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Early Life Predictors Of Adolescent Smoking: Findings From The Mater-University Study Of Pregnancy And Its Outcomes

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Abstract

In this study we have examined the early life predictors of smoking at age 14 in a birth cohort of individuals born in Brisbane, Australia between 1981 and 1984. In stratified and multivariable analyses maternal smoking throughout pregnancy and when the child was aged 14 were both associated with the child smoking: fully adjusted odds ratio [95% confidence interval] comparing maternal smoking throughout pregnancy with never smoking was 1.40 [1.25, 1.65] and that comparing maternal smoking when the child was aged 14 with not smoking was 1.57 [1.19, 2.06]. The association of maternal smoking throughout pregnancy was specific for adolescent smoking and was not associated with alcohol consumption, TV viewing or self-report of poor school performance at age 14. Maternal and paternal educational attainment were also associated with smoking at age 14, with these associations attenuating towards the null with adjustment for childhood behavioural problems and cognitive function. There was no association of family income with smoking at age 14 once other explanatory variables were taken into account.

Introduction

There is increasing evidence that the pathological pro-cesses involved in the development of atherosclerosis are established in childhood, [1–3] and that risk factors from across the life course are important in the development of cardiovascular disease (CVD). [4] Smoking is an important determinant of CVD and a number of other adverse health outcomes. Adolescence has been referred to as a sensitive period with respect to learning about and adopting smoking behaviours which then persist into adulthood [5,6] and, in part, smoking and other behavioural risk factors explain the association between adverse childhood socio-economic position and adult cardiovascular disease. [7]

Smoking among adults, particularly those from the more affluent social classes, has declined in many developed countries in recent decades. [8,9] However, there is evidence that in several industrialised countries smoking in adolescence is increasing. [9,10] In Australia, whilst rates among boys aged 15–19 (the youngest age for which consistent temporal data are available) have declined considerably since the 1940s, in the last 15 years this decline has ceased (Fig. 1). 9,11 Furthermore, among girls in this age group rates have increased since the 1940s and are now greater than those for boys (Fig. 1). In the last period for which data are available (1996–2000)

24.0% of Australian boys and 27.1% of Australian girls aged 15–19 were smokers. 9,11 Thus approximately one-quarter of Australian adolescents are current smokers. In order to develop appropriate preventive interventions to reduce population levels of smoking, understanding the correlates of adolescent, or early life initiation of, smoking is important. [12]

Several studies have shown that smoking in adolescence is socially patterned and also related to parental smoking behaviour. [13–17] However, these studies have been largely cross-sectional and have been unable to determine the influences of these exposures at different stages of the life course. One study has assessed the association of maternal smoking during pregnancy with offspring smoking and found that it was independently (of maternal smoking at the time of assessment) associated with smoking in early adulthood. [18] Similarly a small number of studies provide some evidence that socio-economic position in early childhood is independently (of later socio-economic position) associated with smoking behaviour in young adulthood. [13] To develop effective preventive initiatives it is important, not only to know which factors are associated with adolescent smoking, but also whether there are specific periods of exposure in the life course that particularly increase risk and/or whether there are cumulative effects across the life course. If exposures in early life to parental smoking and socio-economic circumstances in earlier life have important influences on adolescent smoking irrespective of whether these exposures are present around the time of adolescence then preventive initiatives will need to focus on these earlier periods and not just the time around adolescence.

In addition, it is important to understand the path-ways that may link early exposures such as socio-economic position and maternal smoking with adolescent behaviours. There are associations between psychosocial factors, such as self-esteem, childhood mental health and cognitive ability and smoking in adolescence. [17,19–21] These psychosocial factors are themselves influenced by socio-economic position in early life and by maternal smoking. [22–26] Thus, childhood mental health and cognitive ability may mediate any associations between maternal smoking during pregnancy and socio-economic position in infancy and adolescent smoking.

