Are policies implemented where they are most needed? Exploring the evolution of equity in school-based smoking prevention in 2013 and 2016 in 6 European cities

Nora Mélard[a], PhD; Alexandre Jacquemain[b], PhD; Julian Perelman[c], PhD; SILNE-R Consortium; Vincent Lorant[a], PhD

[a] Institute of Health and Society (IRSS), UCLouvain, Belgium

[b] Center for Applied Public Economics (CAPE), UCLouvain Saint-Louis, Belgium

[c] NOVA National School of Public Health, Public Health Research Centre, Comprehensive Health Research Center, NOVA University of Lisbon, Lisbon, Portugal

Corresponding author:

Nora Mélard

30 clos Chapelle-aux-Champs, bte B1.30.15 B-1200 Brussels

nora.melard@uclouvain.be

ABSTRACT

Background. Health policies are key social determinants of health, but may cause inequalities if their implementation does not match local needs, and if resources are misallocated. This study tests the inverse prevention law on school tobacco policies, assessing inequity in their implementation and identifying contributing factors.

Methods. A student survey and a staff survey were conducted in 38 schools across six European cities in 2013 and 2016. We assessed tobacco policy and calculated policy-need ratios to measure how well schools implemented a policy in line with adolescent smoking. Gini coefficients of policy-need ratios were used as inequity measure. We ran a penalised Lorenz regression to identify factors contributing to inequity and used the Shapley decomposition technique to decompose explained Gini coefficients.

Results. Gini coefficients were 8.8% in 2013 and 8.9% in 2016, indicating moderately inequitable implementation of school tobacco policies and limited change over time. Socio-economic characteristics, and family/home environment contributed the most to these inequities.

Conclusions. In line with the inverse prevention law, stronger tobacco policies are not implemented in schools that most need them, and this persisted between 2013 and 2016. Policy-makers should prioritize equity in health policy implementation and devote more resources to contexts with greater need.

Keywords: Health inequities; Smoking Prevention; School Health Promotion; Smoke-free Policy; Adolescent

INTRODUCTION

Smoking initiation often occurs during adolescence, with 83% of smokers starting between ages 14 and 25, and 19% beginning by age 15 [1]. Notably, smoking contributes to health inequalities, particularly affecting adolescents from lower socio-economic backgrounds [2-4]. Given this, preventing smoking initiation among adolescents is crucial, making schools a key target for interventions due to their wide socio-economic reach [5]. School tobacco policies ensure that this public place is not exposed to smoking. Yet, their implementation has been shown to greatly vary from one school to another within a geographical area [6,7]. This variability may contribute to social inequalities resulting from resources not aligning with local needs, a claim made by the "inverse care law" [8].

The "inverse care law" is a theory that states that “the availability of good medical care tends to vary inversely with the need of the population served” [8, p. 412]. The term, originally used to describe medical care, has been applied to a wide range of health interventions, including preventive and population-based strategies [9-11]. Previous studies, such as Moore, Littlecott, Fletcher, Hewitt and Murphy [12], questioned this law's validity, emphasizing the need for further research on the differential implementation of preventive interventions. In the case of school tobacco policies, do schools with higher smoking prevalence, more vulnerable populations, and higher susceptibility to smoking, benefit from stronger school tobacco policies?

School tobacco policies, often vaguely defined, vary in comprehensiveness (to whom, where and when they apply), enforcement, and communication [13-15]. While most studies on these policies focus on their effectiveness in preventing and reducing adolescent smoking, there is a gap in understanding their potential role in perpetuating social inequalities [16]. The social gradient in smoking persists, highlighting the need for early intervention, particularly in schools, where smoking often starts [17].

In the context of smoking denormalization, it is crucial to assess whether school tobacco policies protect all adolescents, an expectation questioned by the inverse prevention law . This paper aims to examine the equity of school tobacco policy implementation, and assess how this equity may have changed over time. Utilizing a new methodological approach, the study also seeks to decompose these inequities into its contributing factors. Importantly, the focus of this paper is on "inequities," referring to avoidable and unfair differences in health, with a commitment to vertical equity - treating individuals with greater needs more favourably [18,19]. This perspective distinguishes between inequities and inequalities in health, emphasizing the value judgment associated with the former.

METHODS

Design and study population

This study is based on data from the SILNE and SILNE-R surveys [20]. Data were collected in six European cities in six countries (Namur in Belgium, Tampere in Finland, Hanover in Germany, Latina in Italy, Amersfoort in the Netherlands, and Coimbra in Portugal) with different national tobacco regulations [21,22] and different school tobacco policies [6]. The cities selected were representative of their countries in terms of average income. Lorant, Soto, Alves, Federico, Kinnunen, Kuipers, Moor, Perelman, Richter and Rimpelä [20] provide more information on the selection of cities and schools. Ethical approval was obtained in each city and updated for the second data collection [20] (see Supplementary materials).

Data collections took place in 38 schools between January and November 2013, and between September 2016 and October 2017. In total, 18,502 students in grades corresponding to ages 14–16 participated: 9,305 students in 2013 (response rate: 85%) and 9,197 in 2016 (response rate: 81%). Adolescents were asked about their tobacco use, family, and school environment. Each school also had a school representative who filled in a worksheet gathering information

on the school, e.g. number of students and number of teachers, socio-economic status of the neighbourhood and of the students. See Lorant, Soto, Alves, Federico, Kinnunen, Kuipers, Moor, Perelman, Richter and Rimpelä [20] for more information on the survey methods.

