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Title: Impact of tobacco control policies on exhaled carbon monoxide in non-smokers

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Contributors: BD initiated the study, contributed to the design of the study and was responsible for data collection as president of French office for tobacco prevention (OFT). ST, JPP and IAM were responsible for data management and statistical analysis, plan of data and wrote the paper. BD and MJJ contributed to interpretation of findings. All authors provided critical comments to the paper and gave final approval of the version to be published.

Ethics approval was not required.

ABSTRACT

Background

Passive smoking is a serious health risk in non-smokers. The strength of tobacco control policies of the EU countries vary. This study aimed to investigate the relationship between second-hand smoke exposure, as assessed by exhaled carbon monoxide (eCO), and the strength of national tobacco control policies, in non-smokers in the EU.

Methods

Data were provided from the EU campaign “HELP: for a life without tobacco” during national events settled in the 27 EU countries in 2006-2007. Individual information on age, gender, and eCO were obtained from 58,919 self-reported non-smokers. The strength of national tobacco control policies was scored by the Tobacco Control Scale (TCS). **The relationship between eCO and TCS score was investigated using both an ecological and a multilevel approaches.**

Results

Both analyses reported a significant linear decrease in eCO per unit increase in TCS score, with a smaller estimation resulting from the multilevel analysis ($\beta = -0.03$ ppm, 95% CI: -0.04 - 0.02 vs. 0.05 (0.02 - 0.08)).

Conclusion

Our study confirms, in a large European non-smoker population, the relevance of strong anti-smoking policies in reducing exposure to passive smoking. Our findings give further reason to encourage European countries to strengthen their tobacco control policies to protect non-smokers from second-hand smoke.

Exposure to second-hand smoke (SHS) has been shown to be responsible for a wide range of diseases and premature deaths in non-smokers.[1] This has led supranational authorities, including the European Union (EU), to launch initiatives promoting a smoke-free lifestyle, by both enforcing the legislative framework and by encouraging health promotion.[2] National policies to limit exposure to second-hand smoke nevertheless vary widely among EU Member States. Instruments have been developed to evaluate national policies, based on the six most effective tobacco control measures, providing a quantitative ranking of EU countries.[3] To raise awareness, the EU funded in 2005 the 4-year campaign “HELP: for a life without tobacco” using media and national events in the 27 EU Member States. The present study explores, using data collected during this campaign, the relationship between SHS exposure, as assessed by exhaled carbon monoxide (eCO) and the strength of national-level tobacco control policies, as scored by the Tobacco Control Scale (TCS), in non-smokers in the 27 EU Member States.[3]

Methods

The campaign HELP enabled to collect data between March 2006 and July 2007 on a convenience sample of 111,835 people interviewed in several cities of the 27 EU countries where national events were organized. Stands were settled in various places such as public places and health care facilities. The present cross sectional study included 58,919 self-reported non-smokers with eCO concentration lower than 10 parts per million (ppm). This threshold was chosen to exclude smokers who denied their status (5.6% of self-reported non-smoker participants).[4]

Individual information were obtained on age, gender and smoking habits from a standardised interview and on exhaled CO in expired air after breath-holding with a portable CO analyser, using an established protocol.[5] An ecological variable, the TCS score, was used to measure the strength of the national tobacco control policies. The TCS, first published in 2005 and updated in 2007, provides an overall national score based on six different tobacco control interventions, namely price and taxes level, clean indoor air laws, comprehensive advertising bans, funding for tobacco control programs, characteristics of health warnings on tobacco packs, and affordability of tobacco dependence treatments.[3, 6] The 2005 TCS score was attributed if no change in tobacco control policies had occurred in the country between 2005 and the date of interview; the 2007 score was attributed, otherwise. This score increases with the strength of tobacco control policies up to a possible maximum of 100 points.

An ecological analysis was initially carried out to estimate the effect of TCS score on exhaled CO, averaged over the country level, using a linear model. Examination of residuals scatterplots found no important deviation from the assumption of normality. A multilevel linear analysis was also performed to assess the association between TCS score and eCO, measured at individual-level, after adjusting for age, gender, and survey setting.[7] In the multilevel approach, the possible clustering of non-smokers within countries in relation to individual eCO was also analysed by the intraclass correlation coefficient (ICC).[8] In both analyses, the strength of the association between TCS score and eCO was appraised by the β coefficient (95% CI). The percentage of country differences in eCO explained by the adjusted model was estimated by the adjusted R^2 for the ecological analysis and by the R^2 as described by Merlo *et al.* for the multilevel analysis.[8]

