Maternal smoking during pregnancy and scholastic achievement in childhood: evidence from the LIFECOURSE cohort study

Alfgeir L. Kristjansson, Ingibjorg E. Thorisdottir, Thora Steingrimsdottir, John P. Allegrante, Christa L. Lilly, Inga D. Sigfusdottir

Introduction

Existing recommendations state that pregnant women should not use tobacco products due to the toxic impact on the fetus, negative influence on birth weight, and increased risks for preterm birth. Maternal smoking during pregnancy (MSDP) has also been shown to be associated with elevated risks of poor cognitive and developmental outcomes in the offspring, with study outcomes ranging in time from shortly after birth into adolescence and young adulthood. For example, an Australian study of almost 4300 mothers and their children found a negative association between MSDP and intellectual and academic outcomes. For another example, an Australian study of almost 4300 mothers and their children found a negative association between MSDP and intellectual and academic outcomes. For another example, an Australian study of almost 4300 mothers and their children found a negative association between MSDP and intellectual and academic outcomes. For another example, an Australian study of almost 4300 mothers and their children found a negative association between MSDP and intellectual and academic outcomes.

However, due to conflicting findings in previous research and limited number of studies that reach into adolescence, the long-term impact of MSDP on cognitive developmental factors such as academic achievement in the offspring are not well understood. Longer term studies have both shown negative and null associations between MSDP and intellectual and academic outcomes. For example, an Australian study of almost 4300 mothers and their children found a negative association between MSDP and intellectual and academic outcomes. For another example, an Australian study of almost 4300 mothers and their children found a negative association between MSDP and intellectual and academic outcomes. For another example, an Australian study of almost 4300 mothers and their children found a negative association between MSDP and intellectual and academic outcomes. For another example, an Australian study of almost 4300 mothers and their children found a negative association between MSDP and intellectual and academic outcomes.

Results

The LIFECOURSE study, a prospective cohort study of all children born in Reykjavik, Iceland, between 1992 and 1994, followed a birth cohort of children aged 7–10 years, 15 years old, and in their young adulthood. The study included information on maternal smoking during pregnancy (MSDP) and scholastic achievement in 4th, 7th and 10th grades. The study also included information on maternal smoking during pregnancy (MSDP) and scholastic achievement in 4th, 7th and 10th grades. The study also included information on maternal smoking during pregnancy (MSDP) and scholastic achievement in 4th, 7th and 10th grades. The study also included information on maternal smoking during pregnancy (MSDP) and scholastic achievement in 4th, 7th and 10th grades.

Methods

The LIFECOURSE study, a prospective cohort study of all children born in Reykjavik, Iceland, between 1992 and 1994, followed a birth cohort of children aged 7–10 years, 15 years old, and in their young adulthood. The study included information on maternal smoking during pregnancy (MSDP) and scholastic achievement in 4th, 7th and 10th grades. The study also included information on maternal smoking during pregnancy (MSDP) and scholastic achievement in 4th, 7th and 10th grades. The study also included information on maternal smoking during pregnancy (MSDP) and scholastic achievement in 4th, 7th and 10th grades. The study also included information on maternal smoking during pregnancy (MSDP) and scholastic achievement in 4th, 7th and 10th grades.

Conclusions

Maternal smoking during pregnancy was negatively related to scholastic achievement in the offspring during 4th, 7th and 10th grade.
or Apgar score (e.g. Lambe et al.) but do not include social and family variables at the time of assessment, and some studies have selected an extensive number of social developmental covariates such as SES-related variables at the time of assessment (e.g. O’Callaghan et al.) but lack birth-related measures. As a result, it has been hypothesized that previous observations regarding the probable impact of MSDP on scholastic outcomes may have been spurious and due to certain missing covariates such as maternal education. Still others have called for a more general improvement and consistency in the selection of covariates in studies of this nature.

The objective of this study is to improve our understanding of the impact of MSDP on academic achievement in early to mid-adolescence. We employ data from the LIFECOURSE study, a registry data-based cohort study conducted in Reykjavik, Iceland. We assess the impact of MSDP on standardized scholastic scores in 4th, 7th and 10th grade with real-time data collected before birth, during the neonatal period, as well as during the time of scholastic observation, therefore consistently including many of the covariates that previous studies have commonly lacked and has been called for.

