


# Education is the strongest socio-economic predictor of smoking in pregnancy

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## ABSTRACT

**Aims** To investigate socio-economic disparities in smoking in pregnancy (SIP) by the mother's education, occupational class and current economic conditions. **Design** Cross-sectional analysis with linked survey and register data. **Setting** South-western Finland. **Participants** A total of 2667 pregnant women [70% of the original sample ( $n = 3808$ )] from FinnBrain, a prospective pregnancy cohort study. **Measurements** The outcome was smoking during the first pregnancy trimester, measured from the Finnish Medical Birth Register. Education and occupational class were linked from population registers. Income support reciprocity and subjective economic wellbeing were questionnaire-based measures of current economic conditions. These were adjusted for age, partnership status, residential area type, parental separation, parity, childhood socio-economic background, childhood adversities (the Trauma and Distressing Events During Childhood scale) and antenatal stress (Edinburgh Postnatal Depression Scale). Logistic regressions and attributable fractions (AF) were estimated. **Findings** Mother's education was the strongest socio-economic predictor of SIP. Compared with university education, adjusted odds ratios (aORs) of SIP were: 2.2 [95% confidence interval (CI) = 1.2–3.9;  $P = 0.011$ ] for tertiary vocational education, 4.4 (95% CI = 2.1–9.0;  $P < 0.001$ ) for combined general and vocational secondary education, 2.9 (95% CI = 1.4–6.1;  $P = 0.006$ ) for general secondary education, 9.5 (95% CI 5.0–18.2;  $P < 0.001$ ) for vocational secondary education and 14.4 (95% CI = 6.3–33.0;  $P < 0.001$ ) for compulsory schooling. The total AF of education was 0.5. Adjusted for the other variables, occupational class and subjective economic wellbeing did not predict SIP. Income support reciprocity was associated positively with SIP (aOR = 1.8; 95% CI = 1.1–3.1;  $P = 0.022$ ). Antenatal stress predicted SIP (aOR = 2.0; 95% CI = 1.4–2.8;  $P < 0.001$ ), but did not attenuate its socio-economic disparities. **Conclusions** In Finland, socio-economic disparities in smoking in pregnancy are attributable primarily to differences in the mother's educational level (low versus high) and orientation (vocational versus general).

**Keywords** Attributable fraction, birth cohort, pregnancy, smoking in pregnancy, socio-economic differences, socio-economic status, tobacco smoking, vocational education.

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Submitted 3 July 2017; initial review completed 21 August 2017; final version accepted 5 January 2018

## INTRODUCTION

Smoking in pregnancy (SIP) is a leading preventable cause of adverse birth outcomes [1,2] and can have long-term health and socio-economic effects on the offspring [3–5]. SIP is socio-economically patterned and expectant mothers in the lowest socio-economic groups are the most likely to smoke [6–9]. Because of its adverse effects, socio-economic (SES) disparities in SIP contribute to health and socio-

economic inequalities between children both in the short- and the long-term [5,10]. Understanding and tackling SES differences in SIP are health and social policy imperatives.

How should SES be measured in research on SIP and smoking more generally? A common practice is to use measures such as education [6,8,11,12], occupation [6,13,14], income [15] or area-level indicators [7,14,16] as proxies for an underlying SES. These measures are

correlated positively and they describe disparities in SIP that are similar, regardless of the measure [17,18].

Interchangeable use of SES measures can be less useful or even misleading for understanding the reasons behind inequalities in SIP. SES is multi-dimensional, and different measures can tap into different proximate determinants of health behaviours, such as smoking [19–21]. Furthermore, SES dimensions are shaped at different life-course stages, which overlap varyingly with the dynamics of smoking initiation, continuation and quitting [1,9,22–25]. Many women attempt to quit or reduce smoking when planning or learning of their pregnancy, and whether they do so and succeed is related to SES [9]. However, social disparities in SIP prevalence are also shaped by the socio-economic life-courses that affect smoking histories prior to pregnancy [9,22,23]. Understanding which SES indicators are the most relevant antecedents of SIP can point to the mechanisms that underlie these inequalities and suggest interventions for reducing them.