Results

Non-smokers in the sample were interviewed most frequently in public places (49%), followed by health care (13%) and educational (13%) facilities, sport (10%), cultural (7%), and music (4%) events, and lastly in workplaces (4%). More than 50% of non-smokers were less than 30 years old and 48.7% were males. Mean eCO ranged from 1.6 ppm (SD=2.1 ppm) in Ireland to 6.6 ppm (SD=1.9 ppm) in Greece. The TCS score varied from 26 in Luxembourg to 74 in Ireland. A significant linear 0.05 ppm decrease in mean eCO per unit increase in TCS

score was estimated by the ecological analysis (95% CI= 0.02 to 0.08) ($p=0.00245$) (figure 1, table 1). This model explained 23.6% of the variation in mean eCO. The multilevel model showed a noticeable clustering of non-smokers within countries by an intraclass correlation equals to 0.28 (table 1). Although individual variables (age, gender, and survey setting) were significantly associated with individual eCO, they explained only 4% of the differences in eCO between countries (table 1). Adjustment for individual variables and TCS score led to an intraclass correlation decrease and explained 27.7% of the differences in eCO between countries. A significant linear 0.03 ppm decrease in eCO per unit increase in TCS score was estimated by the multilevel analysis (95% CI= 0.02 to 0.04) ($p<0.0001$) (table 1).

Discussion

We found that exhaled carbon monoxide concentration decreased with the strength of tobacco control policies, as scored by the Tobacco Control Scale in a large non-smoker European population.

However, this study has several limitations. The HELP campaign aimed to highlight the consequences of active and passive smoking and to promote tobacco-free lifestyles throughout the EU. The CO concentration was used to sensitize individuals to the role of tobacco smoke as a pollutant of the whole body. Its measurement in expired air was chosen since it could be performed non-invasively and for its cost-effectiveness advantages. Exhaled CO was thus, in this study, the most appropriate marker of individual SHS exposure. However, carbon monoxide is not specific to tobacco smoke, as it can also reflect exposure to other environmental sources such as traffic, occupational, or domestic emissions. Therefore, further investigations are needed to validate our results. They should include more detailed information on tobacco smoke exposure of non-smokers relating to sources and intensity of involuntary exposure at home or at work. In smaller-scale studies, cotinine is commonly used as a specific marker. However, its measure in saliva or urine is costly and complex to perform. Nevertheless, Haw et al. showed, by using cotinine concentrations in a national-level study, a large and significant reduction in SHS exposure in non-smoking adults after the implementation of smoke-free legislation.[9]

Our exploratory findings support these results on a large sample from 27 countries, at the European Union level, by confirming the relevance of strong anti-smoking policies integrating a set of tobacco control interventions for the reduction of passive smoking. They constitute a further reason to encourage the EU Member States with the weakest tobacco control policies to strengthen them, in particular to protect non-smokers from second-hand smoke. This could be achieved by launching comprehensive smoke-free legislation with the support of the population, by following the example of Ireland.[10]

Table 1: Effects of individual and country-level variables on exhaled carbon monoxide in 58,919 non-smokers, EU-27, 2006-2007

	Multilevel analysis (individual eCO)			Ecological analysis (mean eCO)	
	Change in eCO (95% CI) in ppm	ICC	R_2^{2*} (%)	Change in eCO (95% CI) in ppm	Adjusted R^2 (%)
<i>Empty model</i>					
Without any independent variable	-	0.280	Reference	-	-
<i>Adjusted model[†]</i>					
Without TCS score	Not shown	0.275	4.0	-	-
With TCS score [‡]	-0.028 (-0.037;-0.018)	0.222	27.7	-0.053 (-0.084;-0.021)	23.6

* R_2^2 defined as $[(\Omega_{u0}-\Omega_{u1})/\Omega_{u0}]*100$; Ω_{u0} =country-level variance of the empty model; Ω_{u1} =country-level variance of the adjusted model

[†]Adjusted for age, gender, and survey setting

[‡] In the ecological analysis, adjusted only for TCS score

Figure 1: Association between the Tobacco Control Scale (TCS) score and mean eCO estimated by the ecological analysis, EU-27, 2006-2007

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What this study adds

Passive smoking is a serious health risk in non-smokers. In the European Union, the scope and character of national tobacco control policies vary widely among the Member States, as indicated by scores on the “Tobacco Control Scale”.

Our measures of exhaled carbon monoxide concentration in a large sample of European non-smokers support the relevance of strong anti-smoking policies, as scored by the TCS, for the reduction of passive smoking.

Policy implications

These findings give further reason to encourage European countries to strengthen their tobacco control policies.

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