Methods

Sample and participants

This report is based on data from the LIFECOURSE study of risk and protective factors being conducted by the Centre for Social Research and Analysis (ICSRA) at Reykjavik University in Iceland. LIFECOURSE is a developmental cohort study that covers the early lifespan of a birth cohort of children from before birth to the age of 15/16. The theoretical framework for the study has been described elsewhere. The study sampling frame consists of all children born, and residing in, Reykjavik, Iceland, in the year 2000 (N = 1151, girls = 49.3%). Study material comprises a combination of official registry data from national data banks and data from a social survey conducted with participants in the spring of 2016 while in 10th grade. For the purpose of this analysis, we used retrospective registry data from the following sources: (i) The National Birth Registry at the Landspitali University Hospital, (ii) Antenatal records from the Primary Health Care Clinics, both overseen by the Icelandic Directorate for Health which oversees the entire health registry system in Iceland, (iii) the Educational Testing Institute overseen by the Ministry of Education, Science, and Culture, (iv) and the Statistical Bureau of Iceland. In addition, (v) prospective data were collected with a social survey of participants. The study was reviewed and approved by the National Bioethics Committee of Iceland (equivalent to a national IRB) and the study has been registered and acknowledged by the Personal Protection Authority.

Procedures

Contact information for the sample was acquired through the Statistical Bureau and sister agencies. A non-traceable research identification number was created for each participant and flash drives with this information delivered to local personnel at each site with the proper authority to handle the sensitive and personal information. The data were then prepared and transferred to files at each site during the years 2014–2016 using the research ID number to identify participants while removing any and all personal information upon delivery of the data files to the research team. Available data for each variable in the registry material ranged from 980 to 1149 or 85.1% to 99.8% of the study sample. A key that links individual names and contact information to research IDs is maintained by a third party at the Primary Health Care Clinics and is not accessible to the research team.

Survey data were collected with participants in their respective schools. Parental informed consent and student assent was required and collected with a combination of take-home paper and email messages that were delivered to parents and students by school nurses on behalf of the Primary Health Care Clinics. The survey data were collected in April 2016 in school classrooms using a protocol that the ICSRA has used in annual surveys for 20 years in collaboration with the Ministry of Education, Science and Culture. The school survey data collection protocol has been published elsewhere. A total of 1103 students were eligible to participate in the survey, or 95.8% of the original sampling frame, of which 497 consented to do so (45.1% of all eligible). Valid survey data were then collected from 464 individuals or (93.4% of consented participants) which are used in the current analyses.

Measures

Dependent variables

From the Educational Testing Institute Scholastic achievement was assessed using official grades in Icelandic and Mathematics in 4th, 7th and 10th grade. These are two of what are referred to as the ‘unitary subjects’ that all students are required to pass in order to progress to the next year of study. For each subject, scores are standardized to a normally distributed scale ranging from 0 to 60. Scores within years were merged to form a single measure (Alpha = .77/.81/.84).

Independent variable

From the primary health care clinics Maternal smoking during pregnancy was assessed during the first antenatal visit which usually takes place towards the end of the first trimester. Expecting mothers are asked whether they currently smoke tobacco or if they did so before knowing about becoming pregnant. The observed smoking ratio (see table 1) is comparable to national estimates provided by National Directorate for Health in Iceland. Based in this information two dichotomous variables were created for smoking status; one for maternal smoking before pregnancy, another for maternal smoking during pregnancy.

Covariates

From the national birth registry Data on birth weight in grams and maternal age at birth of the child were and coded as is. In addition, since maternal age at birth is slightly curvilinear related to the outcomes it was also inserted as a squared variable in the statistical models.

From the Primary Health Care Clinics Birth order was coded 1 = ‘not mother’s first child’ and 0 = ‘first child’. Gender was coded 1 = ‘girls’ and = 0 ‘boys’.

From the statistical bureau Parent’s cohabitating at birth, in 2010, 2013 and 2016 was coded = 1 ‘yes’ and 0 ‘no’. Total household income at the year of birth, in 2010, and in 2013 was recoded into quintiles with the lowest quintile coded = 1 and the highest quintile coded = 5.