Measurements

School tobacco policy score

The school tobacco policy score evaluates the policy that a school has put in place to regulate smoking. We used a score that is detailed elsewhere [6]. It is a 10-point score, calculated at the school level, that is multidimensional (comprehensiveness, enforcement, and communication of the policy), and considers the perceptions of both students and staff. It provided a suitable measure, therefore, for evaluating the policy in each school in our sample. Schools with a higher score have a policy in place which is more comprehensive (applied to students, staff, and visitors at all times and everywhere on the school premises), better enforced (there are sanctions in case of rule infringement that are well thought-out), and better communicated (students, staff, and visitors are fully aware of the policy and it is formally communicated).

Measure of inequities

To assess whether school tobacco policies are implemented where they are most needed, we proceeded in two steps. The first step consisted in fitting a Lorenz curve and computing a Gini coefficient of the policy-need ratios. The Lorenz curve and the Gini coefficient are often used by economists to measure the degree of income-related inequalities. Such measures have been more widely used in other research domains to answer research questions on topics as diverse as public transport provision [23] and the distribution of obesity across socio-economic status [24]. The Lorenz curve offers a visual representation of inequality by representing the cumulative distribution function of wealth across the population, with the diagonal representing a perfectly equal income distribution (see Figure 1) [25]. Figure 2 is similar to Figure 1 but shows the distance

to the diagonal. The Gini coefficient quantifies inequality. It is a ratio of the area between the line of equality and the Lorenz curve divided by the total area under the line of equality [26,27]. The smaller the surface between the Lorenz curve and the line of equality, the more equal the income distribution is. Our interest, however, is not in whether school tobacco policies are implemented equally in all schools, but whether they are implemented equitably according to need. To determine this, we computed a policy-need ratio, defined below, that quantifies the extent to which a school's policy corresponds to its level of need. Computing the Gini coefficient of the policy-need ratio thus captures the inequities, and not the inequalities, in the distribution of school tobacco policies.

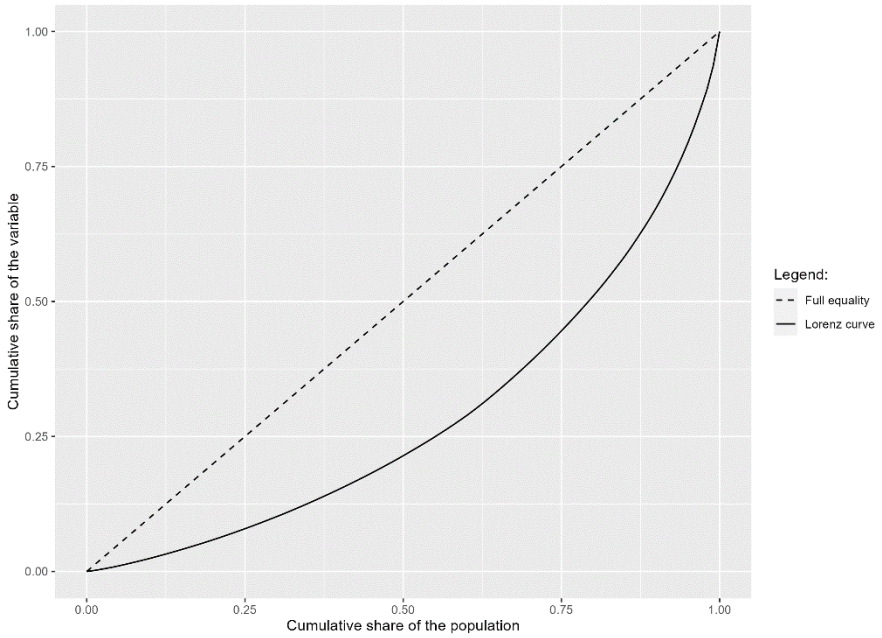

Figure 1. Lorenz curve

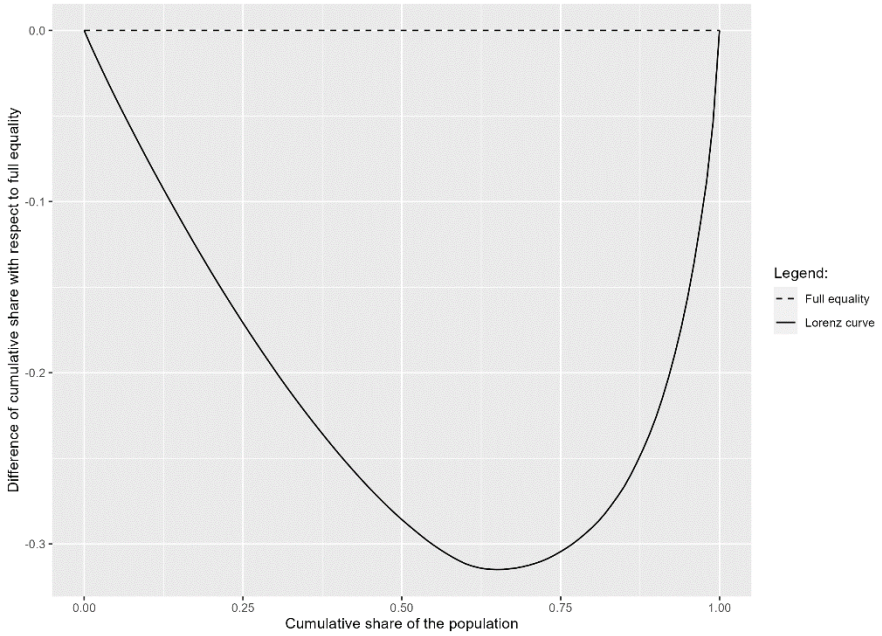

Figure 2. Lorenz curve – Distance to full equality

Definition of the policy-need ratio

Need definition

We defined the schools' need for a policy according to the prevalence of adolescent smoking [28]. The measure of the prevalence of adolescent smoking was the proportion of adolescents who reported that they smoked at least one cigarette per week.