The aim of this study was to examine the associations of early life socio-economic position, parental education and maternal smoking in pregnancy on adolescent smoking behaviour and to determine the role of potential mediating factors (childhood mental health and cognitive function) in explaining these associations.

Methods

Participants

The Mater-University study of pregnancy and its out-comes (MUSP) is a prospective study of women and their offspring, who received antenatal care at a major public hospital (Mater Misericordiae Hospital) in South Brisbane between 1981 and 1984. [27] Consecutive women attending their first antenatal visit were invited to participate in the study (n = 8556). Of these 8556 mothers invited to participate 98 refused, 710 did not deliver a live child at the public hospital (including 169 miscarriages and those who chose to use other facilities), 59 mothers had multiple births, 312 did not complete the postnatal data collection phase, 99 children died during or immediately after delivery and 55 children were adopted prior to discharge. In total 7223 (84% of mothers invited to participate) agreed to participate, delivered a live singleton baby who was not adopted prior to leaving hospital, and completed ante-natal, perinatal and early post-natal phases of data collection; these mothers and their offspring form the MUSP prospective cohort.

Full perinatal data concerning mother and child were obtained at the study initiation from interviews with the mothers at their clinic visits and during their hospital stay and from obstetric records. The mothers and children have been followed up prospectively with maternal questionnaires, covering a wide range of psychosocial and health questions concerning them-selves, their partners and their children, being administered when the children were 6 months, 5 and 14 years old. In addition, at 5 and 14 years detailed physical, cognitive and developmental examinations of the children were undertaken, and at 14 years the children completed health, welfare and lifestyle questionnaires. The original study and subsequent follow-up assessments received ethical approval from ethics committees at the University of Queensland.

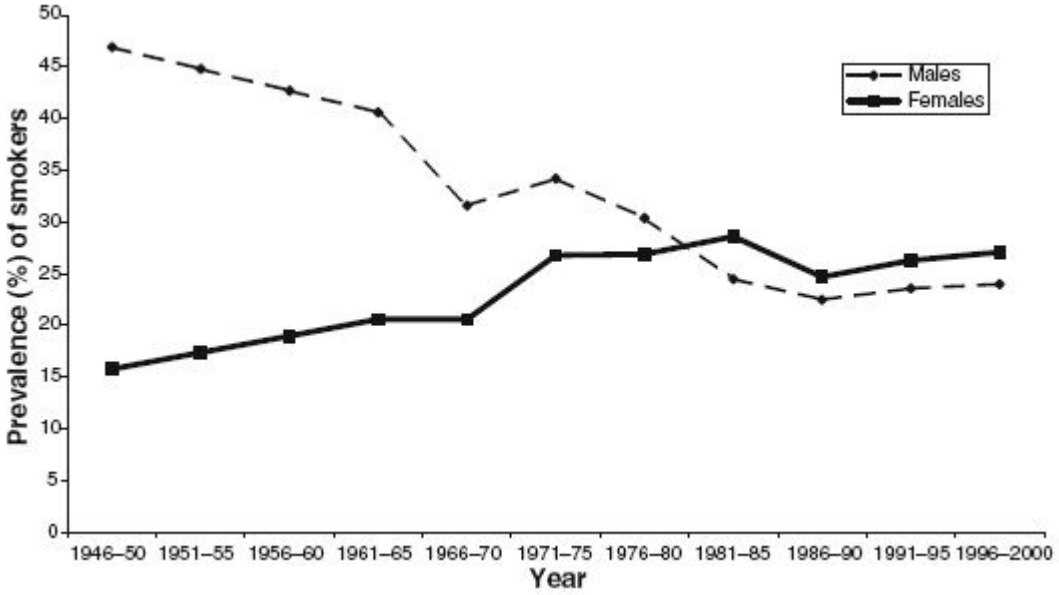

Figure 1. Prevalence (%) of smoking among Australian males and females aged 15–19, 1946–2000.