We adopt a multi-dimensional approach to analysing SES disparities in SIP. Our objective is to test how three dimensions of the mother's SES—educational attainment, occupational class and current economic wellbeing—predict smoking during the first trimester of pregnancy in a recent Finnish birth cohort study (FinnBrain). In contrast to the other Nordic countries, SIP has remained stable in Finland, at approximately 15% [6,26]. It is clearly more prevalent in lower than higher occupational groups. Analyses of smoking in non-pregnant populations have also found similar social gradients by other SES measures [27].

Of the three SES dimensions, economic wellbeing during pregnancy can affect attempts to quit smoking [9]. Economic strain is often accompanied by stress and low psychological wellbeing, which can explain why many disadvantaged women find it difficult to quit smoking [9,28]. Economic wellbeing is itself patterned by occupational class which, particularly in European social scientific research, is defined and measured as aggregates of occupations [29,30]. Occupational classes differ in long-term economic prospects and in working conditions and authority [29,30]. Stressful and repetitive work predicts continued smoking [28,31,32]. Classes also have a cultural dimension and differ in consumption and life-styles [33]. Smoking can form part of the everyday practices among the working classes, whereas those in the middle class can use avoidance of smoking as a cultural means to distinguish themselves from the working class [31,34,35].

Education is perhaps the most commonly used SES indicator in health inequality research, and determines occupational and economic position in later life. It has been argued to improve knowledge and resources that facilitate learned effectiveness and better control over one's life [28,36,37]. This argument is most compatible with a hierarchical definition of educational attainment and

education is nearly always measured accordingly. Yet, many countries' educational systems have separate vocational and general/academic tracks at the same levels of schooling that are difficult to order hierarchically [38]. Smoking behaviours can be patterned independently along these horizontal tracks [39,40]. Vocational and academic tracks prepare for different types of occupations. They can be exposed to expectations and social networks supportive of class-characteristic identities and consumption and behavioural patterns [40,41], including smoking [40,42,43]. Selection into these tracks often occurs in the early- to mid-teenage years (in Finland, at age 16), which overlaps with the ages at which regular smoking habits are generally formed [22,23,44].

We argue that contrasting education, occupational class and current economic conditions as independent predictors of SIP tells more about the source and nature of SES disparities in SIP than using these indicators interchangeably. Furthermore, we argue that recognizing horizontal aspects of educational attainment add to this understanding. In our analysis, we use measures of these three SES dimensions to analyse disparities in SIP, while adjusting for an extensive set of variables. We also test whether psychological stress exhibited as depressive symptoms during pregnancy accounts for the relationship between SES and SIP.

## DATA, MEASURES AND METHODS

### Setting

The FinnBrain Cohort Study is an ongoing transgenerational prospective observational study conducted at the University of Turku, Finland [45]. The subject cohort is a pregnancy cohort from South-western Finland. Participants were recruited between December 2011 and April 2015, at gestational week 12 ( $n = 3808$ ). Self-reported questionnaires—on-line or by mail—were administered three times during the pregnancy. The FinnBrain questionnaire data were linked to the Finnish Medical Birth Register (FMBR), maintained by the Finnish National Institute for Health and Welfare (NIHW), and to educational and occupational registers from Statistics Finland. We used information from the first questionnaire, administered during gestational week 14, which was answered by 81% ( $n = 3094$ ) of the mothers. Of these, 98% gave consent to linkage to Statistics Finland's register data, and 96% consented to linkage to FMBR. We excluded mothers born outside Finland ( $n = 97$ ) and before 1976 ( $n = 131$ ) because of missing register information on their childhood households. The final sample size was 2667 expectant mothers and the number of complete cases was 2396. The compiled data were analysed cross-sectionally. The Ethics Committee of the Hospital District of Southwest Finland approved the study (decision number 57/180/2011).