From the social survey Family financial status at the time of the social survey (10th grade) was assessed with the question ‘How do you rate your family’s financial status compared to other families?’ Scores ranged from 1 = ‘much worse than other families’ to 7 = ‘much better than other families’. Parental education levels were assessed with two survey questions concerning mothers and fathers headed with: ‘What is your mother/father highest level of education?’ Responses ranged from 1=‘elementary school or less’, to 6 = ‘college graduate or higher’. Mother and father education levels were merged to form one variable for parental education. Descriptive statistics for all study variables are displayed in table 1.
Analyses

In order to understand how maternal smoking during pregnancy may affect scholastic achievement, we use a series of OLS regression models run in three hierarchical model blocks. Model 1 includes an analysis of the two smoking variables and the outcomes, scholastic achievement in 4th, 7th and 10th grade, respectively. Model 2 adds covariates associated with the birth period (birth weight, maternal age at birth, participant sex, not the first child, household income during year of birth, parental cohabitation at birth). In model 3, we then add covariates that concern the year of assessment of each dependent variable, respectively (household income and/or family financial status and parental cohabitation in 2010/2013/2016). Data were analysed using SPSS 24 (IBM Corporation, Armonk, New York 2015). The results are shown in tables 2–4.

Given that three covariates in the analyses were from the survey responses in 10th grade (i.e. family structure, parental education and family financial status in 10th grade, which by means of list-wise deletion reduces the number of eligible data by roughly half), we also conducted a sensitivity analysis. We analysed the data for participants while in 4th and 7th grade (tables 2 and 3) both with and without the missing participants on these three variables. This analysis yielded no markedly different results from the original models. Additionally, during model development we ran all statistical models by including gestational length as a covariate but it did not add explanatory power (\( P > 0.05 \)) to any models over birth weight, and was therefore excluded in the final models.

Results

Table 2 includes the linear regression models for maternal smoking during pregnancy on standardized academic achievement in 4th grade. Model 1 shows that children of mothers who smoked tobacco during pregnancy scored an average of 6.30 points less

| Continuous variables | N | Min | Max | Mean | SD |
|----------------------|----|-----|-----|------|----|
| Dependent variables  |    |     |     |      |    |
| Stand. Grades in 4th | 1002 | 10  | 119 | 62.47 | 18.64 |
| Stand. Grades in 7th | 1035 | 3   | 114 | 62.23 | 18.59 |
| Stand. Grades in 10th | 980 | 7   | 119 | 63.78 | 19.22 |
| Independent variables/covariates |     |     |     |      |    |
| Birth weight in grams | 1149 | 450 | 5870 | 3664 | 597.63 |
| Maternal age at birth | 1149 | 16  | 45  | 29.17 | 5.56 |
| Maternal age at birth\(^2\) | 1149 | 0.03 | 250.59 | 30.93 | 38.09 |
| Household income in 2000 (quintiles) | 1079 | 1   | 5   | 2.99 | 1.42 |
| Household income in 2010 (quintiles) | 1079 | 1   | 5   | 2.98 | 1.42 |
| Household income in 2013 (quintiles) | 1079 | 1   | 5   | 3.00 | 1.42 |
| Family financial status in 2016 | 460 | 1   | 7   | 4.70 | 1.02 |
| Parental cohabitation in 2016 | 441 | 2   | 12  | 8.61 | 2.23 |

Table 2 Descriptive statistics for all study variables

| Table 2 Linear regression of maternal smoking during pregnancy on standardized grades in 4th grade |
|-----------------------------------------------------------------------------------------------------|
| Model 1: smoking                                              | Model 2: + birth year var | Model 3: + year of outcome var |
| B                  | SE               | B                  | SE               | B                  | SE               |
| Maternal smoking before pregnancy | −4.26 | 3.81               | −4.18 | 3.73               | −4.59 | 3.75               |
| Maternal smoking during pregnancy | −6.30** | 2.53               | −6.28** | 2.53               | −5.79** | 2.58               |
| Birth weight (gr) | 0.002             | 0.002               | 0.003             | 0.002               |
| Parents cohabitating at birth | −2.80 | 2.91               | −3.83 | 3.03               |
| Household income in 2000 (quintiles) | 1.95** | 0.68               | 1.60** | 0.72               |
| Maternal age at birth | 0.57+             | 0.23               | 0.56+             | 0.23               |
| Maternal age at birth\(^2\) | 0.07+             | 0.03               | 0.07+             | 0.03               |
| Girls | 2.85             | 1.80               | 2.76             | 1.80               |
| Birth order (multiparous) | −9.48** | 2.22               | −10.15** | 2.26               |
| Parents cohabitating in 2010 | 1.24             | 2.70               |
| Household income in 2010 (quintiles) | 1.27             | 0.91               |
| Parental education in 2016 | 0.20             | 0.43               |
| \( R^2 \) | 0.02             | 0.11               | 0.12             | 1.50               |