Assessment of outcome and exposures

At age 14 the children were asked if they smoked cigarettes and were given the response options: often, sometimes, never or rarely. They were further asked 'in the last week how often have you smoked?' (every day, every few days, once/so, not at all) and 'how many cigarettes have you smoked in the previous week?' (nil, 1–9, 10–19, 20–29, 30–49, >-50 cigarettes in the previous week). Smoking at age 14 was categorised as never (answered never/rarely to first question, not at all to second and nil to third) or smoker (answered sometimes or often to first question, at least once/so to second and at least 1–9 cigarettes per week to the third question). This classification resulted in 96 (1.9%) out of 5170 with smoking data at age 14 who could not be classified because of contradictions in their answers, that is, suggesting in one or more questions that they smoked but in at least one question that they did not. For the main analyses presented here these children were allocated to the smoking category. Two sensitivity analyses were undertaken in which these children were allocated to the non-smoking category and were excluded. The results of these sensitivity analyses did not differ from those presented here.

At the start of the study the mothers were asked about gross family income during the year of their pregnancy (0–2599; 2600–5199; 5200–10 399; 10 400–15 599; 15 600–20 799; 20 800–25 999; >-26 000 Aus $). These data were collapsed into three categories of low income: <10 400; middle income: 10 400–15 599 and high income >-15 600 Aus $, each including approximately one-third of the sample. When the child was aged 14 their mothers again reported the gross family income and this was categorised as low: <-25 999; middle: 26 000–$36 499; and high: >!363 500 Aus $, again with each category representing approximately one-third of the sample.

Maternal smoking data were obtained from questionnaires completed by the mother at her first antenatal clinic visit, at the end of pregnancy and when the child was aged 14. Smoking around the time of pregnancy was categorised as never, smoked prior to pregnancy only, smoked throughout pregnancy. Smoking when the child was aged 14 was dichotomised: yes or no. Maternal and paternal educational attainment was only collected at the first antenatal clinic visit with mothers reporting both their own and the father's highest educational attainment (did not complete secondary education, completed secondary education, completed further or higher education).

Child mental health was assessed from maternal reports of child behaviour using Achenbach's child behaviour checklist (CBCL) at ages 5 and 14. [28] Following Achenbach, child behaviour problems and psychiatric morbidity were assessed using two sub-scales which are indicative of the second-order groupings of syndromes that he identified. [28] These sub-scales include externalising behaviour (comprising delinquent and aggressive syndromes) and internalising

behaviour (consisting of items measuring withdrawn behaviour, somatic complaints and symptoms of anxiety/depression). The questionnaires used for maternal report were in their original form, except for a simplification in the presentation. [29] Factor analyses and reliability estimates of sub-scales of the CBCL produced results consistent with Achenbach's original data. [29] Also consistent with Achenbach, a case was defined as a participant scoring above the 90th percentile for the externalising or internalising sub-scales. [28]

When the children were aged 5, cognitive development was assessed using the revised Peabody Picture Vocabulary Test (PPVT-R). [30] Parents were invited to bring their children to the clinic for these assessments, but were also told that home visits could be under-taken if a clinic visit was difficult. It is believed that no more than one-third of the participants had the assessment at home. However, details of which children were assessed at home and which in the clinic were not kept in the database. The same trained paediatric researcher completed the assessments and the same procedures were used whether conducted in the clinic or at home. The PPVT-R is a measure of verbal comprehension. [30] The children look at a series of cards each with four pictures on them and are asked to identify which of the pictures depicts a word spoken by the administrator. It is reliable, correlates well with other measures of childhood intelligence, has good predictive value for future intellectual attainment and has been widely used in previous research. [31–33] The PPVTR scores were age-standardised using 6-monthly age groups in this study.