### Dependent variable: smoking during the first trimester

Our dependent variable was a binary indicator of whether the mother smoked during the first trimester of the pregnancy, constructed from information retrieved from FMBR. This information was collected by maternity clinic personnel who asked about smoking as part of the mother's visits during the pregnancy. Smoking was also surveyed in the FinnBrain questionnaire, and Cohen's kappa between the smoking information from these two sources indicated substantial agreement [46] ( $\kappa = 0.68$ ;  $P < 0.001$ ; agreement = 93.3%). We used the information from FMBR because of its almost complete coverage, but the results were similar with the questionnaire data (results available on request). First-trimester smoking (i.e. SIP) prevalence in the sample was 11.0% (294 of 2667), compared to approximately 15% nationally [6]. This lower prevalence is due possibly to South-western Finland's higher-than-average educational level [14]. Even though FMBR includes information on smoking after the first trimester we did not conduct a separate analysis of smoking cessation, because only 100 mothers (34.0% of those smoking during the first trimester) reported smoking beyond the first trimester.

### Socio-economic measures

Information on the mother's highest completed level of education as well as on occupation came primarily from Statistics Finland's registers (last record before childbirth), and in the case of missing register information from the FinnBrain questionnaire.

Our educational classification follows the International Standard Classification of Education 2011 [38] and addresses the characteristics of the Finnish system of differentiation between vocational and generalist tracks at both the secondary and tertiary levels. We distinguish between six educational levels. Compulsory schooling only (9 years) is the lowest level of education (level 1). At the secondary level, we distinguish between vocational secondary level degrees (level 2, 11–12 years), general/academic secondary level degrees (level 3, 12 years) and a combined general/academic secondary and a vocational secondary level degree (level 4, 12–15 years). At the tertiary level, we distinguish between vocationally orientated (lower) tertiary level education (polytechnics, level 5), and university degrees (level 6).

The mother's occupational class was measured using Eurostat's European Socio-economic Classification (ESeC) [29]. The salaried class includes professional, administrative, managerial and higher-grade technical and supervisory occupations. The intermediate class consists of higher-grade white- and blue-collar workers and the self-employed. The working class includes lower-grade services, sales and clerical technical, as well as routine occupations.

We also added the category 'not classified', that includes unemployed mothers (as reported in the questionnaire) and those who lacked any occupational history in the registers.

There were no missing values for the mother's educational attainment and occupation. We lacked this information for fathers in 776 (29.0%) cases, due mainly to the fathers' study non-participation. This non-participation was selective, which is why we used educational and occupational data only from the mothers. Supplementary analyses (available upon request) of the restricted data suggested that father's education and occupation, as well as household-level occupational class (measured as the highest class of the partners), have limited influence net of the mother's education and occupation.

Economic conditions during the pregnancy were measured using two questionnaire-based indicators. The first measures whether the mother's household received income support during the early pregnancy or the preceding 9 months. Income support is a last-resort social benefit paid to households that cannot cover essential living costs by regular income sources, and is an often-used poverty indicator in Finland [47]. The second indicator—subjective economic wellbeing (SEW)—is a global assessment of economic wellbeing and shaped by factors such as income, housing and consumption [48]. It was measured by asking about the mother's satisfaction with her economic situation on a scale from 0 (not at all satisfied) to 10 (completely satisfied), rescaled into tertiles.

### Additional independent variables

All models were adjusted for the following control variables: age (linear in years), partnership status (lives with a partner or not), type of residential area (urban or rural), parents' separation (before age 18), parity, socio-economic background [childhood household's reference person's socio-economic group (Statistics Finland's standard socio-economic groups)] and the Trauma and Distressing Events During Childhood (TADS) score [49]. We used the sum of the five domain-specific TADS severity scores as the measure of non-specified childhood traumatization [49].

Furthermore, we assessed whether antenatal stress—an important predictor of SIP [50]—attenuates SES differences in SIP. We used the Finnish version of the Edinburgh Postnatal Depression Scale (EPDS) [51], and used an EPDS score  $\geq 10$  to indicate antenatal depression [52].

The descriptive statistics of these variables are reported in Table 1.

