoor entrances of primary school buildings by country (2017–2018). TackSHS project.

Country	N	Median (μg/m^3) (IQR)	Min (μg/m^3)	Max (μg/m^3)	% nicotine presence (n)
All	220	<0.06 (<0.06 to 0.119)	<0.06	5.197	45.9 (101)
Bulgaria	20	0.178 (<0.06 to 0.346)	<0.06	1.442	75.0 (15)
France	20	<0.06 (<0.06 to <0.06)	<0.06	0.440	20.0 (4)
Germany	20	<0.06 (<0.06 to <0.06)	<0.06	0.176	20.0 (4)
Greece	20	0.118 (0.077 to 0.200)	<0.06	0.622	80.0 (16)
Ireland	20	<0.06 (<0.06 to <0.06)	<0.06	1.419	20.0 (4)
Italy	20	0.068 (<0.06 to 0.139)	<0.06	2.125	70.0 (14)
Poland	20	<0.06 (<0.06 to <0.06)	<0.06	0.194	20.0 (4)
Portugal	20	<0.06 (<0.06 to 0.115)	<0.06	1.436	50.0 (10)
Romania	20	0.831 (0.262 to 2.464)	<0.06	5.197	95.0 (19)
Spain	20	<0.06 (<0.06 to 0.097)	<0.06	0.188	50.0 (10)
UK	20	<0.06 (<0.06 to <0.06)	<0.06	0.081	5.0 (1)

Note: IQR, interquartile range. Limit of quantification (LOQ): 0.06 μg/m^3.

<0.06–0.139) had the highest median nicotine concentrations. Most school outdoor entrances in these countries had detectable levels of nicotine (Romania 95%, Greece 80%, Bulgaria 75%, and Italy 70%).

Across all countries, we noticed people smoking in slightly over 40% of the school entrances. The majority of the sites in Italy (80%) and Bulgaria (70%) had people smoking. There was smell of smoke in three out of ten entrances and discarded cigarette butts in three-quarters of the school entrances. We found ashtrays or other receptacles in 15% of the sites. Only in Italy more than half of the school entrances had ashtrays or other receptacles (60%) (Table 2).

Table 3 provides the median nicotine concentrations and nicotine presence in primary school outdoor entrances according to contextual factors. Nicotine levels were highest in the Eastern (0.104 μg/m^3 IQR: <0.06–0.625) and Southern (0.073 μg/m^3 IQR: <0.06–0.126) European regions; in countries scoring less than 50 points in the 2016 version of the TCS (0.092 μg/m^3 IQR: <0.06–0.199); and countries with higher smoking prevalence (0.085 μg/m^3 IQR: <0.06–0.251) ($p<0.05$). Similarly, nicotine presence was more common in the Eastern (63.3%) and Southern (62.5%) European regions, in countries with lower TCS total scores (58.3%), and countries with higher smoking prevalence (61.7%) ($p<0.05$).

People smoking were more often found in entrances of schools located in areas of lower SES (52.5%) ($p<0.05$). Moreover, countries with less than half of the score in the TCS had a greater presence of smell of tobacco smoke (48.3%) and people smoking (58.3%) than countries with scores equal and over 50 points (21.9% and 37.5%, respectively) ($p<0.05$) (Table 4).

Table 5 compares median nicotine concentrations and nicotine presence in school outdoor entrances with and without different signs of tobacco consumption. We found higher nicotine concentrations in school entrances when there was smell of smoke (0.113 μg/m^3 IQR: <0.06–0.312), people smoking (0.083 μg/m^3 IQR: <0.06–0.302), and discarded cigarette butts (0.063 μg/m^3 IQR: <0.06–0.139). In these cases, nicotine presence was also higher: smell of smoke (70.3% vs 35.9%); people smoking (64.2% vs. 32.0%) and discarded cigarette butts (51.5% vs. 29.1%) ($p<0.05$).

Table 2
Tobacco-related variables in outdoor entrances of primary school buildings by country (2017–2018). TackSHS project.

Country	N	Smell of smoke % (n)	People smoking % (n)	Cigarette butts % (n)	Ashtrays % (n)
All	220	29.1 (64)	43.2 (95)	75.0 (165)	14.6 (32)
Bulgaria	20	75.0 (15)	70.0 (14)	100.0 (20)	10.0 (2)
France	20	10.0 (2)	20.0 (4)	25.0 (5)	0.0 (0)
Germany	20	30.0 (6)	45.0 (9)	80.0 (16)	30.0 (6)
Greece	20	40.0 (8)	60.0 (12)	85.0 (17)	0.0 (0)
Ireland	20	25.0 (5)	35.0 (7)	60.0 (12)	0.0 (0)
Italy	20	55.0 (11)	80.0 (16)	80.0 (16)	60.0 (12)
Poland	20	0.0 (0)	10.0 (2)	35.0 (7)	40.0 (8)
Portugal	20	25.0 (5)	25.0 (5)	100.0 (20)	5.0 (1)
Romania	20	40.0 (8)	65.0 (13)	75.0 (15)	0.0 (0)
Spain	20	10.0 (2)	35.0 (7)	100.0 (20)	0.0 (0)
UK	20	10.0 (2)	30.0 (6)	85.0 (17)	15.0 (3)