Table 1 Comparison of socio-economic position and smoking around the time of birth between children who responded at age 14 and those who did not

	% of participants responding at age 14 (*n*=5170)	Crude OR [95% CI] of responding	Adjusted [a] OR [5% CI] of responding
Family income at birth (Aus $)			
≤10 399	64.0	1.00 Reference	1.00 Reference
10 400–15 599	75.8	1.76 [1.56, 2.00]	1.61 [1.41, 1.83]
≥ 15 600	78.4	2.05 [1.78, 2.35]	1.78 [1.53, 2.06]
Maternal education			
Did not complete secondary	66.4	1.00 Reference	1.00 Reference
Completed secondary	72.0	1.31 [1.15, 1.49]	1.12 [0.96, 1.31]
Completed further or higher	75.6	1.57 [1.32, 1.86]	1.17 [0.96, 1.43]
Paternal education			
Did not complete secondary	68.8	1.00 Reference	1.00 Reference
Completed secondary	72.3	1.18 [1.03, 1.35]	1.07 [0.92, 1.25]
Completed further or higher	77.5	1.56 [1.30, 1.86]	1.25 [1.02, 1.52]
Maternal smoking around time of birth			
Never	76.6	1.00 Reference	1.00 Reference
Prior to but not during pregnancy	71.1	0.75 [0.63, 0.89]	0.71 [0.59, 0.86]
Throughout pregnancy	65.5	0.58 [0.52, 0.65]	0.64 [0.57, 0.72]

CI, confidence interval; OR, odds ratio.

[a] Mutually adjusted for all other variables in first column.

At age 14 assessments of cognitive function were based on youth scores on Raven's standard progressive matrices (Raven's SPM) [34] and the wide range achievements test version 3 (WRAT3). [35] Trained paediatric researchers undertook all of the assessments in the clinic. The Raven's SPM is a test of non-verbal reasoning ability or general intelligence (sometimes referred to as '*g*') that has been widely used for psychological assessment in clinical and educational contexts, for research and for personnel selection. [34] The Raven's SPM scores were age-standardised in 6-month intervals. The WRAT3 is an age-normed reference test that assesses reading and word decoding skills. [35] It is reliable, predictive of future educational attainment and has been widely used in research. [36,37]

Statistical analyses

Of the *7223* cohort participants, 5170 *(72%)* children completed the questionnaires and provided smoking data when they were aged 14; all of the mothers of these children completed their questionnaire at the 14 years follow-up. Responders were more likely to have been from high-income families at birth and less likely to have had mothers who smoked throughout their pregnancy (Table 1). Chi-square tests were used to assess differences in characteristics between smokers and non-smokers at age 14. Multiple logistic regression was used to further assess the association of socio-economic position at birth and maternal smoking in pregnancy with smoking at age 14.

There were small amounts of missing data (between 2 and 10% of the 5170) on several of the variables included in the multivariable models with the resultant effect that complete data were only available on every single variable included in the multivariable model on 2970 (57%) of those responding at age 14. We therefore used multiple imputation using all other variables in the analysis data set (i.e. all predictor variables and the outcome) to impute values for the missing data for each of the predictor variables with some missing data. [38] We used switching regression as described by Royston, [38] and carried out 50 cycles of regression switching and generated 10 imputation data sets. In addition, we undertook the multivariable analyses just on those 2970 with complete data on all variables. The simple sex and age-adjusted results in this subgroup were essentially the same as those for the whole sample Table 2). Further, the analyses with multiple imputations were essentially the same as those conducted just on the complete data set sub-group, although the confidence intervals for the former were narrower than the latter. These findings suggest that selection bias owing to missing data on some variables included in the multivariable analyses is unlikely. Results with the multiple imputations only are presented in the paper.

In all models adjustment was made for exact age (continuous variable) in days and sex. To determine whether socio-economic position at birth and maternal smoking in pregnancy were independently (of these characteristics assessed when the child was aged 14) associated with smoking at 14, we included family income and maternal smoking at the 14-year assessment as covariates in the model. To assess the possibility of model violation owing to collinearity, standard errors for each regression coefficient in this final model were compared with the standard errors for the equivalent regression coefficient in a model with only age and the single explanatory variable. [39] There was no evidence of important collinearity, with standard errors and confidence intervals being similar for each coefficient (see Table 3).

