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# Explaining socio-economic inequalities in daily smoking: a social–ecological approach

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**Background:** This study assessed the contributions of individual, household and neighbourhood-level factors to socio-economic inequalities in smoking. **Methods:** Data came from 2706 participants of the 2004 wave of the Dutch GLOBE study. Participants were asked about several social and material characteristics of their households, neighbourhoods and smoking in their environment. Indicators of socio-economic position were education and income. Associations with daily smoking were examined using logistic regression analyses. **Results:** Education and income were independently associated with daily smoking (mutually adjusted odds ratios for the lowest education and income groups: odds ratio (OR): 2.87, 95% confidence interval (95% CI): 1.78–4.62; OR: 1.55, 95% CI: 1.09–2.23, respectively). Individual beliefs about smoking contributed most to the association of education with daily smoking. Individual beliefs about smoking and household material adversity contributed most to the association of income with daily smoking. We found no evidence that negative perceptions of the neighbourhood contributed to smoking inequalities. In fully adjusted models, associations between income and smoking were fully attenuated, but an independent association between education and smoking remained. **Conclusion:** Education and income were related to smoking through partly different pathways. Reducing inequalities in smoking may require a multidimensional approach targeting material and social factors, with strategies targeted towards the individual and the household level.

**Keywords:** inequalities, socio-economic factors, tobacco use, education, smoking

## Introduction

Descriptive research has demonstrated that there are persistent socio-economic health inequalities within Europe.<sup>1–3</sup> Estimates of the contribution of smoking to these inequalities range from around 25% to over 50%.<sup>4,5</sup> Whatever the true magnitude of the contribution of smoking to health inequalities is, smoking is among the greatest single contributors to the gap in health between lower and higher socio-economic groups. This makes the question of what explains inequalities in smoking a high priority for public health.

Previous studies focused on a multitude of potential explanatory factors, including individual material (e.g. financial problems, housing factors), cultural (e.g. norms and values regarding smoking) and psychosocial factors (e.g. [perceived] social support, personality factors, psychosocial working conditions, attitudes, subjective norms, perceived behavioural control).<sup>6–9</sup> There is evidence that these individual factors contribute to the socio-economic gradient in smoking, but do not account for the gradient completely.

Ecological models for health improvement and public health highlight possible social and physical environmental determinants of health behaviours. Environments where people spend much time and interact with other people who are important to them, such as the home, school, workplace or neighbourhood, are believed to be of major importance,<sup>10–13</sup> and such factors may also mediate socio-economic differences in smoking. Specific household characteristics such as the number of members in the

household who smoke have been shown to influence quitting with smoking by household members.<sup>14</sup> In a qualitative study of smoking in deprived neighbourhoods, Stead *et al.*<sup>15</sup> demonstrated that residents in deprived areas could hardly escape being a smoker, that in these areas smoking was part of everyday life, and that non-smokers were regarded as outsiders. The role of neighbourhood characteristics in smoking among residents has been corroborated by recent quantitative analyses.<sup>11,16,17</sup> Clearly, household and neighbourhood conditions may play a role, in addition to individual material, cultural and psychosocial characteristics.

To date, no studies examined individual, household and neighbourhood characteristics simultaneously. The current study takes such an integrative approach. The primary aim of the study was to assess the association of potential determinants at several levels—individual, household and neighbourhood—with socio-economic inequalities in smoking.

Because socio-economic position is multidimensional and pathways between various socio-economic indicators and health-related outcomes may vary, it is important to distinguish between multiple socio-economic indicators when possible.<sup>18–20</sup> This is also of importance when studying the associations with smoking, as research has shown that the magnitude of socio-economic differences in smoking depends on the socio-economic indicator used.<sup>21,22</sup> In the current study, socio-economic position was measured with two indicators: education and income. A secondary aim was to investigate differences in the contribution of the possible determinants to inequalities in smoking.

## Methods

### Sample

We used data from the latest postal survey in the Dutch longitudinal GLOBE study, which was conducted in October 2004 ( $n=4785$ ; response 64.4%) among a sample of adults aged 25–75 years. The study area consisted of Eindhoven, the fifth largest city in the country, and its surrounding municipalities that range from small and rural to mid-sized and urban in character. More about the design, objectives and results of the GLOBE study can be found elsewhere.<sup>23–25</sup>

### Principal dependent variable: smoking status

The outcome measure was daily smoking, which was measured with the question ‘Do you smoke daily?’, with answering options yes/no.