4. Discussion

We performed for the first time SHS exposure measurements in outdoor entrances of primary school buildings in several European countries, where children's school attendance is mandatory. Overall, the median airborne nicotine levels encountered were below the laboratory's LOQ. Nevertheless, our results provide evidence of SHS exposure and visible smoking activities in nearly half the school outdoor entrances. We found nicotine presence in a higher proportion of school entrances in countries with lower tobacco control activity, higher national smoking prevalence, and in the Southern and Eastern European regions. In these cases, median nicotine concentrations were also higher. People were more frequently observed smoking at primary school entrances in lower socioeconomic contexts and in countries with a lesser extent of tobacco control policies.

Following indoor smoking bans being enacted in many jurisdictions in Europe, people who smoke now do so in outdoor settings such as buildings' doorways. These locations appear to smokers as convenient spots to light up, which give shelter from weather, and where smoking plays a role in socializing (Kaufman et al., 2010). Entrance areas are important elements of our built environment and, in the case of schools, are part of the children's learning environment: offering important social interactions at the start and end of the school day. Earlier studies have already identified outdoor entrances as relevant spaces in the furtherance of smoke-free environments. Evidence points toward the need for smoking bans in these settings to further denormalize smoking behaviors and to fully comply with Article 8 in the WHO-FCTC (Kaufman et al., 2010, 2011; Moncada et al., 2011; Sureda et al., 2010, 2012). In fact, outdoor entrances, which can also be partially enclosed, have been described as critical locations in terms of SHS exposure (Sureda et al., 2012). However, to our knowledge, no study has measured SHS exposure in school main outdoor entrances, a setting with the potential to reach a large number of minors.

School entrances should serve as more than acoustic or thermal buffer zones. In almost half the school outdoor entrances, we have found SHS presence within three meters from the entryway. Several studies assessing SHS exposure outside different building entrances (Sureda et al., 2012, 2010) but also in outdoor areas of hospitality venues (Wilson et al., 2011; López et al., 2012a; Fu et al., 2016) concur SHS concentrations outdoors migrate to adjacent indoor spaces. Most of these indoor areas are already covered by smoke-free laws since there is accumulated proof that SHS lingers and causes negative health effects (U.S. Department of Health and Human Services, 2006).

Table 3
Airborne nicotine concentration (μg/m^3) in outdoor entrances of primary school buildings by area-level socioeconomic status, Tobacco Control Scale overall score, national smoking prevalence, and the United Nation's M49 regions (2017–2018). TackSHS project.

Contextual factors	N	Median (μg/m^3) (IQR)	p-Value[a]	Min (μg/m^3)	Max (μg/m^3)	% nicotine presence (n)	p-Value[b]
SES							
High	102	0.064 (<0.06 to 0.154)	0.195	<0.06	5.197	52.0 (53)	0.094
Low	118	<0.06 (<0.06 to 0.109)		<0.06	3.361	40.7 (48)	
TCS overall score (2016)[c]							
≥50	160	<0.06 (<0.06 to 0.090)	0.015	<0.06	5.197	41.3 (66)	0.024
<50	60	0.092 (<0.06 to 0.199)		<0.06	1.442	58.3 (35)	
Smoking prevalence (2017–18)[d]							
<31%	100	<0.06 (<0.06 to 0.064)	<0.0001	<0.06	2.125	27.0 (27)	<0.0001
≥31%	120	0.085 (<0.06 to 0.251)		<0.06	5.197	61.7 (74)	
UN M49 regions[e]							
Northern	40	<0.06 (<0.06 to <0.06)	0.0001	<0.06	1.419	12.5 (5)	<0.0001
Southern	80	0.073 (<0.06 to 0.126)		<0.06	2.125	62.5 (50)	
Western	40	<0.06 (<0.06 to <0.06)		<0.06	0.440	20.0 (8)	
Eastern	60	0.104 (<0.06 to 0.625)		<0.06	5.196	63.3 (38)	

Note: SES, socioeconomic status; TCS, Tobacco Control Scale; UN; United Nations; IQR, Interquartile range. Limit of quantification (LOQ): 0.06 μg/m^3.
[a] Mann-Whitney U or Kruskal-Wallis test.
[b] Chi-squared test.
[c] TCS overall score: ≥50 (France, Italy, Ireland, Poland, Portugal, Romania, Spain, UK); <50 (Bulgaria, Germany, Greece).
[d] Based on a European survey conducted in the TackSHS project. Smoking prevalence (median): <31% (Germany, Ireland, Italy, Poland, UK); ≥31% (Bulgaria, France, Greece, Portugal, Romania, Spain).
[e] United Nation's regions: Northern (Ireland, UK); Southern (Greece, Italy, Portugal, Spain); Western (France, Germany); Eastern (Bulgaria, Poland, Romania).