Stratifying the sample into those with low and medium or high family income at age 14 and those whose mothers did or did not smoke at age 14 further assessed these independent associations. To assess the mediating role of cognitive function and mental health in the associations these were entered into the multi-variable models as follows: (i) cognitive function at age 5 and 14 (Peabody, Raven's and WRAT3 – all continuous variables), and (ii) childhood mental health (any mental health problems – binary variable). Likelihood ratio tests were used to assess possible interactions between explanatory variables.

Results

Of the 5170 14-year-old participants, 743 (14.4%) were smokers. Table 2 shows the age-adjusted association of each potential explanatory variable with smoking at age 14. Family income at birth and age 14 were both associated with smoking at age 14, with those from families with the lowest income at either stage of the life course being more likely to smoke. The magnitudes of these associations were similar at each stage. Both lower maternal and paternal education were associated with increased odds of smoking at age 14, and maternal smoking around the time of birth and at age 14 were associated with offspring smoking at age 14. The magnitude of the associations of smoking throughout pregnancy with offspring smoking at age 14 and that between maternal smoking when the child was aged 14 and offspring smoking at that age were similar.

Table 2 Age-adjusted association of socio-economic position at birth, maternal smoking during pregnancy and other covariates with smoking at age 14 years

	Non-smoker *n* = 4427 (%)	Smoker *n* =743 (%)	AOR [95% CI] of being a smoker	P^b
Sex				
Male	86.0	14.0	1.00 Reference	0.32
Female	85.2	14.8	1.08 [0.93, 1.27]	
Family income at birth (Aus $)				
≤10 399	82.7	17.3	1.00 Reference	<0.001
10 400–15 599	85.5	14.6	0.84 [0.70, 1.01]	
≥ 15 600	88.9	11.1	0.62 [0.50, 0.77]	
Family income age 14 (Aus $)				
≤ 25 999	81.9	18.1	1.00 Reference	<0.001
26 000–36 499	86.7	13.3	0.70 [0.57, 0.85]	
≥ 36 500	88.0	12.0	0.63 [0.53, 0.76]	
Maternal education				
Did not complete secondary	81.8	18.2	1.00 Reference	<0.001
Completed secondary	85.4	14.6	0.78 [0.64, 0.96]	
Completed further or higher	89.8	10.2	0.53 [0.40, 0.70]	
Paternal education				
Did not complete secondary	82.7	17.3	1.00 Reference	0.001
Completed secondary	86.0	14.0	0.78 [0.64, 0.96]	
Completed further or higher	8.2	11.8	0.64 [0.49, 0.84]	
Maternal smoking around time of birth				
Never	89.2	10.8	1.00 Reference	<0.001
Prior to but not during pregnancy	86.4	13.6	1.30 [1.00, 1.71]	
Throughout pregnancy	80.1	19.9	2.02 [1.71, 2.39]	
Maternal smoking when child age 14				
No	89.1	10.9	1.00 Reference	<0.001
Yes	78.1	21.9	2.23 [1.90, 2.61]	
Mother's partner's smoking when child age 14				
No	10.4	89.6	1.00 Reference	<0.001
Yes	18.9	81.1	1.96 [1.64, 2.33]	
Childhood behaviours age 5				
Internalising				
No	86.0	14.0	1.00 Reference	0.23
Yes	87.5	12.5	0.85 [0.64, 1.11]	
Externalising				
No	87.1	12.9	1.00 Reference	<0.001
Yes	79.1	20.9	1.81 [1.43, 2.30]	
Any behavioural problems				
No	86.4	13.6	1.00 Reference	0.22
Yes	83.7	16.3	1.22 [0.87, 1.67]	
Childhood behaviours age 14				
Internalising				
No	86.3	13.7	1.00 Reference	<0.001
Yes	79.0	21.0	1.67 [1.31, 2.10]	
Externalising				
No	87.8	12.2	1.00 Reference	<0.001
Yes	66.1	33.9	3.60 [2.93, 4.42]	
Any behavioural problems				
No	87.2	12.8	1.00 Reference	<0.001
Yes	71.0	29.0	2.75 [2.23, 3.40]	
Cognitive function age 5				
Peabody (mean)[c]	100.2 (13.6)	98.9 (13.0)	0.91 [0.82, 0.99]	0.05
Cognitive function age 14				
Raven (mean) [c]	100.6 (14.8)	96.9 (15.0)	0.80 [0.73, 0.87]	<0.001
WRAT3 (mean) [c]	100.2 (14.9)	98.6 (15.0)	0.90 [0.82, 0.98]	0.02