### Statistical methods

We conducted three sets of cross-sectional analyses. First, we estimated SIP prevalence separately by each SES

**Table 1** Descriptive statistics of the additional independent variables and  $P$ -value of  $\chi^2$  test,  $t$ -test or median test comparing non-smokers and smokers.

	All ( $n = 2667$ )	Non-smokers ( $n = 2373$ )	Smoked during the 1st trimester ( $n = 294$ )	$P$ -value
Age				< 0.001 ( $t$ -test)
Mean	29.9	30.1	28.2	
SD	4.1	3.9	4.7	
TADS score				< 0.001 (median test)
Mean	9.7	9.2	13.5	
95% CI for mean	9.3–10.1	8.8–9.6	12.1–15.0	
median	6.0	6.0	9.5	
Lives with partner				< 0.001 ( $\chi^2$ test)
Yes	96.1%	97.2%	86.7%	
No	3.9%	2.8%	13.3%	
Nulliparous				0.003 ( $\chi^2$ test)
Yes	53.4%	52.3%	61.6%	
No	46.6%	47.7%	38.4%	
Type of residential area				0.041 ( $\chi^2$ test)
Urban	71.1%	71.7%	66.0%	
Rural	28.9%	28.3%	34.0%	
Parent's separation during childhood				< 0.001 ( $\chi^2$ test)
Yes	28.5%	26.2%	47.0%	
No	71.5%	73.8%	53.0%	
Childhood household's reference person's socio-economic group				< 0.001 ( $\chi^2$ test)
Upper-level employee	29.5%	31.2%	16.0%	
Lower-level employee <sup>a</sup>	44.5%	44.0%	48.3%	
Manual worker	23.6%	22.7%	31.3%	
Other/not classified	2.4%	2.2%	4.4%	
EPDS score				< 0.001 ( $\chi^2$ test)
< 10	86.1%	87.8%	73.2%	
$\geq 10$	13.9%	12.2%	26.8%	

Target population: the FinnBrain cohort mothers born 1976 or after ( $n = 2667$ ); data sources: FinnBrain questionnaires, except smoking in first trimester (linked from the Finnish Medical Birth Registry), and childhood household's reference person's socio-economic group (linked from Statistics Finland's registers). Number of missing values: age 0; TADS 161; partnership status 0; parity 0; type residential area 0; parent's separation during childhood 67; childhood household's reference person's socio-economic group 0; EPDS 111. Simulated multiple imputes for missing values were used for estimating proportions of cases in different categories of parent's separation and EPDS, and for linear predictions of mean and median of TADS. Non-imputed data were used for calculating  $\chi^2$  tests,  $t$ -test and median test. <sup>a</sup>Including farmers, self-employed and small-business employers. SE = standard error; CI = confidence interval; EPDS = Edinburgh Postnatal Depression Scale; TADS = Trauma and Distress Scale.

variable. Second, we estimated a set of logistic regression models. Model 1 estimated the effects of the SES variables separately and model 2 entered them simultaneously, in both cases adjusting for the control variables. Model 3 assessed whether the SES differences remained once adjusting additionally for antenatal stress (EPDS score). Logistic regressions were estimated using the Stata software (version 14.1). Some of the explanatory variables had missing values, and we used Stata's simulation-based multivariate imputation by chained equations (MICE) procedure [53,54] to include the cases with missing values. We used linear, multinomial and binary logistic regressions for the 20 imputations of continuous, categorical and dichotomous variables, respectively.

Third, we complemented the logistic regressions by calculating attributable fractions (AF), stratum-specific attributable fractions ( $sTAF$ ) and total attributable fractions

( $TAF$ ) to quantify the burden of SIP due to the differences by the socio-economic variables [8,55].  $AF$  represents the proportion of SIP in group  $i$  that can be attributed to the excess smoking in that group, and was calculated with [55]:

$$AF_i = (aOR_i - 1)/aOR_i. \quad (1)$$

$aOR_i$  is the adjusted odds ratio (OR) of SIP in group  $i$  relative to the reference group, estimated with logistic regression in model 3. Categories with the lowest SIP prevalences (university education, salaried class, no income support, highest tertile of SEW) were used as the reference groups.