Any exposure to SHS does not come without risk (U.S. Department of Health and Human Services, 2006) and children are considered a vulnerable population to the effects of SHS (Öberg et al., 2010). While SHS exposure could be avoided in outdoor settings, there is no other way around entering a building than through its entrance. According to our results, overall median nicotine levels at the outdoor entrances were below the LOQ, an outcome that could be explained by the type of venue we were targeting (outdoor child-related settings). However, more than half the schools in Romania, Greece, Bulgaria, and Italy had SHS presence and, particularly in schools in Romania, median SHS levels were comparable to those found at smokers' homes (Arechavala et al., 2018).

Table 4
Tobacco-related variables in outdoor entrances of primary school buildings by area-level socioeconomic status, Tobacco Control Scale overall score, national smoking prevalence, and the United Nation's M49 regions (2017–2018). TackSHS project.

Contextual factors	N	Smell of smoke % (n)	People smoking % (n)	Cigarette butts % (n)	Ashtrays % (n)
SES					
High	102	24.5 (25)	32.4 (33)	72.6 (74)	12.8 (13)
Low	118	33.1 (39)	52.5 (62)	77.1 (91)	16.1 (19)
p-Value[a]		0.164	0.003	0.435	0.481
TCS overall score (2016)[b]					
≥50	160	21.9 (35)	37.5 (60)	70.0 (112)	15.0 (24)
<50	60	48.3 (29)	58.3 (35)	88.3 (53)	13.3 (8)
p-Value[a]		<0.0001	0.005	0.005	0.755
Smoking prevalence (2017–18)[c]					
<31%	100	24.0 (24)	40.0 (40)	68.0 (68)	29.0 (29)
≥31%	120	33.3 (40)	45.8 (55)	80.8 (97)	2.5 (3)
p-Value[a]		0.129	0.384	0.029	<0.0001
UN M49 regions[d]					
Northern	40	17.5 (7)	32.5 (13)	72.5 (29)	7.5 (3)
Southern	80	32.5 (26)	50.0 (40)	91.3 (73)	16.3 (13)
Western	40	20.0 (8)	32.5 (13)	52.5 (21)	15.0 (6)
Eastern	60	38.3 (23)	48.3 (29)	70.0 (42)	16.7 (10)
p-Value[a]		0.067	0.117	<0.0001	0.571

Note: SES, socioeconomic status; TCS, Tobacco Control Scale; UN, United Nations.
[a] Chi-squared test.
[b] TCS overall score: ≥50 (France, Italy, Ireland, Poland, Portugal, Romania, Spain, the UK); <50 (Bulgaria, Germany, Greece).
[c] Based on a European survey conducted in the TackSHS project. Smoking prevalence (median): <31% (Germany, Ireland, Italy, Poland, the UK) ≥31% (Bulgaria, France, Greece, Portugal, Romania, Spain).
[d] United Nation's regions: Northern (Ireland, the UK); Southern (Greece, Italy, Portugal, Spain); Western (France, Germany); Eastern (Bulgaria, Poland, Romania).

Children tend to emulate normative behaviors they observe in everyday situations (Pattemore, 2013). Our results show people were smoking in more than four out of ten school entrances, implying likely visibility of smoking in educational settings across Europe. Smoking visibility in different public places has been linked to positive beliefs toward smoking (Lagerweij et al., 2019). Moreover, smoking examples in immediate social environments, such as teachers smoking on school premises (Poulsen et al., 2002; Roohafza et al., 2014; Escario and Wilkinson, 2018), have been associated with students' smoking behaviors.

We found a higher level of smoking visibility in school entrances from lower socioeconomic areas. These results suggest children in more deprived contexts might be at greater risk of being exposed to environmental cues that convey the impression of smoking as a normative and socially desirable behavior. In September 2015, the WHO European Region issued a roadmap of actions to strengthen the implementation of the WHO FCTC by 2025. Among the report's guiding principles was the protection of children, and one of the three focus areas involved denormalizing tobacco (WHO Regional Office for Europe, 2015). Still, to further advance in lessening potential health inequalities, policy actions should target the social determinants that predispose children to tobacco-related harms, as highlighted in the Health 2020 policy framework (WHO Regional Office for Europe, 2013), the European child and adolescent health strategy 2015–2020 (WHO Regional Office for Europe, 2014), and several human right treaties (United Nations, 1948; United Nations, 1989; WHO Regional Office for Europe, 2017).

Schools located in countries with lower legislative tobacco control efforts had higher SHS exposure and considerably greater occurrence of people smoking at the outdoor entrances. These results align with previous studies that show comprehensive smoke-free policies are effective means to reduce SHS exposure (Hyland et al., 2009; Blanco-Marquizo et al., 2010; Filippidis et al., 2016) and decrease the social acceptability of smoking (Hamilton et al., 2007). Along the same lines, countries with more developed tobacco control measures have experienced over the years a decrease in the prevalence of tobacco use and

Table 5
Airborne nicotine concentrations (μg/m^3) and tobacco-related variables in outdoor entrances of primary school buildings in 11 European countries (2017–2018). TackSHS project.