\( *: P<0.05. \)

\( **: P<0.01. \)

\( ***: P<0.001. \)
than children of mothers who did not smoke during pregnancy (P = 0.01) but maternal smoking before pregnancy was not related to scholastic achievement. Model 2 includes the covariates that are associated with the time of birth, both biological (e.g. birth weight, maternal age and not first child), and social factors (e.g. household income and parental cohabitation). In short, the explanatory power improves significantly between the two models [F (7, 367) = 5.08, P = 0.000] but the impact of MSDP remains mostly unchanged. Model 3 adds the covariates associated with the year of student assessment (2010) to model 2; however, the addition of these covariates do not add a significant explanation to the model [F (3, 364) = 1.50, P = 0.215] and neither do they change the impact of MSDP on academic achievement in 4th grade, which is 5.79 points less for children of mothers who smoked tobacco during pregnancy compared with children of mothers that did not (P = 0.025).

Tables 3 and 4 include the linear regression models for MSDP on standardized scholastic achievement in 7th and 10th grade, respectively. In short, both models paint a very similar picture as the models displayed in table 2. In 7th grade, the impact of MSDP on grades is −7.14 points in model 1 and drops to −5.98 points in the 3rd and final model while including all covariates. Explained variance increased significantly between models 1 and 2 [F (7, 377) = 5.68, P = 0.000] as well as models 2 and 3 [F (3, 374) = 3.62, P = 0.013]. In 10th grade, the impact of MSDP on grades is −8.30 points in model 1 and drops to −6.22 points in the 3rd and final model while including all covariates. Explained variance increases significantly between models 1 and 2 [F (7, 367) = 5.96, P = 0.000] but not between models 2 and 3 [F (3, 364) = 0.48, P = 0.697].

### Discussion

The results of this study show a consistent negative relationship between MSDP and standardized scholastic achievement in the offspring at the time of 4th, 7th and 10th grades. In the smoking only analyses (models 1), the differences in scholastic achievement ranged from 5.3% (6.30/120 points in 4th grade students) to 6.9% (8.30 points in 10th grade students) and from 4.8% (5.79 points in 4th grade students) to 5.2% (6.22 points in 10th grade students) in the full models including all control variables and covariates.

---

**Table 3** Linear regression of maternal smoking during pregnancy on standardized grades in 7th grade

| Model 1: smoking | Model 2: + birth year var | Model 3: + year of outcome var |
|------------------|---------------------------|-------------------------------|
| B                | SE                        | B                             | SE                        | B                             | SE                        |
| Maternal smoking before pregnancy | −5.06 3.69 | −5.51 3.61 | −5.52 3.59 |
| Maternal smoking during pregnancy | −7.14** 2.45 | −6.76** 2.44 | −5.98** 2.46 |
| Birth weight (gr) | 0.002 0.001 | 0.003 2.81 | 0.80 0.66 |
| Parents cohabitating at birth | 1.20 0.64 | 0.55 0.22 | 0.80 0.66 |
| Household income in 2000 (quintiles) | 0.08** 0.03 | 0.07 0.03 |
| Maternal age at birth | 3.79 1.71 | 3.74 1.70 |
| Birth order (multiparous) | −10.25*** 2.13 | −10.83*** 2.14 |
| Parents cohabitating in 2013 | 5.51 3.59 | 3.61 2.45 | 3.59 2.46 |
| Household income in 2013 (quintiles) | 1.71 3.59 | 2.45 2.46 |
| Parental education in 2016 | 0.24 0.58 | 0.22 0.55 | 0.22 0.55 |