### Principal independent variable: socio-economic position

Socio-economic position was measured by educational attainment and net household income. Educational attainment was scored into four categories: primary education only, lower secondary education, upper secondary education and tertiary education. Household income was divided into four categories: less than €1200 monthly, €1200–1800 monthly, €1800–2600 monthly and more than €2600 monthly, with a special additional category ‘Don’t want to say/don’t know’.

### Explanatory variables: individual-, household- and neighbourhood-level factors

The range of potential explanatory factors that were included consisted of measures of material and (psycho-) social adversity at the individual-, the household- and the neighbourhood levels. Individual-level factors were grouped into two types of explanatory factors. One group included measures of personal beliefs about stress and stressors, and about smoking in people’s environment, and another group included measures of social adversity. Questions that were asked were: ‘I have a lot of stress’, ‘most people in my surroundings smoke’, ‘housemates, or visitors smoke in my house’, ‘I can smoke at my work’, ‘cigarettes are affordable’. Response options were yes/no. Psychosocial adversity was measured by asking for a number of psychosocial stressors that respondents experienced over the past year, including stressors such as moving house, becoming unemployed, divorce or death of partner or family member (response options were yes/no). We calculated a score based on the count of the number of stressors respondents indicated to have experienced.

Social adversity was measured with four questions about specific social events that respondents participated in. Respondents were asked whether or not they (i) have friends/family over for dinner at least once a month, (ii) go out for a night at least once a month, (iii) go on holiday for at least 1 week per year and (iv) they are a member of a social, cultural or sports club/association. When respondents answered ‘no’ to any of these questions they were asked to indicate if this was due to financial reasons or not.

Household-level factors included measures of material adversity. Respondents were asked how many financial problems they experienced during the previous year (response options were ‘no’, ‘some’ or ‘many’). Also, they were asked about the current financial situation of their household (response options: ‘can save lots of money’, ‘can save money’, ‘can make ends meet’, ‘have to spend savings’ or ‘have to loan/make debts’). Respondents further indicated whether or not they owned a car, whether or not their house was renovated in the past 10 years. Using indicators of household and dwelling size, the number of people per room

was calculated for each household (dichotomized into ‘<1 person per room’, and ‘≥1 person per room’).

Neighbourhood-level determinants were measured by asking for people’s perceptions about material and social conditions in their neighbourhood. In previous analyses, the perceptions were subjected to a factor analysis which yielded four factors (Eigenvalue >1). These factors were: (i) neighbourhood social network; a factor based on 13 items concerning aspects of social relationships (e.g. ‘I borrow stuff from my neighbours’, ‘I visit neighbours in their house’), (ii) social cohesion; factor based on 13 items about specific aspects of social relationships (e.g. ‘People in this neighbourhood agree on norms and values’, ‘People in this neighbourhood are willing to help each other’), (iii) feeling at home in one’s neighbourhood; a factor based on 13 items about one’s position within the neighbourhood (e.g. ‘I feel alone in this neighbourhood’, ‘I feel at home in this neighbourhood’) and (iv) social disorganization; a factor based on 11 items concerning the frequency at which certain adverse neighbourhood events occurred (e.g. litter, graffiti, people being hassled on the streets). The factor scores were divided into quartiles.

Associations of each of the factors mentioned above with smoking were estimated through logistic regression analyses, and were adjusted for age, sex and marital status. Second, we estimated educational and income inequalities in smoking, and we estimated the contribution of each of the factors to these inequalities, by subsequently including their measures in the regression analyses. Explanatory factors were only included if they proved to be related to smoking, and to education and/or income in logistic regression analyses, adjusted for age, sex and marital status. The distribution of smoking and the basic demographic variables across education and income are shown in table 1. All analyses performed were based on complete cases. The total (weighted) sample for this particular study amounted to  $n=2948$  (unweighted  $n=2706$ ).

We checked the variance of smoking between neighbourhoods to see if multi-level analyses were necessary. However, although there was variance in smoking between neighbourhoods, this variance was explained for a large part by differences in individual education level, and after adjusting for education, sex and age, neighbourhood variance in smoking was small. Random neighbourhood variance after adjustment was 0.026, with standard error of 0.024.