Contextual factors	N	Median (μg/m^3) (IQR)	p-Value[a]	Min (μg/m^3)	Max (μg/m^3)	% nicotine presence (n)	p-Value[b]
Smell of smoke							
Yes	64	0.113 (<0.06 to 0.312)	<0.0001	<0.06	5.197	70.3 (45)	<0.0001
No	156	<0.06 (<0.06 to 0.080)		<0.06	3.361	35.9 (56)	
People smoking							
Yes	95	0.083 (<0.06 to 0.302)	<0.0001	<0.06	5.197	64.2 (61)	<0.0001
No	125	<0.06 (<0.06 to 0.075)		<0.06	3.361	32.0 (40)	
Cigarette butts							
Yes	165	0.063 (<0.06 to 0.139)	0.001	<0.06	5.197	51.5 (85)	0.004
No	55	<0.06 (<0.06 to 0.069)		<0.06	3.361	29.1 (16)	
Ashtrays							
Yes	32	<0.06 (<0.06 to 0.070)	0.156	<0.06	0.735	43.8 (14)	0.791
No	188	<0.06 (<0.06 to 0.140)		<0.06	5.197	46.3 (87)	

Note: IQR, Interquartile range. Limit of quantification (LOQ) 0.06 μg/m^3.
[a] Mann-Whitney *U* test.
[b] Chi-squared test.

an increase in the cessation rates (Feliu et al., 2019). Consistent with our findings regarding smoke-free policies, we found that countries above the median smoking prevalence had higher SHS exposure at school outdoor entrances. Similar results have been documented for indoor spaces across Europe (Filippidis et al., 2016).

We found disparities in SHS exposure according to European regions, SHS levels being higher in the Southern and Eastern regions. To date, there is a generalized lack of smoking bans for most outdoor areas in Europe (Martinez et al., 2014). Therefore, these results cannot be directly explained by the smoking restrictions adopted but could reflect the differences in the extent of coverage, the level of enforcement, or the later implementation of comprehensive smoke-free policies in countries in the Southern and Eastern regions. Both the coverage and enforcement are key policy determinants in protecting non-smokers from SHS exposure (Filippidis et al., 2016), and a higher degree might have translated into societal smoking denormalization to outdoor areas devoted to children.

School outdoor entrances have been neglected in most smoke-free policies in Europe. In Canada, Australia, or the United States several jurisdictions already legally require outdoor areas around specific buildings, like educational centers, to be smoke-free within a certain perimeter. The State of New York outlaws smoking within 100 ft (approximately 30 m) of the entrance, exit, and outdoor areas of schools (New York Public Health Law, 2017). The Government of Québec bans smoking within 9 m outside a public place where smoking indoors is forbidden (Government of Québec, 2015). This restriction also applies to the windows and air-intake ducts. A bylaw in the city of Toronto also prohibits smoking within 9 m of different buildings used by the public (Toronto City Government, 2013). In Queensland, smoking is only allowed beyond 5 m from the boundaries of different public buildings (Government of Queensland, 2016). In Victoria, smoking is prohibited within 4 m from all public entrances to childcare centers, kindergartens, preschools, or schools (Government of Victoria, 2014). A four-meter ban for pedestrian access points is now in place in New South Wales covering among other public places, childcare facilities, schools, colleges, and universities (Government of New South Wales, 2000). Therefore, European countries, as is the case in other jurisdictions, should consider banning smoking in school outdoor entrances with a clear perimeter to further prevent children and adult non-smokers to be exposed to SHS.

This study presents some limitations. Firstly, we conducted a SHS exposure assessment of a convenience sample of schools. The non-representative nature of our sample hampers the generalizability of our results to other school entrances in the same city and country but does not compromise the main objective of the study of assessing nicotine concentrations. Second, this study is based on a geographically extended but limited number of schools per country which constrains the comparability of the results among countries. Even so, we have described SHS exposure at school outdoor entrances by grouping countries into different contextual exposure determinants. Finally, we assess SHS exposure levels based on measurements taken for 30 min at a specific point in time. Still, these measurements were conducted in each country following the same protocol and at the beginning and end of schooling hours, when SHS exposure at outdoor school entrances most likely takes place.

Despite the limitations, this study is the first one to describe SHS exposure in primary school outdoor entrances in Europe. We have measured SHS levels in 11 strategically selected countries, encompassing geographical, cultural, and legislative variations in Europe, accounting for almost 80% of the European population. Following a validated method (Hammond et al., 1987), we provide SHS exposure measurements using airborne nicotine that, unlike $PM_{2.5}$ concentrations, is an objective and specific marker of SHS exposure (Apelberg et al., 2013), and considering different contextual exposure determinants.

The findings reported in this study raise concerns over SHS exposure in outdoor areas devoted to children. Our analyses confirm the need to expand smoking bans to cover school outdoor entrances. Smoking bans in outdoor entrances should be implemented stating a clear perimeter in which smoking is not allowed and forbidding the presence of ashtrays or similar tobacco receptacles, which sends confusing messages. While implementing smoking bans in school outdoor entrances, an emerging source of SHS exposure, potential socioeconomic inequalities in SHS exposure might be also better addressed.