Expected score of school tobacco policies

Within each country, we attributed an expected score of school tobacco policies to schools based on implementation being fully equitable, i.e. corresponding to their need. If school A has the lowest level of need in its country, i.e. the lowest prevalence of adolescent smoking, its expected score is the lowest school tobacco policy score in the country. On the contrary, if school B has the highest level of need, i.e. the highest prevalence of adolescent smoking, its expected score is the highest school tobacco policy score in the country. Considering each country separately was necessary, as the national context and the overall denormalisation of

tobacco might be reflected in the implementation of school tobacco policies. In some countries, improving the implementation of tobacco control policies is seen as a minor policy issue [29].

Policy-need ratio

For each school, we computed the policy-need ratio as the ratio between the actual school tobacco policy score and the expected school tobacco policy score. The value of the policy-need ratio was 1 if the school policy was exactly what was expected according to its need, lower than 1 if the school policy was less than what it needed, and higher than 1 if the school policy was more than it needed.

Independent variables

Independent variables that are known to affect the social context of smoking were used to decompose the measured inequity. They can be grouped into: (a) socio-demographic characteristics, (b) socio-economic characteristics, (c) family and home environment, (d) school environment, (e) history of smoking, and (f) peer network. A broad range of variables was included in order to best capture these factors. See Supplementary material for detailed descriptions of each variable.

Analysis

Ecological analyses were performed at the school level using the R software, version 4.1.2 [30] and more precisely, the LorenzRegression package.

Gini coefficients

We calculated a Gini coefficient on the policy-need ratios. As mentioned before, in our case, the Gini coefficient captures inequities as it measures the inequality in the distribution of the policy-need ratios. A value of 0 signifies perfect equity: all policy-need ratios are equal to 1,

meaning that all schools have the policy score they ideally should have according to their need. The further it is from 0, the more inequitable the distribution is.

Explained Gini coefficients

We decomposed inequities using Lorenz regressions on the school samples of 2013 and 2016, with the policy-need ratio as the dependent variable and the independent variables mentioned above [31]. This procedure estimates the explained Gini coefficient, which represents the inequality in the dependent variable that is attributable to the independent variables. Given the high number of independent variables compared to the sample sizes, we first ran a penalized Lorenz regression [32]. The penalization is useful as it automatically selects the relevant variables and avoids overestimation of the explained Gini coefficient. It is, however, important to notice that given the small sample sizes, the precise sets of selected variables may be unstable. To enhance the comparability of the results, we added a further step. We retrieved the set of variables which were selected in at least one of the two years and ran non-penalized Lorenz regressions for each year using this common set of independent variables. The ratio between the explained Gini coefficient and the Gini coefficient is called the Lorenz-R^2, which represents the share of inequity that the selected independent variables help reproduce.

Decomposition

We used the Shapley decomposition technique used by Jacquemain, Heuchenne and Van Kerm [33] to decompose the explained Gini coefficient into the contributions of each of the selected independent variables.

RESULTS

Table 1 shows individual-level and school-level descriptive statistics. The school tobacco policy score did not vary much from 2013 to 2016, with a mean score of 6.00 and 6.48 respectively. The prevalence of smoking among adolescents significantly decreased from 19%

to 14%. Smoking was more prevalent in schools that had a lower policy score than they needed, but it decreased slightly more in those schools. The rest of the table summarises the factors used in the decomposition of inequities.

Table 2Figure 3 displays a series of Lorenz curves. It plots the cumulative proportion of the population (here, the schools), ranked by policy-need ratio from the schools with the lowest policy-need ratios to those with the highest (x-axis), against the difference of cumulative proportion of policy-need ratios with respect to full equity, from lowest to highest (y-axis). The "Observed inequity" curve is the Lorenz curve of the policy-need ratios, computed by the procedure described in the "Policy-need ratio" subsection of the "analysis" section above. It is nested between two extreme scenarios, based on hypothetical policy-need ratios. If there is full equity, all schools receive a school tobacco policy score that corresponds to their need, and the policy-need ratios are all equal to one. The Lorenz curve thus obtained is labelled "Full equity". At the other extreme, the "Full inequity" curve corresponds to a situation in which, in each country, schools receive a school tobacco policy score that is inversely proportional to their need. The school with the lowest need thus receives the highest score, the school with the second lowest need receives the second-lowest score, etc. Finally, the "Explained inequity" curve is the concentration curve of the policy-need ratios fitted by the selected independent variables. The higher the Lorenz-R^2, the closer the explained inequity curve is to the observed inequity curve.

Table 2 provides the Gini coefficients of the policy-need ratios, which is our measure of inequity in the distribution of school tobacco policies according to the schools' level of need. Gini coefficients were similar over time, with a value of 8.8% in 2013 and 8.9% in 2016. To help interpret these coefficients, we can compare them to the hypothetical situation of "Full inequity" (Figure 3), in which the Gini coefficients would be 13.7% in 2013 and 12.7% in 2016.

Through the explained Gini coefficients, the Lorenz regression estimates the level of inequity that we were able to explain with the independent variables selected by the procedure, i.e. those with an estimated coefficient different from zero in either 2013 or 2016, which are detailed in Table 3. Explained Gini coefficients were similar over time, with a value of 6.4% in 2013 and 6.3% in 2016. Looking at the Lorenz-R^2, the selected independent variables contributed to inequities to a slightly lower extent in 2016 (70.5%) than in 2013 (73.2%).