## Results

Associations of all explanatory factors with daily smoking are shown in [Supplementary Appendix tables S1–S4](#). Results indicated that several personal beliefs were associated with smoking. Those who indicated having a lot of stress (OR: 1.73; CI: 1.43–2.10), that most people in their surroundings smoke (OR: 4.31; CI: 3.51–5.30), that housemates/visitors smoke in their house (OR: 6.39; CI: 5.16–7.91), and that they can smoke at work (OR: 1.83; CI: 1.53–2.19) all had relatively high levels of smoking. In contrast, those who indicated that cigarettes were affordable had lower smoking levels (OR: 0.56, CI: 0.44–0.73). Psychosocial stressors were also associated with smoking, where those reporting having experienced two, or three or more life events reported more often to be smokers than those having experienced one or no life events.

Results indicated that all social adversity indicators were associated with higher levels of daily smoking. However, there were differences in the associations with smoking between individuals who reported that the reason for the adversity was financial and those who reported that the adversity was due to other reasons. Respondents who indicated that they did not participate in social activities because of financial reasons were daily smokers more often than those who indicated that they did not participate for non-financial reasons.

**Table 1** Characteristics of the GLOBE study—a stratified sample from the city of Eindhoven, The Netherlands (2004) with percentages of daily smoking

Sample characteristics	n <sup>a</sup> (%) <sup>b</sup>	Daily smoking <sup>b</sup>	
		No	Yes
Total	2706	77.8	22.2
Men	1357 (48.4)	77.7	22.3
Women	1349 (51.6)	78.0	22.0
Age group (in years)			
25–34	508 (22.0)	76.6	23.4
35–44	620 (27.0)	76.0	24.0
45–54	567 (24.4)	76.1	23.9
55–64	642 (19.2)	79.2	20.8
65–74	369 (7.4)	90.4	9.6
Marital status			
Married	1837 (67.0)	80.2	19.8
Registered partnership	125 (5.1)	73.3	26.7
Unmarried	472 (19.0)	73.5	26.5
Divorced	194 (6.9)	70.1	29.9
Widowed	78 (1.9)	77.2	22.8
Educational level			
Primary (Lowest)	123 (3.7)	68.2	31.8
Lower secondary	777 (26.2)	72.1	27.9
Upper secondary	781 (31.4)	74.5	25.5
Tertiary (Highest)	1025 (38.7)	85.4	14.6
Income (in €)			
<1200	260 (9.0)	67.7	32.3
1200–1800	553 (18.7)	74.4	25.6
1800–2600	748 (26.8)	75.2	24.8
>2600	912 (36.1)	83.8	16.2
Don't want to say/don't know	233 (9.4)	79.3	20.7

a: These numbers are unweighted, and reflect the actual numbers of participants in our data set

b: These percentages are weighted and thereby represent the prevalence rates as they existed in the population of Eindhoven by October 2004, the source population. The weight factors are calculated from the distribution of the characteristics in a random sample drawn from the municipal registry in Eindhoven, October 2004

Associations of household material and social characteristics with smoking demonstrated that the higher the material adversity, the higher the level of smoking. Associations were especially pronounced among participants reporting financial problems (OR many problems: 2.77; CI: 2.00–3.84, compared with those reporting no problems), and a bad financial situation in the household (OR have to loan/make debts: 3.23; CI: 2.13–4.90, compared with those who can save lots of money).

In contrast to the individual and household factors, neighbourhood factors were less strongly associated with smoking in our data. Social contacts and social cohesion in the neighbourhood were not associated with smoking. Neither did those reporting eight or more adverse neighbourhood conditions have higher odds of daily smoking in comparison to those reporting less adverse neighbourhood conditions. Respondents reporting more negative feelings towards the neighbourhood had lower odds of daily smoking than respondents reporting less negative feelings.

The contribution of these explanatory factors to educational and income inequalities in smoking were assessed. All explanatory factors included in the study were associated with one or both socio-economic indicators (data not shown). Potential explanatory factors that were not associated with daily smoking after adjustment for age, sex and marital status were excluded from further analyses. These factors were: car possession, house crowding, social contacts and social cohesion in the neighbourhood.