CRediT authorship contribution statement

Elisabet Henderson: Formal analysis, Writing - original draft, Visualization. **Xavier Continente:** Conceptualization, Investigation, Validation, Writing - review & editing. **Esteve Fernández:** Investigation, Writing - review & editing. **Olena Tigova:** Investigation, Writing - review & editing. **Nuria Cortés-Francisco:** Investigation, Writing - review & editing. **Silvano Gallus:** Investigation, Writing - review & editing. **Alessandra Lugo:** Investigation, Writing - review & editing. **Sean Semple:** Investigation, Writing - review & editing. **Rachel O'Donnell:** Investigation, Writing - review & editing. **Luke Clancy:** Investigation, Writing - review & editing. **Sheila Keogan:** Investigation, Writing - review & editing. **Ario Ruprecht:** Investigation, Writing - review & editing. **Alessandro Borgini:** Investigation, Writing - review & editing. **Anna Tzortzi:** Investigation, Writing - review & editing. **Vergina K. Vyzikidou:** Investigation, Writing - review & editing. **Giuseppe Gorini:** Investigation, Writing - review & editing. **Angel López-Nicolás:** Investigation, Writing - review & editing. **Joan B. Soriano:** Investigation, Writing - review & editing. **Gergana Geshanova:** Investigation, Writing - review & editing. **Joseph Osman:** Investigation, Writing - review &

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Ajuntament de Barcelona, 2017. Distribució territorial de la Renda Familiar Disponible per càpita a Barcelona. Available from: https://ajuntament.barcelona.cat/barcelonaeconomia/sites/default/files/RFD_2017_BCN.pdf [Accessed 8 March 2017].

Apelberg, B.J., Hepp, L.M., Avila-Tang, E., Gundel, L., Hammond, S.K., Hovell, M.F., Hyland, A., Klepeis, N.E., Madsen, Madsen, 2013. Environmental monitoring of secondhand smoke exposure. Tob. Control. 22, 147–155. https://doi.org/10.1136/tobaccocontrol-2011-050301.

Arechavala, T., Continente, X., Pérez-Ríos, M., Schiaffino, A., Fernandez, E., Cortés-Francisco, N., Centrich, F., Muñoz, G., López, M.J., 2018. Second-hand smoke exposure in homes with children: assessment of airborne nicotine in the living room and children's bedroom. Tob. Control. 27, 399–406. https://doi.org/10.1136/tobaccocontrol-2017-053751.

Aurrekoetxea, J.J., Murcia, M., Rebagliato, M., Guxens, M., Fernández-Somoano, A., López, M.J., Lertxundi, A., Castilla, A.M., Espada, M., Tardón, A., Ballester, F., Santa-Marina, L., 2016. Second-hand smoke exposure in 4-year-old children in Spain: sources, associated factors and urinary cotinine. Environ. Res. 145, 116–125. https://doi.org/10.1016/j.envres.2015.11.028.

Blanco-Marquizo, A., Goja, B., Peruga, A., Jones, M.R., Yuan, J., Samet, J.M., Breysse, P.N., Navas-Acien, A., 2010. Reduction of secondhand tobacco smoke in public places following national smoke-free legislation in Uruguay. Tob. Control. 19, 231–234. https://doi.org/10.1136/tc.2009.034769.

Caranci, N., Biggeri, A., Grisotto, L., Pacelli, B., Spadea, T., Costa, G., 2010. The Italian deprivation index at census block level: definition, description and association with general mortality. Epidemiol. Prev. 34, 167–176 (Accessed 12 September 2017).

CARB (California Air Resources Board), 2005. Proposed Identification of Environmental Tobacco Smoke as a Toxic Air Contaminant. Office of Environmental Health Hazard Assessment, Sacramento, CA. Available from: https://ww3.arb.ca.gov/toxics/id/summary/etspt_a.pdf. (Accessed 19 September 2019).

Carreras, G., Lugo, A., Gallus, S., Cortini, B., Fernandez, E., Lóepz, M.J., Soriano, J.B., López-Nicolás, A., Semple, S., Gorini, G., 2018. Burden of disease attributable to second-hand smoke exposure: a systematic review. Prev. Med. 129, 105833. https://doi.org/10.1016/j.ypmed.2019.105833.

Escario, J.J., Wilkinson, A.V., 2018. Visibility of smoking among school-teachers in Spain and associations with student smoking: a cross-sectional study. BMJ Open 8. https://doi.org/10.1136/bmjopen-2017-018736 e018736.

Feliu, A., Filippidis, F.T., Joossens, L., Fong, G.T., Vardavas, C.I., Baena, A., Castellano, Y., Martínez, C., Fernández, E., 2019. Impact of tobacco control policies on smoking prevalence and quit ratios in 27 European Union countries from 2006 to 2014. Tob. Control. 28, 101–109. https://doi.org/10.1136/tobaccocontrol-2017-054119.