ΔR²

| F (2, 384) | F (7, 377) | F (3, 374) |
|------------|------------|------------|
| 0.03       | 0.12       | 0.14       |

### Table 4** Linear regression of maternal smoking during pregnancy on standardized grades in 10th grade

| Model 1: smoking | Model 2: + birth year var | Model 3: + year of outcome var |
|------------------|---------------------------|-------------------------------|
| B                | SE                        | B                             | SE                        | B                             | SE                        |
| Maternal smoking before pregnancy | −2.55 3.98 | −2.06 3.88 | −1.77 3.90 |
| Maternal smoking during pregnancy | −8.30** 2.70 | −6.76** 2.68 | −6.22* 2.73 |
| Birth weight (gr) | 0.003 0.002 | 0.003 0.002 |
| Parents cohabitating at birth | −0.74 3.17 | −0.45 3.27 |
| Household income in 2000 (quintiles) | 1.98** 0.70 | 1.87** 0.72 |
| Maternal age at birth | 0.61** 0.24 | 0.58 0.24 |
| Maternal age at birth² | 0.07* 0.03 | 0.07* 0.03 |
| Girls | 6.34*** 1.87 | 6.19*** 1.88 |
| Birth order (multiparous) | −9.37*** 2.32 | −9.14*** 2.36 |
| Parents cohabitating in 2016 | 1.45 2.13 |
| Family financial status in 2016 | 0.53 0.97 |
| Parental education in 2016 | 0.40 0.44 |

ΔR²

| F (2, 374) | F (7, 367) | F (3, 364) |
|------------|------------|------------|
| 0.03       | 0.12       | 0.13       |

ΔR²

| F (2, 374) | F (7, 367) | F (3, 364) |
|------------|------------|------------|
| 0.03       | 0.12       | 0.13       |

*: P < 0.05. **: P < 0.01. ***: P < 0.001.
Interestingly, smoking before pregnancy was unrelated to scholastic achievement in all models. The consistency of these findings are particularly noteworthy given the large range of covariates that was selected for the analysis and are both associated with the physical birth (e.g. birth weight, maternal age at birth and sex), the social environment into which the baby is born (e.g. birth order, parental cohabitation status and total family income during the year of birth), as well as SES related variables at the year of scholastic assessment (e.g. parental cohabitation status, total family income and parental education). The findings differ from the review results by Clifford et al.13 where many reviewed studies showed little or no impact of MSDP on cognitive performance and observed relationships were often masked out by other factors. In addition, the homogenous nature of the Icelandic population should ideally serve to deter the observed differences in scholastic achievement as it operates as a natural environmental control measure. Iceland has been described as being universally middle-class where the lifestyle, values and beliefs tend to be alike across the population.24 Iceland’s relative lack of social hierarchy therefore serves as evidence of a greater likelihood for a biological link between MSDP and scholastic outcomes in the offspring given that we were able to control for the little variation that exists. Also, the fact that smoking before pregnancy was consistently unrelated to the outcome measures lends further support to the potential biological link between MSDP and scholastic achievement in the offspring.

There are several potential biological explanations for these findings. First, cigarette smoking creates carbon monoxide which creates carboxyhemoglobin that in turn serves to decrease the oxygen carrying capacity of maternal and fetal blood and may in some cases lead to fetal hypoxia.25–28 Also, nicotine causes vasoconstriction, which decreases placental blood flow.26,27 Decreased oxygen flow and blood stream have been linked to low birth weights and smaller head circumference.26,29 Low birth weights have been associated with significant neurologic consequences such as the risk for behaviour problems,30,31 decreased intellectual capacity, hyperactivity and learning disabilities,2,6,32,33 as well reduced brain growth in utero.25,34 Other plausible impacts are more distal in nature but authors have also speculated that a combination of factors and compound exposure may explain the longer term impact of MSDP on cognitive outcomes in the offspring.3,25

Strengths

Our study has notable strengths. First, we selected and included in our analyses more extensive control variables than most studies have to date. Second, scholastic achievement was assessed at three time points, which enabled us to assess a consistent pattern of probable impact from 4th grade through 10th grade across developmental stages. Third, the registry-based data add robustness to the study because such data substantially decrease the prospects of systematic bias due to sampling variation.