CI, confidence interval; OR, odds ratio; WRAT3, wide range achievement test version 3.
[a] Age adjusted in days.
[b] *P* for the effect of the exposure on smoking at age 14 derived from the logistic regression model. Chi-square for binary and *F* -test for continuous.
[c] Odds ratio is per increase in one standard deviation.

Children who exhibited externalising behavioural problems at age 5 were more likely to be smokers at 14 and, both internalising and externalising problems at age 14 were associated with smoking at that age. All three measures of cognitive function were associated with smoking at age 14 with those with lower cognitive function being more likely to smoke. The strongest association was with Raven's test of general intelligence measured at age 14. Girls were slightly more likely to smoke than boys, although this difference was not statistically significant.

Table 3 shows the multivariable associations of socio-economic position at birth and maternal smoking throughout pregnancy with smoking at age 14. The width of the confidence intervals for the simple age and sex-adjusted odds ratios do not differ markedly from those for the fully adjusted odds ratios, suggesting that collinearity is not an important problem in these models.

Table 3 Multivariable association of socio-economic position at birth and maternal smoking throughout pregnancy with smoking at age 14 years

	OR (95% CI) of smoking after adjustment					
Main exposures	Model 1[a]	Model 2[b]	Model 3[c]	Model 4[d]	Model 5[e]	Model 6[f]
Family income at birth (Aus $)						
≤10 399	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference
10 400–15 599	0.83 [0.70, 0.98]	0.98 [0.83, 1.17]	1.14 [0.96, 1.36]	1.15 [0.97, 1.37]	1.20 [1.00, 1.43]	1.19 [1.00, 1.42]
≥15 600	0.64 [0.51, 0.79]	0.78 [0.62, 0.98]	0.93 [0.74, 1.16]	0.96 [0.77, 1.20]	0.97 [0.78, 1.21]	1.02 [0.82, 1.28]
P trend	<0.001	0.03	0.37	0.73	0.89	0.90
Maternal education						
Did not complete secondary	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference
Completed secondary	0.78 [0.64, 0.96]	0.80 [0.66, 0.98]	0.82 [0.67, 1.00]	0.84 [0.69, 1.02]	0.87 [0.71, 1.06]	0.88 [0.72, 1.07]
Completed further or higher	0.51 [0.39, 0.67]	0.62 [0.47, 0.82]	0.62 [0.47, 0.82]	0.63 [0.48, 0.83]	0.76 [0.58, 1.00]	0.75 [0.57, 0.99]
P trend	<0.001	<0.001	<0.001	0.002	0.05	0.04
Paternal education						
Did not complete secondary	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference
Completed secondary	0.78 [0.64, 0.96]	0.80 [0.66, 0.98]	0.84 [0.69, 1.02]	0.82 [0.67, 1.00]	0.86 [0.71, 1.05]	0.87 [0.71, 1.06]
Completed further or higher	0.65 [0.49, 0.86]	0.69 [0.52, 0.92]	0.72 [0.54, 0.96]	0.73 [0.55, 0.97]	0.82 [0.62, 1.09]	0.80 [0.60, 1.07]
P trend	0.001	0.001	0.003	0.003	0.08	0.08
Maternal smoking through pregnancy						
Never	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference
Prior to but not during pregnancy	1.30 [1.00, 1.69]	1.29 [0.99, 1.68]	1.27 [0.98, 1.65]	1.13 [0.87, 1.47]	1.11 [0.85, 1.44]	1.13 [0.87, 1.47]
Throughout pregnancy	2.02 [1.71, 2.38]	1.95 [1.66, 2.29]	1.90 [1.62, 2.24]	1.41 [1.20, 1.66]	1.40 [1.19, 1.65]	1.40 [1.25, 1.65]
P trend	<0.001	<0.001	<0.001	0.006	0.006	0.006