Fernández, E., López, M.J., Gallus, S., Semple, S., Clancy, L., Behrakis, P., Ruprecht, A., Gorini, G., López-Nicolás, Á., Radu-Loghin, C., Soriano, J.B., 2020. Tackling second-hand exposure to tobacco smoke and aerosols of electronic cigarettes: the TackSHS project protocol. Gac. Sanit. 34, 77–82. https://doi.org/10.1016/j.gaceta.2019.07.002.

Filippidis, F.T., Agaku, I.T., Girvalaki, C., Jiménez-Ruiz, C., Ward, B., Gratziou, C., Vardavas, C.I., 2016. Relationship of secondhand smoke exposure with sociodemographic factors and smoke-free legislation in the European Union. Eur. J. Pub. Health 26, 344–349. https://doi.org/10.1093/eurpub/ckv204.

Fu, M., Fernández, E., Martínez-Sánchez, J.M., San Emeterio, N., Quirós, N., Sureda, X., Ballbè, M., Muñoz, G., Riccobene, A., Centrich, F., Saltó, E., López, M.J., 2016. Second-hand smoke exposure in indoor and outdoor areas of cafés and restaurants: need for extending smoking regulation outdoors? Environ. Res. 148, 421–428. https://doi.org/10.1016/j.envres.2016.04.024.

Gallus, S., Lugo, A., Liu, X., Behrakis, P., Boffi, R., Bosetti, C., Carreras, G., Chatenoud, L., Clancy, L., Continente, X., Dobson, R., Effertz, T., Filippidis, F.T., Fu, M., Geshanova, G., Gorini, G., Keogan, S., Ivanov, H., López, M.J., López-Nicolás, A., Precioso, J., Przewozniak, K., Radu-Loghin, C., Ruprecht, A., Semple, S., Soriano, J.B., Strachenko, P., Trapero-Bertran, M., Tigova, O., Tzortzi, A.S., Vardavas, C., Vyzikidou, V.K., Colombo, P., Fernandez, E., 2020. Who smokes in Europe? Data from 12 European countries in the TackSHS survey (2017–2018). J. Epidemiol. https://doi.org/10.2188/jea.JE20190344 In press.

Government of New South Wales, 2000. Smoke-free environment act. Available from. https://www.legislation.nsw.gov.au/#/view/act/2000/69/part2/sec6a. (Accessed 12 February 2020).

Government of Québec, 2015. Tobacco control act. Chapter L-6.2. Available from. http://legisquebec.gouv.qc.ca/en/pdf/cs/L-6.2.pdf. (Accessed 19 February 2020).

Government of Queensland, 2016. Tobacco and other smoking products (smoke-free places) amendment act 2016. Available from. https://www.legislation.qld.gov.au/view/html/asmade/act-2016-006. (Accessed 17 February 2020).

Government of Victoria, 2014. Tobacco act 1987. Sect 5RD. Available from. http://classic.austlii.edu.au/au/legis/vic/consol_act/ta198773/s5rd.html. (Accessed 17 February 2020).

Hamilton, W.L., Biener, L., Brennan, R.T., 2007. Do local tobacco regulations influence perceived smoking norms? Evidence from adult and youth surveys in Massachusetts. Health Educ. Res. 23, 709–722. https://doi.org/10.1093/her/cym054.

Hammond, S.K., Leaderer, B.P., Roche, A.C., Schenker, M., 1987. Collection and analysis of nicotine as a marker for environmental tobacco smoke. Atmos. Environ. 21, 457–462. https://doi.org/10.1016/0004-6981(87)90027-8.

Hyland, A., Hassan, L.M., Higbee, C., Boudreau, C., Fong, G.T., Borland, R., Cummings, K.M., Yan, M., Thompson, M.E., Hastings, G., 2009. The impact of smokefree legislation in Scotland: results from the Scottish ITC Scotland/UK longitudinal surveys. Eur. J. Pub. Health 19, 198–205. https://doi.org/10.1093/eurpub/ckn141.

IARC (International Agency for Research on Cancer), 2004. Tobacco smoke and involuntary smoking. In: IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. 83, pp. 1–1438 Available from: https://publications.iarc.fr/Book-And-

Report-Series/Iarc-Monographs-On-The-Identification-Of-Carcinogenic-Hazards-To-Humans/Tobacco-Smoke-And-Involuntary-Smoking-2004 (Accessed 19 September 2019).

Jarvis, M.J., Feyerabend, C., 2015. Recent trends in children's exposure to second-hand smoke in England: cotinine evidence from the health survey for England. Addiction 110, 1484–1492. https://doi.org/10.1111/add.12962.

Joossens, L., Raw, M., 2016. The Tobacco Control Scale 2016 in Europe. Avaliable: https://www.tobaccocontrolscale.org/2016-edition/ [Accessed 19 June 2019].

Kaufman, P., Griffin, K., Cohen, J., Perkins, N., Ferrence, R., 2010. Smoking in urban outdoor public places: behaviour, experiences, and implications for public health. Health Place 16, 961–968. https://doi.org/10.1016/j.healthplace.2010.05.012.

Kaufman, P., Zhang, B., Bondy, S.J., Klepeis, N., Ferrence, R., 2011. Not just "a few wisps": real-time measurement of tobacco smoke at entrances to office buildings. Tob. Control. 20, 212–218. https://doi.org/10.1136/tc.2010.041277.