$sTAF$  represents the proportion of SIP in the total population that would not exist in the absence of the excess SIP in group  $i$ , and is calculated by weighting the  $AF$  value of each group (stratum) by its relative size  $P_i$  [55]:

$$sTAF_i = AF_i \times P_i. \quad (2)$$

Finally, *TAF* is the sum of the *sTAF* values for each variable and it estimates the proportion of SIP in the total population that would not exist in the absence of differences between the categories of each respective variable [55]:

$$TAF = \sum_i (sTAF_i). \quad (3)$$

## RESULTS

The prevalence of SIP was clearly determined by the socio-economic variables (Table 2). Expectant mothers who received income support were more likely to smoke during the first trimester (36.4%) than those who did not (9.8%), and mothers within the lowest SEW tertile smoked more (14.9%) than mothers in the middle (8.9%) or highest (7.4%) tertiles. By class, SIP prevalence ranged from 3.6% among the salaried class to 24.1% among the unemployed or those without any occupational career. SES differences were the largest when measured by educational attainment, ranging from 2.2% (university degree holders) to 43.8% (compulsory schooling only). Education also differentiated SIP along its horizontal dimension, and expectant mothers with vocational degrees were consistently more likely to smoke than those with general/academic degrees at the nominally same

educational level. This was true even for those with a dual secondary degree, who smoked more often (12.7%) than those with only a general/academic degree (9.3%).

Table 3 presents the results from the logistic regression analyses. Each socio-economic variable had a statistically significant association with SIP when adjusting for the control variables (model 1). The associations were (inversely) gradient-like, with the exception of education, which differentiated SIP both along its level and vocational orientation. The OR of SIP was always higher for the mothers with vocational than generalist (/academic) education of the nominally same level.

Model 2 included all of the SES variables simultaneously. Occupational class and SEW were no longer statistically significant predictors of SIP and the ORs were substantially attenuated. The OR for income support recipients was similarly attenuated, but it remained statistically significant [OR = 1.9, 95% confidence interval (CI) = 1.1–3.2;  $P = 0.018$ ].

Education remained the most consistent socio-economic predictor of SIP, and was the main variable responsible for the attenuated effects of the other SES variables (additional analyses, not shown), although the educational differences were somewhat attenuated. Education continued to determine SIP both along its vertical and horizontal dimensions. Smoking was the least common

**Table 2** Smoking in the first pregnancy trimester by education, occupational class, income support reciprocity and subjective economic wellbeing.

	N	Non-smoker		Smoked during the 1st trimester		P-value of $\chi^2$ test
		n	%	n	%	
Level and type of highest education						< 0.01
Tertiary level: university degrees	776	759	97.8	17	2.2	
Tertiary level: vocational degrees	804	762	94.8	42	5.2	
Secondary level: vocational + general sec. school degree	220	192	87.3	28	12.7	
Secondary level: general sec. school degree	216	196	90.7	20	9.3	
Secondary level: vocational degree	578	423	73.2	155	26.8	
Compulsory schooling only	73	41	56.2	32	43.8	
Occupational class (ESeC)						< 0.01
Salaried class	1130	1089	96.4	41	3.6	
Intermediate class	406	368	90.6	38	9.4	
Working class	965	790	81.9	175	18.1	
Not classified	166	126	75.9	40	24.1	
Received income support						< 0.01
Yes	107	68	63.6	39	36.4	
No	2523	2275	90.2	248	9.8	
Subjective economic wellbeing (SEW)						< 0.01
Lowest tertile	1112	946	85.1	166	14.9	
Middle tertile	824	751	91.1	73	8.9	
Highest tertile	719	666	92.6	53	7.4	

Target population: the FinnBrain cohort mothers born 1976 or after ( $N = 2667$ ); data sources: FinnBrain questionnaires, except smoking in first trimester (linked from the Finnish Medical Birth Registry), education, occupational class and childhood household's reference person's socio-economic group (linked from Statistics Finland's registers). Number of missing values: education 0; ESeC 0; income support reciprocity 37; SEW 12. Non-imputed data were used for calculating smoking prevalences and  $\chi^2$  tests. ESeC = European Socio-economic Classification.