CI, confidence interval; OR, odds ratio.
[a] Model 1, adjusted for age and sex.
[b] Model 2, Model 1 + mutual adjustment for other variables in column 1.
[c] Model 3, Model 2 + adjustment for family income at 14.
[d] Model 4, Model 3 + parental smoking at 14.
[e] Model 5, Model 4 + behavioural problems at ages 5 and 14.
[f] Model 6, Model 5 + cognitive function at ages 5 and 14.

The inverse associations between maternal and paternal educational attainment and smoking at age 14 and the positive association between maternal smoking throughout pregnancy and smoking at age 14 remained with adjustment for each other, family income at birth and age 14 and parental smoking at age 14. The association between maternal and paternal education and smoking at 14 were influenced by adjustment for childhood behavioural problems and cognitive function with the odds ratio attenuating towards the null with further adjustment for these variables. The association of maternal smoking throughout pregnancy with smoking at age 14 was not importantly influenced by childhood behaviours or cognitive function.

There was no evidence of any interactions between variables at different stages of the life course (i.e. between socio-economic position at birth and age 14; between smoking around the time of birth and at age 14) in their associations with smoking at age 14 (all *P*-values > 0.4). The fully adjusted (for age, sex, smoking throughout pregnancy, family income at birth and age 14, parental education, paternal smoking, childhood behavioural problems and cognitive function) odds ratio of smoking at age 14 comparing maternal smoking at age 14 with not smoking was 1.57 (1.19, 2.06). The magnitude of this effect did not differ from that of the fully adjusted association between maternal smoking throughout pregnancy and offspring smoking at age 14 (*P*-difference = 0.51).

To further investigate the independent contribution of maternal smoking during pregnancy and at age 14, the children were stratified into one of four groups based on maternal smoking: (i) non-smoker during pregnancy and at age 14; (ii) smoker during pregnancy but not at age 14;

(iii) non-smoker during pregnancy but smoker at age 14; and (iv) smoker both during pregnancy and at age 14. In these analyses women who smoked prior to pregnancy but not throughout pregnancy were combined with those who had never smoked at the time of birth. For each of these categories age-adjusted prevalences of smoking at age 14 were estimated. These show the cumulative effect of maternal smoking across the life course with (i) the greatest prevalence of adolescent smoking being among those whose mothers smoked both during their pregnancy and when the child was aged 14: 22.3% [95% CI: 20.1, 24.6], (ii) the lowest prevalence being amongst those whose mothers were non-smokers at both stages: 10.2% [95% CI: 9.1, 11.4], and (iii) intermediate in those whose mothers smoked through pregnancy but not when they were 14: 16.8% [95% CI: 12.2, 23.0] and those whose mothers smoked when they were aged 14 but not during their pregnancy 16.0% [95% CI: 12.6, 18.7].

In order to determine whether the association between maternal smoking during pregnancy was specific to adolescent smoking, we assessed the association between maternal smoking during pregnancy and other adolescent behaviours: (i) self-report of drinking alcohol regularly (at least monthly), (ii) self-report of watching at least 7 h of television during the weekdays (Monday–Friday), and (iii) self-report of performing below average at school. Maternal smoking during pregnancy was not associated with any of these outcomes in either simple age and sex-adjustedmodels or in models with additional adjustment for family income, parental education and maternal smoking when the offspring was age 14 (all P-values > 0.7).