After mutual adjustment, educational level showed a strong association with smoking, although an independent association with income remained (table 2). Figures 1 and 2 demonstrate

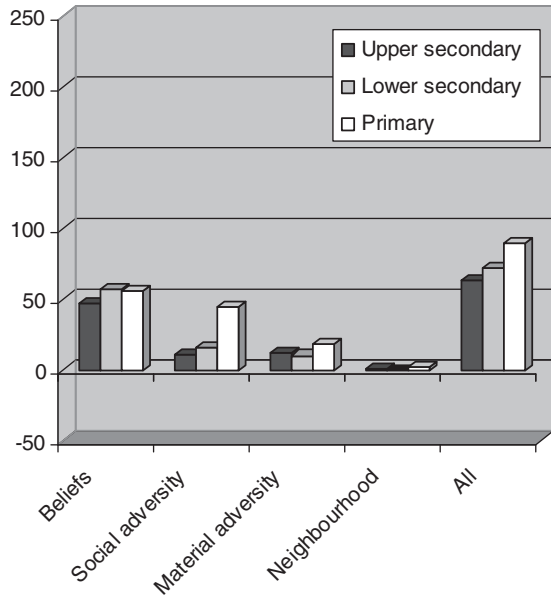
**Table 2** Socio-economic inequalities in daily smoking, and the contribution of explanatory factors

Socio-economic factor	Model 1: socio-economic status. Model contains either education or income	Model 2: education + income	Model 3: education + income + personal beliefs <sup>a</sup>	Model 4: education + income + social adversity <sup>b</sup>	Model 5: education + income + household material adversity	Model 6: education + income + neighbourhood factors	Full model
Education							
Tertiary	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upper secondary	2.08 (1.66–2.60)	1.93 (1.53–2.43)	1.49 (1.16–1.93)	1.83 (1.44–2.31)	1.82 (1.44–2.31)	1.92 (1.52–2.42)	1.34 (1.03–1.75)
Lower secondary	2.62 (2.06–3.34)	2.38 (1.83–3.08)	1.59 (1.19–2.11)	2.17 (1.66–2.83)	2.24 (1.72–2.92)	2.39 (1.84–3.10)	1.39 (1.03–1.87)
Primary	3.32 (2.12–5.21)	2.87 (1.78–4.62)	1.83 (1.09–3.08)	2.03 (1.24–3.32)	2.53 (1.56–4.11)	2.84 (1.76–4.57)	1.19 (0.69–2.06)
Income (in €)							
>2600	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1800–2600	1.73 (1.37–2.18)	1.39 (1.09–1.77)	1.19 (0.92–1.55)	1.29 (1.01–1.66)	1.17 (0.91–1.50)	1.38 (1.09–1.76)	1.04 (0.78–1.38)
1200–1800	1.74 (1.34–2.25)	1.23 (0.93–1.62)	0.84 (0.62–1.14)	1.01 (0.75–1.36)	0.86 (0.64–1.17)	1.22 (0.92–1.61)	0.66 (0.47–0.92)
<1200	2.31 (1.66–3.21)	1.55 (1.09–2.23)	1.09 (0.72–1.65)	0.99 (0.65–1.49)	0.88 (0.59–1.32)	1.52 (1.05–2.19)	0.68 (0.42–1.09)
Don't want to say/don't know	1.41 (1.00–1.97)	1.05 (0.74–1.49)	0.91 (0.62–1.14)	0.88 (0.61–1.28)	0.89 (0.62–1.28)	1.03 (0.73–1.47)	0.71 (0.47–1.07)

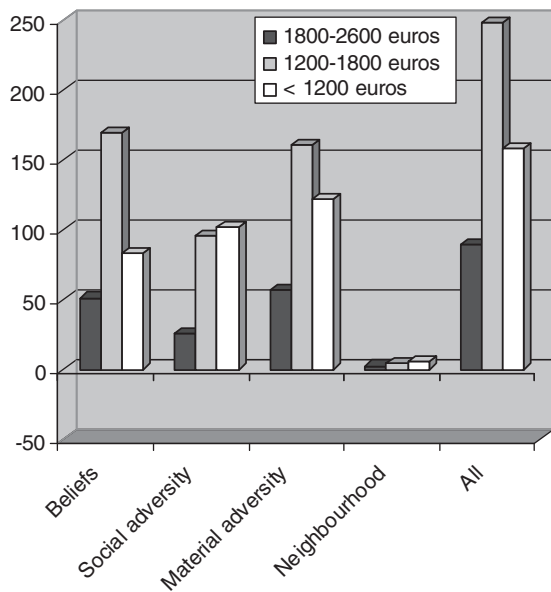
All associations adjusted for age, sex and marital status