Kuntz, B., Lampert, T., 2016. Social disparities in parental smoking and young children's exposure to secondhand smoke at home: a time-trend analysis of repeated cross-sectional data from the German KiGGS study between 2003-2006 and 2009-2012. BMC Public Health 16, 485. https://doi.org/10.1186/s12889-016-3175-x.

Lagerweij, N.A., Kuipers, M.A.G., Schreuders, M., Grard, A., Mlinarić, M., Richter, M., Leão, T., Kinnunen, J.M., Kunst, A.E., 2019. The visibility of smoking in Europe and its relationship with youth's positive beliefs about smoking. Int. J. Public Health 64, 1335–1344. https://doi.org/10.1007/s00038-019-01288-z.

Lazuras, L., Rodafinos, A., Eiser, J.R., 2011. Adolescents' support for smoke-free public settings: the roles of social norms and beliefs about exposure to secondhand smoke. J. Adolesc. Health 49, 70–75. https://doi.org/10.1016/j.jadohealth.2010.10.013.

López, M.J., Fernández, E., Gorini, G., Moshammer, H., Polanska, K., Clancy, L., Dautzenberg, B., Delrieu, A., Invernizzi, G., Muñoz, G., Precioso, J., Ruprecht, A., Stansty, P., Hanke, W., Nebot, M., 2012a. (a). Exposure to secondhand smoke in terraces and other outdoor areas of hospitality venues in eight European countries. PLoS One 7 (8). https://doi.org/10.1371/journal.pone.0042130 e42130.

López, M.J., Nebot, M., Schiaffino, A., Pérez-Ríos, M., Fu, M., Ariza, C., Muñoz, G., Fernández, E., 2012b. (b). Two-year impact of the Spanish smoking law on exposure to secondhand smoke: evidence of the failure of the "Spanish model". Tob. Control. 21, 407–411. https://doi.org/10.1136/tc.2010.042275.

López, M.J., Arechavala, T., Continente, X., Schiaffino, A., Pérez-Ríos, M., Fernández, E., 2018. Social inequalities in secondhand smoke exposure in children in Spain. Tob. Induc. Dis. 16 (April), 14. https://doi.org/10.18332/tid/85717.

Martinez, C., Guydish, J., Robinson, G., Martínez-Sánchez, J.M., Fernández, E., 2014. Assessment of the smoke-free outdoor regulation in the WHO European region. Prev. Med. 64, 37–40. https://doi.org/10.1016/j.ypmed.2014.03.020.

Moncada, A., Schiaffino, A., Basart, E., 2011. Entornos escolares sin humo de tabaco: entre la protección y la promoción de la salud. Gac. Sanit. 25, 339–341. https://doi.org/10.1016/j.gaceta.2011.02.012.

Moore, G.F., Currie, D., Gilmore, G., Holliday, J.C., Moore, L., 2012. Socioeconomic inequalities in childhood exposure to secondhand smoke before and after smoke-free legislation in three UK countries. J. Public Health 34, 599–608. https://doi.org/10.1093/pubmed/fds025.

New York Public Health Law, 2017. Article 13-E section 1399-O: regulation of smoking and vaping in certain public areas. Available from. https://www.nysenate.gov/legislation/laws/PBH/1399-O. (Accessed 12 June 2020).

Öberg, M., Jaakkola, M.S., Prüss-Üstün, A., Schweizer, C., Woodward, A., 2010. Second-hand smoke: Assessing the environmental burden of disease at national and local levels. WHO Environmental Burden of Disease Series, No. 18. World Health Organization, Geneva Available from: https://www.who.int/quantifying_ehimpacts/publications/SHS.pdf?ua=1. (Accessed 12 September 2019).

Pattemore, P.K., 2013. Tobacco or healthy children: the two cannot co-exist. Front. Pediatr. 1, 20. https://doi.org/10.3389/fped.2013.00020.

Pobal Deprivation Index, 2017. Available from. https://maps.pobal.ie/WebApps/DeprivationIndices/index.html. (Accessed 3 April 2017).

Poulsen, L.H., Osler, M., Roberts, C., Due, P., Damsgaard, M.T., Holstein, B.E., 2002. Exposure to teachers smoking and adolescent smoking behaviour: analysis of cross sectional data from Denmark. Tob. Control. 11, 246–251. https://doi.org/10.1136/tc.11.3.246.

Ribeiro, A.I., Mayer, A., Miranda, A., Pina, M.F., 2017. The Portuguese version of the European deprivation index: an instrument to study health inequalities. Acta Medica Port. 30, 17–25. https://doi.org/10.20344/amp.7387 (Accessed 28 April 2017).

Roohafza, H., Heidari, K., Omidi, R., Alinia, T., Sadeghi, M., Mohammad-Shafiee, G., Naji, M., 2014. Adolescent perception on school environment and smoking behavior: analysis of Isfahan tobacco prevention program. Int. J. Prev. Med. 5 (Suppl. 2), S139–S145. https://doi.org/10.4103/2008-7802.157677.