**Table 3** Logistic regression on the risk of smoking in the first pregnancy trimester (multiple imputation estimates): effects of education, occupational class (ESeC), income support reciprocity, subjective economic wellbeing (SEW) and depressive state in the first trimester (the EPDS score).

	<i>Model 1</i>			<i>Model 2</i>			<i>Model 3</i>		
	OR	95% CI	<i>P</i> value	OR	95% CI	<i>P</i> value	OR	95% CI	<i>P</i> -value
Level and type of highest education									
Tertiary level: university degrees	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Tertiary level: vocational degrees	2.2	(1.2–4.0)	0.007	2.1	(1.2–3.8)	0.013	2.2	(1.2–3.9)	0.011
Secondary level: vocational + general sec. School degree	5.4	(2.8–10.2)	< 0.001	4.3	(2.1–8.9)	< 0.001	4.4	(2.1–9.0)	< 0.001
Secondary level: general sec. school degree	3.5	(1.7–6.9)	0.001	2.8	(1.3–6.0)	0.006	2.9	(1.4–6.1)	0.006
Secondary level: vocational degree	12.3	(6.8–22.1)	< 0.001	9.7	(5.1–18.6)	< 0.001	9.5	(5.0–18.2)	< 0.001
Compulsory schooling only	20.5	(9.8–43.0)	< 0.001	14.4	(6.3–33.0)	< 0.001	14.4	(6.3–33.2)	< 0.001
Occupational class (ESeC)									
Salaried class	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Intermediate class	2.3	(1.4–3.6)	0.001	1.2	(0.7–2.0)	0.508	1.2	(0.7–2.0)	0.509
Working class	4.0	(2.8–5.8)	< 0.001	1.3	(0.8–2.1)	0.322	1.3	(0.8–2.1)	0.295
Unemployed or no occupation	4.4	(2.6–7.5)	< 0.001	1.2	(0.6–2.3)	0.613	1.2	(0.6–2.3)	0.569
Received income support									
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	2.5	(1.6–4.1)	< 0.001	1.9	(1.1–3.2)	0.018	1.8	(1.1–3.1)	0.022
Subjective economic wellbeing (SEW)									
Lowest tertile	1.7	(1.2–2.4)	0.003	1.3	(0.9–1.8)	0.178	1.2	(0.8–1.7)	0.334
Middle tertile	1.0	(0.7–1.5)	0.804	1.0	(0.7–1.5)	0.912	1.0	(0.6–1.4)	0.803
Highest tertile	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
EPDS									
< 10							Ref.	Ref.	Ref.
≥10							2.0	(1.4–2.8)	< 0.001

Target population: the FinnBrain cohort mothers born 1976 or after ( $N = 2667$ ); controls (estimates not presented): age, partnership status, type of residential area, parents' separation, parity, childhood household's reference person's socio-economic group and the TADS score; model 1: separate models (each adjusted for controls) for education, ESeC class, income support reciprocity and SEW; model 2 = education + ESeC class + income support reciprocity + SEW + controls; model 3 = Model 2 + EPDS. Data sources: FinnBrain questionnaires, except smoking in first trimester (linked from the Finnish Medical Birth Registry), education, ESeC and childhood household's reference person's socio-economic group (linked from Statistics Finland's registers). Number of missing values: education 0; ESeC 0; income support reciprocity 37; SEW 12; age 0; TADS 161; partnership status 0; parity 0; type residential area 0; parent's separation during childhood 67; childhood household's reference person's socio-economic group 0; EPDS 111. Logistic regressions were estimated using multiply imputed data for missing values. EPDS = Edinburgh Postnatal Depression Scale; TADS = Trauma and Distress Scale; ESeC = European Socio-economic Classification.

among university graduates and clearly the most common among mothers with only compulsory schooling (OR = 14.4, 95% CI = 6.3–33.0;  $P < 0.001$ ). Mothers with vocational degrees continued to have higher ORs of SIP than mothers with generalist (/academic) education at the nominally same level.