a: Model 3 contains the following explanatory factors: 'I have a lot of stress', 'most people in my surroundings smoke', 'housemates, or visitors smoke in my house', 'I can smoke at my work', 'cigarettes are affordable' and psychosocial adversity

b: Model 4 contains the following explanatory factors: 'I have friends/family over for dinner at least once a month', 'I go out for a night at least once a month', 'I go on holiday for at least one week per year', 'I am a member of a social, cultural or sports club/association'



**Figure 1** Contribution of explanatory factors to educational inequalities in smoking



**Figure 2** Contribution of explanatory factors to income inequalities in smoking

the percentage contribution of the groups of explanatory factors to education and income inequalities in daily smoking. These percentages were calculated with the following formula:  $[100 \times (\text{OR reference model} - \text{OR full model}) / (\text{OR reference model} - 1)]$ . Percentages  $>100$  indicate that inequalities in smoking became reversed (i.e. higher socio-economic groups smoking more) after adjustment for a factor. In theory, factors could have contributed negatively to inequalities in smoking when they appeared to be related to non-smoking rather than smoking, or to higher socio-economic position rather than lower position. A negative contribution would indicate that a factor in fact reduces socio-economic inequalities in smoking. We only observed a very small and negligible negative contribution of neighbourhood factors in relation to education inequalities in smoking ( $-1\%$ ).

Adjusting income inequalities in smoking for household material adversity resulted in ORs  $<1$ , indicating that smoking was higher in higher income groups after adjustment,

corresponding to percentages of explained inequalities  $>100\%$ , although confidence intervals of the OR estimates included the value of 1. However, it accounted for relatively little of education inequalities in smoking; only between 10% and 18%. The contribution of personal beliefs was relatively important for education inequalities, contributing between 47% and 57%. In models with all explanatory factors included, income inequalities were completely attenuated (and reverse associations of income with smoking were observed), and education inequalities were attenuated largely—between 63 and 90%—but not completely. The following factors remained associated with daily smoking in these full models, suggesting that these constitute the main explanatory factors in our data: having a lot of stress, having smoking housemates and smoking people in surroundings, (not) being a member of social, cultural or sports club, not going on holidays yearly and having financial problems (data not shown).

## Discussion

In this study, we examined associations between education and income with smoking in a general population sample of adult men and women, and we estimated the contribution of a broad range of potential explanatory factors at the individual-, household- and neighbourhood-levels to these socio-economic inequalities in smoking. After adjustment for income, education remained strongly associated with smoking. Although an independent association between income and smoking remained, it appeared less strong than that observed for education. Individual beliefs about smoking contributed between 47% and 57% to the association of education with daily smoking. Household material adversity appeared to contribute most to the association of income with smoking; between 56% and 160%. We did not find evidence for a contribution of people's perceptions of their neighbourhood to inequalities in smoking. That material adversity contributed  $>100\%$  to income inequalities in smoking indicates that in situations where material adversity is absent, it is the higher income groups in our sample that show higher smoking rates.

This study was cross-sectional, which limits investigating causal pathways between explanatory factors and socio-economic inequalities in smoking. It does not seem likely that smoking causes psychosocial disadvantage and negative perceptions of the neighbourhood environment (at least not the kind that were measured in our study), although this cannot be completely ruled out; for instance, in situations where smokers interact with people or within a neighbourhood with outspoken negative norms and values toward smoking. With regard to individual beliefs, more doubts remain about the causal direction. It could well be that smoking increases levels of experienced stress,<sup>26</sup> and that people who smoke are more aware of places where they are able to smoke and places where they are not. Further research is required to firmly establish the direction and causality of relationships that were observed in the present study.