Table 4 shows the decomposition of the explained Gini coefficients into the contributions of the selected independent variables. Socio-economic factors, and family and home environment, contribute the most to the decomposition of inequities. In 2013, the adolescents' family and home environment accounted for 46.9% of the explained Gini coefficient, factors related to adolescents' socio-economic characteristics for 44.3%, the school environment for 4.7% and peer network for 4.1%. In 2016, the family and home environment accounted for 39.6% of the explained Gini coefficient, socio-economic characteristics for 28.9%, the school environment for 20.9% and peer network for 10.6%. In 2013, schools were more likely to have a higher policy score than needed when adolescents' (step)sisters smoked or when they performed better at school. On the contrary, schools were more likely to have a lower policy score than needed when adolescents who had never smoked were more central in the school network, when their (step)fathers smoked, when some of their friends smoked, when their (step)mothers had a medium-level education, or when they performed less at school. In 2016, schools were more likely to have a lower policy score than needed when adolescents who had never smoked were more central in the school network, when adolescents' (step)sisters or (step)fathers smoked, when they performed better or lesser at school, when some of their friends smoked, or when their (step)mothers had a medium-level education.

Table 1. Descriptive statistics. SILNE and SILNE-R, 2013-2016.

	2013 (*n* = 9305) %	**2016** (*n* = 9197) %	**p-value**[a]
Cities – Countries			<.0001
Namur – Belgium	20.9	21.1	
Tampere – Finland	16.1	16.6	
Hanover – Germany	8.3	5.7	
Latina – Italy	21.4	21.6	
Amersfoort – the Netherlands	12.9	14.9	
Coimbra – Portugal	20.4	20.3	
School tobacco policy (0-10) [b, c]	6.00 (1.33)	6.48 (1.11)	
Adolescent smoking in a school with			
…a lower policy score than needed [d]	23.78	17.83	<.0001
…a policy score equal or higher than needed [e]	15.07	12.10	<.0001
Socio-demographic factors			
Age [b]	15.28 (1.05)	15.10 (1.04)	<.0001
Gender male	47.28	49.99	0.0002
Socio-economic factors			
Socio-economic status (0-10) [b]	6.71 (1.51)	6.67 (1.60)	0.0378
School performance (0-2) [b]	1.26 (0.73)	1.20 (0.76)	<.0001
Low	16.86	21.20	<.0001
Middle	40.12	37.64	
High	43.02	52.15	
Mother's education (0-2) [b]	1.15 (0.74)	1.22 (0.74)	<.0001
Low	21.14	19.24	<.0001
Middle	42.54	39.98	
High	36.61	40.78	
Father's education (0-2) [b]	1.06 (0.77)	1.13 (0.78)	<.0001
Low	26.83	24.58	<.0001
Middle	39.84	38.33	
High	33.32	37.10	
Wealth of school's neighbourhood (0-4) [b, c]	1.89 (1.07)	1.92 (0.77)	
Wealth of school's families (0-6) [b, c]	2.74 (1.22)	2.97 (0.97)	
Family and home environment			
Parental smoking (0-2) [b]	0.57 (0.74)	0.53 (0.73)	0.0005
No (step-)parent smoking	58.07	61.03	0.0003
One (step-)parent smoking	26.95	24.90	
Two and + (step-)parents smoking	14.98	14.07	
Sister(s) smoking	15.29	13.97	0.0635
Brother(s) smoking	19.90	18.22	0.0296

Continued

Table 1 continued

	2013 (n = 9305) %	**2016** (n = 9197) %	**p-value**[a]
Rules at home regarding smoking (0-2) [b]	1.51 (0.63)	1.51 (0.63)	0.9117
Smoking allowed nowhere	58.05	57.85	0.9242
Smoking allowed in certain areas	34.70	34.98	
Smoking allowed everywhere	7.26	7.17	
School environment			
Perceived smoking (%) [b]	53.49 (23.53)	40.67 (26.78)	<.0001
School connectedness (0-3) [b]	2.01 (0.54)	2.02 (0.52)	0.5820
Number of students in the school [b, c]	727 (435)	710 (517)	
Smoking-related behaviours			
Age of initiation [b]	13.31 (1.72)	13.38 (1.65)	0.0471
Ever tried vaping	-	36.85	
Peer network			
Friends' smoking (0-2) [b]	0.98 (0.73)	0.84 (0.73)	<.0001
None of them	27.32	35.59	<.0001
Some of them	47.18	44.46	
Most/All of them	25.50	19.95	
Friends' disapproval of smoking (0-2) [b]	1.38 (0.71)	1.44 (0.72)	<.0001
(Would) approve	13.52	13.55	<.0001
(Would) not care	35.41	29.31	
(Would) disapprove	51.08	57.24	
Difficulty of access to cigarettes (0-3) [b]	1.25 (1.05)	1.49 (1.06)	<.0001
Very easy	28.32	20.76	<.0001
Fairly easy	35.29	32.87	
Fairly difficult	19.20	23.11	
Very difficult	17.19	23.26	
Indegree centrality [b]			
Never smoked	3.27 (2.03)	3.36 (2.04)	0.0290
Ever smoked	3.48 (2.11)	3.46 (2.14)	0.6729
Regularly smokes	3.40 (2.16)	3.44 (2.22)	0.5792