In model 3 (see Table 3), the inclusion of antenatal depression attenuated the associations between the socio-economic measures and SIP only marginally.

Table 4 shows the relations between the socio-economic variables and SIP in terms of ORs, AFs, sTAFs and TAFs. The ORs reported in Table 4 and used for calculating the AF measures were from the fully adjusted model (model 3 in Table 3). The sTAFs and TAFs show how much the excess SIP in specific socio-economic groups contributed to the total burden of SIP. For example, the sTAF for mothers with vocational secondary-level education (sTAF = 0.19) means that the total burden of SIP would have been 19% lower

without their excess SIP. Even though the OR of SIP was even higher among mothers with only compulsory schooling, the small size of this group meant that its contribution to the total burden of SIP remained limited (sTAF = 0.03).

Fifty per cent of SIP could be attributed to excess SIP among mothers who did not have a university degree, as shown by the TAF for education (TAF = 0.5). Next to vocational secondary education, the excess SIP of vocational tertiary educated mothers contributed 16% to its total burden (sTAF = 0.16). The contributions of the remaining educational groups were smaller. Similarly limited were the TAFs of the other socio-economic variables and of antenatal stress.

## DISCUSSION

Mother's education is the most important socio-economic predictor of smoking during the first pregnancy trimester.

**Table 4** The effects of the socio-economic status (SES) measures on the burden of smoking: number (*n*) and fraction (%) of women in each socio-economic stratum, adjusted odds ratio (aOR; from model 3, Table 3), attributable fraction (AF) and stratum-specific total attributable fraction (sTAF).

	<i>N</i>	%	aOR	AF	sTAF
Level and type of highest education					
Tertiary level: university degrees	776	29.1	Ref.	Ref.	Ref.
Tertiary level: vocational degrees	804	30.1	2.2	0.54	0.16
Secondary level: vocational + general sec. school degree	220	8.2	4.4	0.77	0.06
Secondary level: general sec. school degree	216	8.1	2.9	0.65	0.05
Secondary level: vocational degree	578	21.7	9.5	0.89	0.19
Compulsory schooling only	73	2.7	14.4	0.93	0.03
All categories (TAF)					0.50
Occupational class (ESeC)					
Salaried class	1130	42.4	Ref.	Ref.	Ref.
Intermediate class	406	15.2	1.2	0.16	0.02
Working class	965	36.2	1.3	0.23	0.08
Unemployed or no occupation	166	6.2	1.2	0.17	0.01
All categories (TAF)					0.12
Received income support					
No	2523	95.8	Ref.	Ref.	Ref.
Yes	107	4.2	1.8	0.46	0.02
All categories (TAF)					0.02
Subjective economic wellbeing (SEW)					
Lowest tertile	1112	41.9	1.2	0.16	0.07
Middle tertile	824	31.0	1.0	-0.05	-0.02
Highest tertile	719	27.1	Ref.	Ref.	Ref.
All categories (TAF)					0.05

Target population: the FinnBrain cohort mothers born 1976 or after ( $n = 2667$ ). Data sources: FinnBrain questionnaires, except smoking in first trimester (linked from the Finnish Medical Birth Registry), education and occupational class (linked from Statistics Finland's registers). Non-imputed data were used when reporting number of cases in variable categories. Simulated multiple imputations for missing values were used for estimating proportions of cases in categories of income support reciprocity ( $n$  missing values = 37) and SEW ( $n$  missing values = 12). ESeC = European Socio-economic Classification.

Of the other socio-economic variables (occupational class, subjective wellbeing and income support reciprocity), only income support reciprocity remained a statistically significant predictor once adjusting for the other SES measures. Because receiving income support is relatively uncommon among pregnant women, the excess SIP in this group contributed only marginally to the total burden of SIP. At the same time, SIP prevalence would be reduced by 50% by eliminating its educational differences. Importantly, we found that educational disparities in SIP are determined both vertically and horizontally. In addition to the commonly reported inverse SIP gradients by vertically measured education [8,9,11,12], SIP was robustly more common among expectant women who had vocationally orientated degrees, at both the secondary and tertiary levels.