None of the explanatory factors included in our study really tap into elements of the broader cultural background. In truth, this may be difficult to operationalize in quantitative research [but for a discussion of methods to investigate culture effects on health, see Hruschka and Hadley (2008), and/or Weiss (2001),<sup>27,28</sup>] but qualitative research convincingly demonstrates its importance.<sup>15</sup> Strong cultural norms relating to smoking shape the smoking behaviour of communities and quantitative studies will not be able to provide a complete understanding of (socio-economic inequalities in) smoking if they do not include measures of such norms. In the current study, we measured respondent perceptions of norms through questions such as 'most people in my surroundings smoke', and 'I can smoke at work'. While these questions, to some extent, illustrate the norms with regard to smoking in surroundings of respondents, responses to these questions may be biased, as outlined in the previous paragraph.

Substantial missing data due to non-response reduced the sample size of the study and is likely to influence observed associations. When we checked the associations of education and income with smoking in the sample that had complete data on smoking and education and income, but could have missing data on other covariates ( $n=4281$ ), we observed that associations of education and of income with smoking were somewhat larger than the ones reported on the basis of complete case analyses (OR primary education in sample with complete cases only: 3.32; OR primary education in almost full sample: 3.79. OR income less than €1200 in sample with complete cases only: 2.31; OR income less than €1200 in almost full sample: 2.60). Item non-response was especially high for individual-level factors (up until 17.6% of cases for 'I can smoke at my work'), but was less high for household and neighbourhood factors. Missing values on individual-level factors were most often associated with education and income in a gradient, where the lower socio-economic groups displayed more item non-response, and were more frequent among smokers (with the exception of 'Cigarettes are affordable' which had much more missing among non-smokers as compared with smokers: 12.2% and 3.8%, respectively). These patterns of missing values suggest that the contribution of individual-level explanatory factors to socio-economic inequalities in smoking might have been underestimated relative to the contribution of household and neighbourhood explanatory factors. However, this possibility could not be tested in our sample.

It is important to identify additional factors that could explain socio-economic inequalities in smoking. For example, our neighbourhood factors were limited to people's perceptions about their neighbourhood and did not cover structural neighbourhood conditions that might well be relevant for understanding inequalities in smoking such as greater availability of cigarettes or worse provision of preventive health services.<sup>29</sup> Examples of household- and individual-level factors, which may be explanatory factors, between socio-economic status and smoking about which we had no information include the proportion of smokers in the household, detailed information on smoking history or nicotine dependence and personality factors such as mastery. The contribution of such factors should be addressed by future studies taking a comprehensive social-ecological approach.

Our study provided indications of important differences in both the magnitude and explanation of education versus income inequalities in smoking. This finding corresponds to previous indications that education appears to be more strongly associated with smoking than income is, before and/or after mutual adjustment of associations.<sup>21,30</sup> Because the proportion of the sample with a low level of education was smaller than the proportion in the lowest income category, it might be that this lowest educational group is more extremely disadvantaged and is therefore more strongly associated with smoking. We checked this by estimating the Relative Index of Inequality (RII) in addition to the regular OR estimates. RIIs enables direct comparison between socio-economic variables because they take account of differences in the proportions of the population in the different categories of a socio-economic variable.<sup>31</sup> RIIs also pointed out that the association of education with smoking was stronger than the association of income with smoking, after mutual adjustment (RII education 3.36; CI: 2.25–5.02, RII income 1.73; CI: 1.16–2.58). Income is a volatile measure of socio-economic position and measures of current income, such as the ones used in this study and in the previous studies, may not accurately reflect potential effects of cumulative exposure to low income. Nonetheless, these findings signal the importance of educational attainment as a fundamental determinant of smoking. While education has an influence on occupational class and income later in life, these are likely to be important factors in the causal pathway linking education to smoking.<sup>32</sup>

The major strength of this study was that we could investigate the contribution of a broad range of potential explanatory factors,

including material and psychosocial adversity, perceptions of people's neighbourhood environment and specific individual beliefs regarding barriers to smoking in one's environment. What these results demonstrate is that while it will be good to target tobacco control interventions to people's perceptions that are favourable toward smoking, tackling material and psychosocial adversity remains pertinent for reducing socio-economic inequalities in smoking.

## Supplementary Data

Supplementary data are available at *Eurpub* online.

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*Conflicts of interest:* None declared.

## Key points

- Both education and income had independent (of each other) associations with daily smoking.
- Individual beliefs about smoking contributed most to the association of education with daily smoking.
- Individual beliefs about smoking and household material adversity contributed most to the association of income with daily smoking.
- This study provided no evidence that differences in people's perceptions of their neighbourhood contributed to socio-economic inequalities in daily smoking.

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