Limitations

Four study limitations are worth noting. First, we did not control for post-partum smoking exposure. This represents a particular challenge in studies of this nature as comprehensive measures of smoking exposure are difficult in a life-course study without collecting real-time data during the course of an individual participant’s lifetime. Second, our measure of MSDP is conducted at the end of the first trimester and does not differentiate among differing levels of maternal smoking nor smoking following the first trimester. Third, although we do control for several variables highlighted as important in previous research we cannot rule out that the observed relationships between MSDP and scholastic achievement is due to residual confounding or other missing variables. Finally, although the data from the LIFECLASS study is longitudinal in nature, our analyses for this current study are conducted by treating the data as cross-sectional. Based on these findings it appears that children exposed to MSDP have lower baseline academic achievement and then fail to catch up over the life course.

Conclusions

We believe the results of this study provide convincing evidence of the negative impact of MSDP on academic achievement in the offspring in 4th, 7th and 10th grade. A large number of control variables and covariates were included in statistical models and which only minimally decreased the observed bivariate relationship between MSDP and scholastic achievement. Future studies should strive to control for both post-partum smoking exposure as well as the amount of maternal smoking during pregnancy.

Funding

This study was funded by the European Research Council (ERC-CoG-2014-647860). The ERC had no role in formulating the study objectives and did not impact the analyses, reporting or selection of a journal outlet.

Conflicts of interest: None declared.

Key points

- Life course data were analysed to assess potential impact of maternal smoking during pregnancy on scholastic achievement in the offspring in 4th, 7th and 10th grade.
- Across all grades, children of mothers who smoked tobacco during the first trimester consistently had 5–7% lower standardized scholastic scores than children of non-smoking mothers.
- Early detection and prevention of maternal smoking during pregnancy should be a policy priority.