[a] P-values of differences between 2013 and 2016, calculated with Pearson's chi-squared tests and Students' t-tests for each variable separately. [b] Mean and standard deviation provided. [c] School-level. [d] n=18 in 2013, and n=17 in 2016. [e] n=20 in 2013, and n=21 in 2016

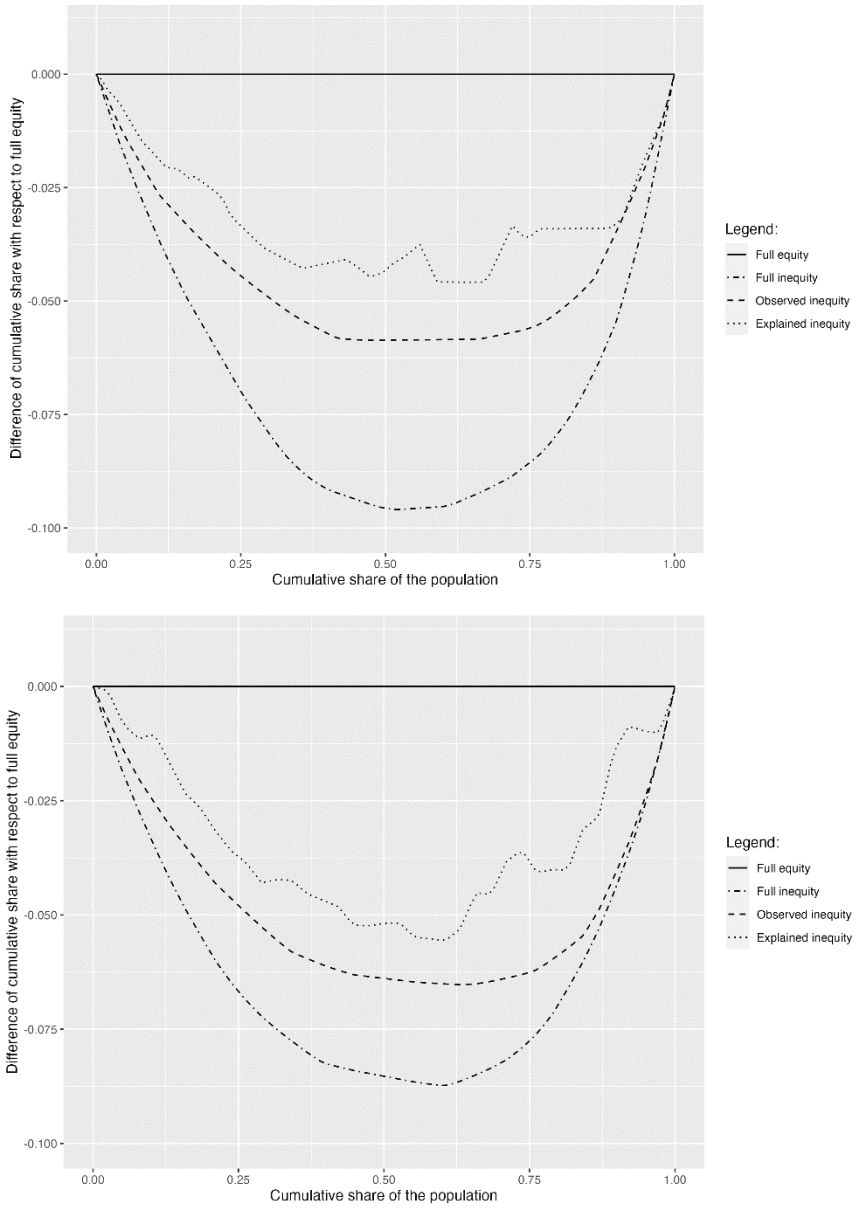

Figure 3. Lorenz curves of the policy-need ratios in 2013 (top) and 2016 (bottom). Distance to full equity

Table 2. Gini coefficients of the policy-need ratios. SILNE and SILNE-R, 2013-2016. n=38 schools.

Year	Gini[a]	Explained Gini[b]	Lorenz-R^2[c]	Gini under full inequity[d]
2013	8.77	6.42	73.19	13.72
2016	8.91	6.28	70.52	12.73

[a] Gini coefficient of the policy-need ratio
[b] Explained Gini coefficients, as estimated by the final non-penalized Lorenz regressions
[c] Ratio between the explained Gini coefficient and the Gini coefficient
[d] Situation in which, in each country, schools receive a school tobacco policy score that is inversely proportional to their need

Table 3. Relevant variables selected among the explanatory variables using the penalised Lorenz regression, 2013-2016

2013	2016
Indegree when never smoked	Sister(s) smoking
Father smoking	Low school performance
Having some friends who smoke	
High school performance	
Middle-level mother education	

Table 4. Decomposition of the explained Gini coefficients. SILNE and SILNE-R, 2013-2016. n=38 schools

Year	Contributions of factors (%)					
	Socio-demographic	**Socio-economic**	**Family and home environment**	**School environment**	**History of smoking**	**Peer network**
2013	0	44.32[a]	46.89[c]	4.67[e]	0	4.12[f]
2016	0	28.93[b]	39.64[d]	20.85[e]	0	10.58[f]

(+): Schools more likely to have a higher policy score than needed

(-): Schools more likely to have a lower policy score than needed

[a] High school performance (+), Middle-level mother education (-), Low school performance (-)

[b] High school performance (-), Middle-level mother education (-), Low school performance (-)

[c] Father smoking (-), Sister(s) smoking (+)

[d] Father smoking (-), Sister(s) smoking (-)

[e] Indegree when never smoked (-)

[f] Having some friends who smoke (-)

DISCUSSION

Effective policies rely on the commitment of resources at the local level, with insufficient or inadequate implementation leading to health inequalities. In this regard, school tobacco policies are an interesting case study, as their effectiveness is highly dependent on coherent and rigorous implementation. This study tests the inverse prevention law, and adds to the knowledge on the role of school tobacco policies in addressing health inequalities.