What do these findings imply for understanding social disparities in SIP? First, although multiple SES measures can be used to describe social disparities in SIP, different measures tap into different dimensions of SES. They are formed varyingly over the life-course and highlight different social mechanisms that shape smoking. Interchangeable use of SES measures does not inform about these

dimensions and hinders understanding of the reasons for these social disparities [19–21,37]. Secondly, the central role of education in understanding disparities in SIP suggests that they have their roots in early adolescence [44,56]. Educational disparities in smoking prevalence are due more to differential initiation than quitting rates [22]. Although current socio-economic conditions can predict SIP independently, education is much more important for its total burden, pointing to the importance of the life-course stage when educational disparities are formed. Thirdly, education determines SIP along both its vertical and horizontal dimensions, suggesting that differences in knowledge and learned effectiveness provide at most a partial explanation to educational disparities in SIP [28,36,37]. Furthermore, although psychological stress predicted higher rates of SIP [28,50], it did not explain its social disparities.

A possible explanation for the excess SIP among mothers with vocationally orientated educations includes a mutually reinforcing process between socialization into 'class cultures' of smoking [31,33–35,41,43] and peer influences [42,44,56]. Different educational experiences can expose youths to behavioural expectations specific to

their future occupation and class [36], and peers can reinforce the behavioural effects of these expectations [37,39,56].

The prevalence of early pregnancy smoking in Finland has remained at approximately 15% [6,26]. The reasons for why SIP is more common in Finland than in the other Nordic countries are not well understood. Our findings point to the importance of addressing emerging educational disparities in smoking in adolescence for reducing the total burden of SIP and its consequences [2,8]. Reducing the smoking of women with vocationally orientated education would be particularly effective in reducing SIP. Future research should attempt to reproduce these findings in other contexts and aim to understand the structural, cultural and social processes that lead to differentiation in adolescent smoking habits across school tracks [40,42–44].

### Strengths and limitations

A major strength of this study was the integration of questionnaire and population register data that enabled us to construct a richer data set than would be possible with the separate data sources alone. The former enabled us to measure SEW and psychosocial symptoms as well as control for several potential childhood root causes of smoking. The register information on education and occupation allowed accurate measurement of these variables. We are not aware of previous studies of SES differences in SIP that have separated horizontal from vertical educational disparities. This provides more detailed substantive information on inequalities in SIP and functions as a more effective control variable.

The well-documented benefits and disadvantages of using self-reported information on smoking apply to this study [57]. The findings can also be biased due to other types of misclassification and study non-participation. The lack of smoking history data limit tracing the life-course sources of smoking disparities, and our limited case numbers did not allow separate analysis of quitting after the first trimester. We also did not know whether the expectant mother received any treatment for quitting smoking.

Our data had only limited information on the education and occupation of the partner. The relevance of the household's, or other household members', SES has been discussed in the literature on SES measurement [19,58]. Individual SES measures have been argued to be theoretically the most meaningful for analysing behavioural outcomes such as smoking [58]. Our supplementary analyses (available upon request) suggested that education and occupation of the partner (or class measured at the household level) indeed have limited influence on SIP, but due to our data restrictions, definitive conclusions are left

for future research. Our data were restricted similarly regarding information on the partner's smoking.

### CONCLUSIONS

Different SES measures should not be used interchangeably if we want to understand the reasons for social disparities in SIP. Education is the most important socio-economic predictor of SIP and determines SIP along both its vertical and horizontal dimensions. Programmes to reduce inequalities in and prevalence of SIP should aim to prevent smoking during the late teenage years, and should particularly target adolescent girls attending vocational education.

### Declaration of interests

None.

### Acknowledgements

This research was supported by funding from the Academy of Finland (decision numbers 134950, 253270 and 287908) and the Signe and Ane Gyllenberg Foundation.

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