Discussion

We have found that maternal educational attainment and maternal smoking both during pregnancy and when the child was 14 were associated with increased risk of the child smoking when they were aged 14. These results suggest that, irrespective of maternal smoking when the child is aged 14, and other potential confounding or mediating factors, children of women who smoked during pregnancy are more likely to smoke themselves when they are aged 14. The magnitudes of the associations between maternal smoking throughout pregnancy and adolescent smoking and maternal smoking when the child was in adolescence and adolescent smoking were similar to each other. Further, the association between maternal smoking during pregnancy was specific for adolescent smoking and was not associated with alcohol consumption, TV watching or self-report of poor school performance at age 14.

Study limitations

The follow-up of 72% is high. However, those children who did not respond at age 14 years were more likely to have had mothers who smoked during pregnancy and to be from families with low income. Our results would only exaggerate the true associations if the associations we have found were either in the opposite direction or non-existent in those who did not respond; that is, if maternal smoking in pregnancy and low maternal educational attainment reduced the risk of adolescent smoking or were not associated with it in non-responders. Although we cannot determine whether this is the case, it seems unlikely. An important limitation is the lack of an objective measure of smoking (e.g. cotinine levels) in either mothers or children. Smoking during pregnancy and in adolescence are sensitive issues, and it is possible that some moth-ers and children who did smoke denied this in the questionnaires despite assurances of confidentiality. Smoking prevalence (14%) in this study population is somewhat lower than prevalence for the whole of Australia in the 15–19 age group (25% – see Fig. 1). This may be due to the younger age of this study population compared with these routine data, with 14-year-olds being less likely to smoke than older adolescents.[40] It may also reflect some under-reporting in our study.

We do not have data on paternal smoking at the time of birth, which in addition to maternal smoking may also be an important determinant of offspring smoking. Future life-course studies should consider paternal smoking and other paternal characteristics as well as maternal characteristics throughout the pregnancy, as these data may help to distinguish intrauterine from non-intrauterine effects.

Comparisons with other studies and implications

Our results are consistent with other cross-sectional studies that have found that socio-economic position and parental smoking around adolescence are associated with adolescent smoking.[13–17] Our findings add to these previous studies by finding an effect of maternal smoking during pregnancy. One previous prospective study found that maternal smoking during pregnancy was associated with offspring smoking and nicotine dependence at age 29.[18] Our association between maternal smoking during pregnancy and offspring smoking at age 14 may be due to residual confounding. Maternal smoking during pregnancy may result in nicotine dependence in the developing fetus, it may influence maternal attitudes towards their child's smoking, or it may 'normalise' smoking in adolescence if the child knows that their mother smoked when they were younger. The specificity of the association, with no association with other adolescent behaviours such as alcohol consumption, TV watching and self-report of school performance provide some evidence that residual confounding is an unlikely explanation. Further research, including studies that assess the association of paternal smoking during the child's intrauterine period as well as later in life, may help to determine the specific mechanism. Whatever mechanisms link smoking throughout pregnancy to offspring smoking at age 14, this is further evidence of the adverse effects of smoking during pregnancy for both mother and offspring.

Conclusion

Adolescence is a sensitive period for the development of smoking patterns. Our results show that maternal educational attainment and maternal smoking during pregnancy and when the child is aged 14 are associated with adolescent smoking. Childhood behavioural problems and cognitive function are also associated with smoking at age 14, and in part these childhood characteristics explain the association between maternal education and adolescent smoking. These findings suggest that initiatives aimed at supporting young women not to take up smoking and/or to quit if they are smokers, and at improving educational attainment of women, are important in reducing adolescent smoking. They highlight the importance of a life-course approach to adolescent smoking prevention rather than initiatives which focus just on the late childhood/ adolescent period.

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