We used Lorenz curves to describe the extent to which these policies are implemented where they are most needed. The results reveal moderate inequity in the current implementation, indicating that policies often do not align with the prevalence of adolescent smoking in the six European cities. Importantly, the inequity disproportionately benefits adolescents who least need the policies, aligning with the concept of "negative equity impact" [16]. This finding supports the inverse prevention law hypothesis, suggesting that current policies may not effectively reduce health inequalities and could even contribute to maintaining them.

The degree of inequity remained stable between 2013 and 2016, while at the same time, countries have made significant efforts to increase the regulation of tobacco products [21]. The persistence of inequities highlights a disconnect between tobacco control policies and their implementation in the areas where they are most needed.

It is important to note that part of the inequity in the implementation of school tobacco policies was explained by factors that are mostly external to the school environment. The family and home environment contributed greatly to explaining inequity. Parents who smoke might be less supportive to school initiatives to enforce tobacco policies [34]. Schreuders, Kuipers, Mlinarić, Grard, Linnansaari, Rimpela, Richter, Perelman, Lorant, van den Putte and Kunst [35] found that

school tobacco policies were generally associated with anti-smoking beliefs, but more so among adolescents from smoking prohibitive than from permissive families. Moreover, stricter rules at home regarding smoking might be associated with stricter school tobacco policies because parents who apply a smoke-free home policy might be more inclined to support the implementation of a policy in their children's school. Overall, the school environment and the family and home environments are enmeshed, and both play important roles in the development of adolescents' attitudes to smoking.

Socio-economic characteristics also contributed to explaining the inequity in the distribution of school tobacco policies. The association between poorer school performance and increased smoking has been highlighted previously [3,36,37]. One possible explanation is that school staff members at low-performing schools prioritize teaching over health promotion and maintaining their relationships with the adolescents, making implementing a strong school tobacco policy a lesser priority [38].

Regarding the school environment characteristics, school authorities are less likely to take action when adolescents who have never smoked are more popular. This could be due to smoking being less socially visible, although still prevalent.

This study is subject to limitations. First, our study is based on the assumption that the need for policies can be measured using the prevalence of adolescent smoking. The risk of reserve causation is low as smoking prevalence is unlikely to be reduced by school tobacco policies [6,39-41]. Second, this study allows comparison between schools across, but not between or within different contexts. A larger sample of schools would have been necessary to conclude on inequalities within each city/country. Finally, more information on school resources would have

helped to understand our findings, such as the ratio between the number of school staff members and the number of adolescents, or the school's financial resources.

Despite the impetus for research on school tobacco policies, few studies have looked at these policies from the perspective of equity. This study is the first to observe that the implementation of school tobacco policies does not correspond to schools' level of need. It also indicates that the inverse prevention law is enmeshed into the complex web of multi-layered contextual factors, including the school, family and home environments. This echoes Thimm-Kaiser, Benzekri and Guilamo-Ramos [42]'s suggested framework to better understand how social determinants of health shape health inequities through contextual influences, and the non-deterministic effect of social determinants of health.

Conclusion

In conclusion, this study highlights the inequitable distribution of school tobacco policies across six European cities. The policies often do not align with schools' needs, disproportionately benefiting those with less need. External factors, especially the family and home environment, significantly contribute to this inequity. Policymakers should adopt a vertical equity perspective, providing more resources to schools with greater needs, and fine-tune strategies to consider these external influences. Improved collaboration with school health services is suggested to inform schools about the need for increased efforts. Addressing these issues is crucial for utilizing school tobacco policies as effective tools against adolescent smoking in order to reduce health inequalities.

Further research is needed to better understand how external factors, such as the family and home environment, as well as internal factors, such as governance model, financial and human resources, and school staff members' smoking, can be identified and taken into account in the

design and implementation of school tobacco policies, to ensure that such policies do not perpetuate health inequalities.

Acknowledgements

We would like to thank all school staff members and students who participated in the study. We would like to acknowledge our colleagues who took part in the collection of the SILNE WP5 data: Jaana Kinnunen, Geatano Roscillo, Pierre-Olivier Robert, and Joanna Alves, as well as the SILNE-R WP8 data: Pauline A.W. Nuyts, Michael Schreuders, Diego Marandola, Teresa Leão, Pierre-Olivier Robert, Adeline Grard, Jaana Kinnunen, Laura Hoffmann, and Martin Mlinaric. We would like to acknowledge the work done by Mostafa Berdii and Adeline Grard on the data management. We would like to thank Laura Jones for the English editing. Computational resources have been provided by the supercomputing facilities of the Université catholique de Louvain (CISM/UCL) and the Consortium des Équipements de Calcul Intensif en Fédération Wallonie Bruxelles (CÉCI) funded by the Fonds de la Recherche Scientifique de Belgique (F.R.S.-FNRS) under convention 2.5020.11 and by the Walloon Region.

Contributors

Nora Mélard: Conceptualization, Methodology, Formal analysis, Data curation, Writing – Original Draft, Writing – Review & Edition. **Alexandre Jacquemain**: Methodology, Formal analysis, Data curation, Writing – Review & Edition. **Julian Perelman**: Writing – Review & Edition, Project administration, Funding acquisition. **Vincent Lorant:** Conceptualization, Methodology, Resources, Writing – Review & Edition, Supervision, Project administration, Funding acquisition.