References

1. Rogers JM. Tobacco and pregnancy. Reprod Toxicol 2009;28:152–60.
2. Gilmann SE, Gardener H, Buka SL. Maternal smoking during pregnancy and children's cognitive and physical development: a causal risk factor? Am J Epidemiol 2008;168:522–31.
3. Vila Candell R, Soriano-Vidal FJ, Hevilla Cucarella E, et al. Tobacco use in the third trimester of pregnancy and its relationship to birth weight. A prospective study in Spain. Women Birth J Aust Coll Midwives 2015;28:e134–9.
4. Ion RC, Wills AK, Bernal AL. Environmental tobacco smoke exposure in pregnancy is associated with earlier delivery and reduced birth weight. Reprod Sci Thousand Oaks Calif 2015;22:1603–11.
5. Huijbregts SCJ, Séguin JR, Zelazo PD, et al. Interrelations between maternal smoking during pregnancy, birth weight and sociodemographic factors in the prediction of early cognitive abilities. Infant Child Dev 2006;15:593–607.
6. Braun JM, Daniels JL, Kalkbrenner A, et al. The effect of maternal smoking during pregnancy on intellectual disabilities among 8-year-old children. Paediatr Perinat Epidemiol 2009;23:482–91.
7. Heinenon K, Räikkönen K, Pesonen A-K, et al. Longitudinal study of smoking cessation before pregnancy and children’s cognitive abilities at 56 months of age. Early Hum Dev 2011;87:553–9.
8. Melchior M, Hser R, van der Waerden J, et al. Maternal tobacco smoking in pregnancy and children’s socio-emotional development at age 5: the EDEN mother-child birth cohort study. Eur Psychiatry J Assoc Eur Psychiatr 2015;30:562–4.
9. Cornelius MD, Goldschmidt L, Day NL. Prenatal cigarette smoking: Long-term effects on young adult behavior problems and smoking behavior. Neurotoxicol Teratol 2012;34:554–9.
10. Martin RP, Dombrowski SC, Mullis C, et al. Smoking during pregnancy: association with childhood temperament, behavior, and academic performance. J Pediatr Psychol 2006;31:490–500.
11 Muraro AP, Gonçalves-Silva RMV, Moreira NF, et al. Effect of tobacco smoke exposure during pregnancy and preschool age on growth from birth to adolescence: a cohort study. BMC Pediatr 2014;14:99.
12 Dürr DW, Høyer BB, Christensen LH, et al. Tobacco smoking during pregnancy and risk of adverse behaviour in offspring: A follow-up study. Reprod Toxicol 2015;38:65–72.
13 Clifford A, Lang L, Chen R. Effects of maternal cigarette smoking during pregnancy on cognitive parameters of children and young adults: a literature review. Neurotoxicol Teratol 2012;34:560–70.
14 O’Callaghan FV, Al Mamun A, O’Callaghan M, et al. Is smoking in pregnancy an independent predictor of academic difficulties at 14 years of age? A birth cohort study. Early Hum Dev 2010;86:71–6.
15 Lambe M, Hultman C, Torräng A, et al. Maternal smoking during pregnancy and school performance at age 15. Epidemiol Camb Mass 2006;17:524–30.
16 D’Onofrio BM, Singh AL, Iliadou A, et al. A quasi-experimental study of maternal smoking during pregnancy and offspring academic achievement. Child Dev 2010;81:88–100.
17 Kafouri S, Leonard G, Perron M, et al. Maternal cigarette smoking during pregnancy and cognitive performance in adolescence. Int J Epidemiol 2009;38:158–72.
18 Batty GD, Der G, Deary IJ. Effect of maternal smoking during pregnancy on offspring’s cognitive ability: empirical evidence for complete confounding in the US national longitudinal survey of youth. Pediatrics 2006;118:94–50.
19 Inamdar AS, Croucher RE, Chokhandre MK, et al. Maternal smokeless tobacco use in pregnancy and adverse health outcomes in newborns: a systematic review. Nicotine Tob Res 2015;17:1058–66.
20 Sigfusdottir ID, Kristjansson AL, Thorlindsson T, Allegranite JP. Stress and adolescent well-being: the need for an interdisciplinary framework. Health Promot Int 2016; psci daw038.
21 Kristjansson AL, Sigfusson J, Sigfusdottir ID, Allegranite JP. Data collection procedures for school-based surveys among adolescents: the youth in Europe study. J Sch Health 2013;83:662–7.
22 Jonasdottir LS, Jenson V. Íslen Íslenska Tóbaksleys & Íslandi [Tobacco Use Trends in Iceland]. Reykjavik: Directorate of Health; 2016.
23 Noble KG, Fifer WP, Rauh VA, et al. Academic achievement varies with gestational age among children born at term. Pediatr 2012; 130:e257–64.
24 Kristjansson AL. On social equality and perceptions of insecurity a comparison study between two European countries. Eur. J Criminal 2007;4:59–86.
25 Källen K. Maternal smoking during pregnancy and infant head circumference at birth. Early Hum Dev 2000;58:197–204.
26 Mezzacappa E, Buckner JC, Earls F. Prenatal cigarette exposure and infant learning stimulation as predictors of cognitive control in childhood. Dev Sci 2011;14:881–91.
27 Slotkin TA. Cholinergic systems in brain development and disruption by neurotoxins: nicotine, environmental tobacco smoke, organophosphates. Toxicol Appl Pharmacol 2004;198:132–51.
28 Soothill PW, Morafa W, Ayida GA, Rodeck CH. Maternal smoking and fetal carboxyhaemoglobin and blood gas levels. BJOG Int J Obstet Gynaecol 1996;103:78–82.
29 Herrmann M, King K, Weitzman M. Prenatal tobacco smoke and postnatal secondhand smoke exposure and child neurodevelopment. Curr Opin Pediatr 2008;20:184–90.
30 McCarton C. Behavioral outcomes in low birth weight infants. Pediatrics 1998;102:1293–7.
31 Ovrum A. Socioeconomic status and lifestyle choices: evidence from latent class analysis. Health Econ 2011;20:971–84.
32 Breslau N, Chilcoat HD. Psychiatric sequelae of low birth weight at 11 years of age. Biol Psychiatry 2000;47:1005–11.
33 Lundberg F, Cnattingius S, D’Onofrio B, et al. Maternal smoking during pregnancy and intellectual performance in young adult Swedish male offspring. Paediatr Perinat Epidemiol 2010;24:79–87.
34 Vardavas CI, Chatzi L, Patelarou E, et al. Smoking and smoking cessation during early pregnancy and its effect on adverse pregnancy outcomes and fetal growth. Eur J Pediatr 2010;169:741–8.