Scottish Government, 2016. Scottish Index of Multiple Deprivation 2016. Available from: https://simd.scot/2016/#/simd2016/BTTTFTT/9/-4.0000/55.9000/ (Accessed 19 April 2017].

Stadt Heidelberg, 2011. Bericht zur Sozialen Lage in Heidelberg 2010. Available from: https://www.heidelberg.de/site/Heidelberg_ROOT/get/documents/heidelberg/PB5Documents/pdf/12_pdf_BerichtzurSozialenLagein%20Heidelberg_2010_k.pdf (Accessed 10 October 2017).

Stadt Mannheim, 2009. Baiträge zur Jugendhilfe, Sozialraumtypologie. Available from: https://www.mannheim.de/sites/default/files/page/2887/51-sozialraumtypologie.pdf (Accessed 6 September 2017).

Sureda, X., Fu, M., López, M.J., Martínez-Sánchez, J.M., Carabasa, E., Saltó, E., Martínez, C., Nebot, M., Fernández, E., 2010. Second-hand smoke in hospitals in Catalonia (2009): a cross-sectional study measuring $PM_{2.5}$ and vapor-phase nicotine. Environ. Res. 110, 750–755. https://doi.org/10.1016/j.envres.2010.09.008.

Sureda, X., Martínez-Sánchez, J.M., López, M.J., Fu, M., Agüero, F., Saltó, E., Nebot, M., Fernández, E., 2012. Secondhand smoke levels in public building main entrances: outdoor and indoor $PM_{2.5}$ assessment. Tob. Control. 21, 543–548. https://doi.org/10.1136/tobaccocontrol-2011-050040.

Sureda, X., Fernández, E., López, M.J., Nebot, M., 2013. Secondhand tobacco smoke exposure in open and semi-open settings: a systematic review. Environ. Health Perspect. 121, 766–773. https://doi.org/10.1289/ehp.1205806.

Sureda, X., Bilal, U., Fernández, E., Valiente, R., Escobar, F.J., Navas-Acien, A., Franco, M., 2018. Second-hand smoke exposure in outdoor hospitality venues: smoking visibility and assessment of airborne markers. Environ. Res. 165, 220–227. https://doi.org/10.1016/j.envres.2018.04.024.

Toronto City Government, 2013. Toronto municipal code chapter 709, smoking. Available from. https://www.toronto.ca/legdocs/municode/1184_709.pdf. (Accessed 14 February 2020).

U.S. Department of Health and Human Services, 2006. The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, Atlanta, GA Available from. https://www.ncbi.nlm.nih.gov/books/NBK44324/. (Accessed 16 September 2019).

United Nations, 1948. The universal declaration of human rights. New York. Avaliable from. https://www.ohchr.org/EN/UDHR/Documents/UDHR_Translations/eng.pdf. (Accessed 15 June 2020).

United Nations, 1989. Convention on the Rights of the Child. United Nations, New York 1989. Available from. https://www.ohchr.org/en/professionalinterest/pages/crc.aspx. (Accessed 15 June 2020).

United Nations, 1999. Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings. Avaliable from. https://unstats.un.org/unsd/methodology/m49/. (Accessed 18 June 2019).

US Environmental Protection Agency, 1992. Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders. Publication EPA/600/6–90/006F. US Environmental Protection Agency, Office of Air and Radiation, Washington, DC 1992. Available from. https://www.epa.gov/sites/production/files/2014-09/documents/passive_smoke.pdf. (Accessed 16 September 2019).

WHO Regional Office for Europe, 2013. Health 2020. A European policy framework and strategy for 21st century. Copenhagen. Available from. https://www.euro.who.int/__data/assets/pdf_file/0011/199532/Health2020-Long.pdf. (Accessed 15 June 2020).

WHO Regional Office for Europe, 2014. Investing in children: the European child and adolescent health strategy 2015–2020. Copenhagen. Available from. https://www.euro.who.int/__data/assets/pdf_file/0010/253729/64wd12e_InvestCAHstrategy_140440.pdf. (Accessed 15 June 2020).

WHO Regional Office for Europe, 2015. Roadmap of actions to strengthen implementation of the WHO Framework Convention on Tobacco Control in the WHO European Region 2015–2025: making tobacco a thing of the past. Copenhagen. Available from. https://www.euro.who.int/__data/assets/pdf_file/0005/297563/WHO-Roadmap-report-tobacco-control-15-25-en.pdf. (Accessed 15 June 2020).

WHO Regional Office for Europe, 2017. Tobacco-free generations. Protecting children from tobacco in the WHO European Region. Copenhagen. Avaliable from. https://www.euro.who.int/__data/assets/pdf_file/0008/343376/20170428_WHO-TobaccoFreeGeneration-DRAFT09.pdf. (Accessed 12 June 2020).

Wilson, N., Edwards, R., Parry, R., 2011. A persisting secondhand smoke hazard in urban public places: results from fine particulate ($PM_{2.5}$) air sampling. N. Z. Med. J. 124, 34–47.