Funding

This study is part of the SILNE-R project “Enhancing the effectiveness of programmes and strategies to prevent smoking by adolescents: a realist evaluation comparing seven European countries”, which was supported by the European Union’s Horizon 2020 research and innovation programme under the SILNE-R Grant Agreement number 635056. The Belgian team was also supported by a grant from the FNRS: Crédit de Recherche n°23593456.

REFERENCES

1. Reitsma MB, Flor LS, Mullany EC, Gupta V, Hay SI, Gakidou E. Spatial, temporal, and demographic patterns in prevalence of smoking tobacco use and initiation among young people in 204 countries and territories, 1990–2019. *The Lancet Public Health*. 2021/07/01/ 2021;6(7):e472-e481. doi:https://doi.org/10.1016/S2468-2667(21)00102-X

2. Petrovic D, de Mestral C, Bochud M, et al. The contribution of health behaviors to socioeconomic inequalities in health: A systematic review. *Prev Med*. 2018/08/01/ 2018;113:15-31. doi:https://doi.org/10.1016/j.ypmed.2018.05.003

3. Moor I, Rathmann K, Lenzi M, et al. Socioeconomic inequalities in adolescent smoking across 35 countries: A multilevel analysis of the role of family, school and peers. *Eur J Public Health*. 2015:cku244. doi:https://doi.org/10.1093/eurpub/cku244

4. Shackleton N, Milne BJ, Jerrim J. Socioeconomic inequalities in adolescent substance use: Evidence from twenty-four European countries. *Subst Use Misuse*. 2019/05/12 2019;54(6):1044-1049. doi:https://doi.org/10.1080/10826084.2018.1549080

5. Fox KR, Cooper A, McKenna J. The school and promotion of children's health-enhancing physical activity: Perspectives from the United Kingdom. *Journal of Teaching in Physical Education*. 2004;23(4):338-358.

6. Mélard N, Grard A, Robert P-O, et al. School tobacco policies and adolescent smoking in six European cities in 2013 and 2016: A school-level longitudinal study. *Prev Med*. 2020;(138):106142. doi:https://doi.org/10.1016/j.ypmed.2020.106142

7. Cole AG, Aleyan S, Qian W, Leatherdale ST. Assessing the strength of secondary school tobacco policies of schools in the COMPASS study and the association to student smoking behaviours. *Canadian Journal of Public Health*. 2019/04/01 2019;110(2):236-243. doi:https://doi.org/10.17269/s41997-019-00178-4

8. Hart JT. The inverse care law. *The Lancet*. 1971;297(7696):405-412. doi:https://doi.org/10.1016/S0140-6736(71)92410-X

9. White M, Adams J, Heywood P. How and why do interventions that increase health overall widen inequalities within populations. In: Babones SJ, ed. *Social inequality and public health*. Policy Press; 2009:65-82.

10. Lorenc T, Petticrew M, Welch V, Tugwell P. What types of interventions generate inequalities? Evidence from systematic reviews. *J Epidemiol Community Health*. 2013;67(2):190-193. doi:https://doi.org/10.1136/jech-2012-201257

11. Acheson D. Health inequalities impact assessment. *Bull World Health Organ*. 2000;78:75-76.

12. Moore GF, Littlecott HJ, Fletcher A, Hewitt G, Murphy S. Variations in schools' commitment to health and implementation of health improvement activities: A cross-sectional study of secondary schools in Wales. *BMC Public Health*. 2016/02/10 2016;16(1):138. doi:https://doi.org/10.1186/s12889-016-2763-0

13. Ross JG, Einhaus KE, Hohenemser LK, Greene BZ, Kann L, Gold RS. School health policies prohibiting tobacco use, alcohol and other drug use, and violence. *J Sch Health*. 1995;65:333-333.

14. Adams ML, Jason LA, Pokorny S, Hunt Y. The relationship between school policies and youth tobacco use. *J Sch Health*. 2009;79(1):17-23. doi:https://doi.org/10.1111/j.1746-1561.2008.00369.x.

15. Galanti MR, Coppo A, Jonsson E, Bremberg S, Faggiano F. Anti-tobacco policy in schools: Upcoming preventive strategy or prevention myth? A review of 31 studies. *Tob Control*. 2013;23(4):295-301. doi:https://doi.org/10.1136/ tobaccocontrol-2012-050846

16. Brown T, Platt S, Amos A. Equity impact of interventions and policies to reduce smoking in youth: Systematic review. *Tob Control*. 2014;23(e2):e98-e105. doi:https://doi.org/10.1136/tobaccocontrol-2013-051451

17. Carnazza G, Liberati P, Resce G. Income-related inequality in smoking habits: A comparative assessment in the European Union. *Health Policy*. 2023/02/01/ 2023;128:34-41. doi:https://doi.org/10.1016/j.healthpol.2022.12.002

18. Whitehead M. The concepts and principles of equity and health. *Health Promot Int*. 1991;6(3):217-228. doi:https://doi.org/10.2190/986L-LHQ6-2VTE-YRRN

19. Culyer AJ, Wagstaff A. Equity and equality in health and health care. *J Health Econ*. 1993/12/01/ 1993;12(4):431-457. doi:https://doi.org/10.1016/0167-6296(93)90004-X

20. Lorant V, Soto VE, Alves J, et al. Smoking in school-aged adolescents: Design of a social network survey in six European countries. *BMC Res Notes*. 2015;8(1):91. doi:https://doi.org/10.1186/s13104-015-1041-z

21. Joossens L, Raw M. *The Tobacco Control Scale 2016 in Europe*. Association of European Cancer Leagues; 2017. Accessed 25/01/2018. https://www.cancer.be/sites/default/files/tobacco_control_scale.pdf

22. Joossens L, Raw M. *The Tobacco Control Scale 2013 in Europe.* Association of European Cancer Leagues; 2013. Accessed 27/07/2023. https://www.tobaccocontrolscale.org/TCS2013.pdf

23. Delbosc A, Currie G. Using Lorenz curves to assess public transport equity. *Journal of Transport Geography*. 2011/11/01/ 2011;19(6):1252-1259. doi:https://doi.org/10.1016/j.jtrangeo.2011.02.008

24. Zhang Q, Wang Y. Socioeconomic inequality of obesity in the United States: Do gender, age, and ethnicity matter? *Soc Sci Med*. 2004/03/01/ 2004;58(6):1171-1180. doi:https://doi.org/10.1016/S0277-9536(03)00288-0

25. Lorenz MO. Methods of measuring the concentration of wealth. *Publications of the American Statistical Association*. 1905/06/01 1905;9(70):209-219. doi:https://doi.org/10.1080/15225437.1905.10503443

26. Illsley R, Le Grand J. The measurement of inequality in health. *Health and Economics: Proceedings of Section F (Economics) of the British Association for the Advancement of Science, Bristol, 1986*. Springer; 1987:12-36.

27. Le Grand J. Inequalities in health: Some international comparisons. *European Economic Review*. 1987/02/01/ 1987;31(1):182-191. doi:https://doi.org/10.1016/0014-2921(87)90030-4

28. Adams J, Schaefer DR. How initial prevalence moderates network-based smoking change: Estimating contextual effects with stochastic actor-based models. *J Health Soc Behav*. 2016;57(1):22-38. doi:https://doi.org/10.1177/0022146515627848

29. Mlinarić M, Hoffmann L, Lindfors P, Richter M, SILNE-R study group. Enhancing implementation of smoke-free places: A comparative qualitative study across seven European cities. *Soc Sci Med*. 2020;247:112805. doi:https://doi.org/10.1016/j.socscimed.2020.112805

30. *R: A language and environment for statistical computing.* R Foundation for Statistical Computing; 2021. https://www.R-project.org/

31. Heuchenne C, Jacquemain A. Inference for monotone single-index conditional means: A Lorenz regression approach. *Computational Statistics & Data Analysis*. 2022/03/01/ 2022;167:107347. doi:https://doi.org/10.1016/j.csda.2021.107347

32. Jacquemain A, Heuchenne C, Pircalabelu E. A penalised bootstrap estimation procedure for the explained Gini coefficient. *Under review*. 2023;

33. Jacquemain A, Heuchenne C, Van Kerm P. A penalized Lorenz regression analysis of inequality of opportunity. *Under review*. 2023;

34. Linnansaari A. *Implementing preventive tobacco policies: The role of contextual factors in policy implementation at school and national levels*. Tampere University; 2023. Accessed 04/10/2023. https://trepo.tuni.fi/handle/10024/148974

35. Schreuders M, Kuipers MAG, Mlinarić M, et al. The association between smoke-free school policies and adolescents' anti-smoking beliefs: Moderation by family smoking norms. *Drug Alcohol Depend*. 2019/11/01/ 2019;204:107521. doi:https://doi.org/10.1016/j.drugalcdep.2019.06.023

36. Pennanen M, Haukkala A, de Vries H, Vartiainen E. Longitudinal study of relations between school achievement and smoking behavior among secondary school students in Finland: Results of the ESFA study. *Subst Use Misuse*. 2011/03/15 2011;46(5):569-579. doi:https://doi.org/10.3109/10826084.2010.517725

37. Kinnunen JM, Paakkari L, Rimpelä AH, et al. The role of health literacy in the association between academic performance and substance use. *Eur J Public Health*. 2022;doi:https://doi.org/10.1093/eurpub/ckab213

38. Schreuders M, van den Putte B, Kunst AE, consortium S-R. Why secondary schools do not implement far-reaching smoke-free policies: Exploring deep core, policy core, and secondary beliefs of school staff in the Netherlands. *Int J Behav Med*. 2019/12/01 2019;26(6):608-618. doi:https://doi.org/10.1007/s12529-019-09818-y

39. Kuipers MA, de Korte R, Soto VE, et al. School smoking policies and educational inequalities in smoking behaviour of adolescents aged 14–17 years in Europe. *J Epidemiol Community Health*. 2015;70(2):132-139. doi:https://doi.org/10.1136/jech-2015-205831

40. Lovato CY, Pullman AW, Halpin P, et al. The influence of school policies on smoking prevalence among students in grades 5-9, Canada, 2004-2005. *Prev Chronic Dis*. 10/15 2010;7(6):A129.

41. Darling H, Reeder AI, Williams S, McGee R. Is there a relation between school smoking policies and youth cigarette smoking knowledge and behaviors? *Health Educ Res*. 2005;21(1):108-115. doi:https://doi.org/10.1093/her/cyh047

42. Thimm-Kaiser M, Benzekri A, Guilamo-Ramos V. Conceptualizing the Mechanisms of Social Determinants of Health: A Heuristic Framework to Inform Future Directions for Mitigation. *The Milbank Quarterly*. 2023;101(2):486-526. doi:https://doi.org/10.1111/1468-0009.12642