Preventive Medicine 113 (2018) 74–79

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Maternal smoking during pregnancy and academic achievement of offspring over time: A registry data-based cohort study

Alfgeir L. Kristjansson[a,b,*], Sabena Thomas[a], Christa L. Lilly[c], Ingibjorg E. Thorisdottir[b,d], John P. Allegrante[b,e,f], Inga Dora Sigfusdottir[b,d,e]

[a] Department of Social and Behavioral Sciences, School of Public Health, West Virginia University, Morgantown, WV 26505, USA
[b] Icelandic Center for Social Research and Analysis, Reykjavik University, 101 Reykjavik, Iceland
[c] Department of Biostatistics, School of Public Health, West Virginia University, Morgantown, WV, USA
[d] Department of Psychology, Reykjavik University, 101 Reykjavik, Iceland
[e] Department of Health and Behavior Studies, Teachers College, Columbia University, New York 10027, NY, USA
[f] Mailman School of Public Health, Columbia University, New York 10032, NY, USA

ARTICLE INFO

Keywords:
Maternal smoking during pregnancy
Prenatal tobacco exposure
LICEFOURSE
Iceland
Cohort study
Academic achievement

ABSTRACT

Few studies have assessed the cumulative impact of maternal smoking during pregnancy (MSDP) on scholastic outcomes over time. We examined the relations between MSDP and academic achievement in the 4th, 7th and 10th grades using registry data collected at birth, during the neonatal period, and at each grade level from the 2000, LIFECOURSE study birth cohort in Reykjavik, Iceland ($N = 1151$, girls = 49.3%). Latent growth modeling showed that MSDP influenced Icelandic achievement scores, standardized to a range from 0 to 60, at baseline ($\beta = -0.04$), and over time ($\beta = -0.05$). Likewise, MSDP was negatively associated with standardized mathematics scores at baseline ($ß = -0.09$) and continued to exert a negative impact on mathematics scores over time ($ß = -0.08$) after controlling for gender, income, cohabitation, and baseline mathematics and Icelandic achievement scores. Results provide evidence of the persistent negative impact of MSDP on academic achievement in offspring. Findings support the proposition that children whose mothers smoke during the first trimester of pregnancy are, on average, at greater risk for poor scholastic outcomes over time than children whose mothers do not smoke during their first trimester. To our knowledge, this is the first study using a longitudinal cohort design to assess whether the impacts of maternal smoking during pregnancy may persist over time. This study contributes to the current state of knowledge by providing an assessment that focuses on the impact of smoking during pregnancy on academic achievement from childhood into early adolescence.

1. Introduction

Maternal smoking during pregnancy (MSDP) has been shown to be negatively related to offspring's physical development, both in fetal and newborn stages, with corresponding impact reaching into infancy, adolescence and even young adulthood (Clifford et al., 2012; Gilman et al., 2008; Inamdar et al., 2015; Ion et al., 2015; Ko et al., 2014; Lanting et al., 2009; Polanska et al., 2015; Roelands et al., 2009; Rogers, 2009). Among the antepartum and postpartum developmental complications associated with MSDP are spontaneous abortion (Pineles et al., 2014), ectopic pregnancy (Roelands et al., 2009), pre-eclampsia (Roelands et al., 2009; Wikström et al., 2010), placental rupture (Jauniaux and Burton, 2007), fetal growth restriction, pre-term birth, and low birth weight (Ko et al., 2014). MSDP has also been associated with neurological and cognitive dysfunctions such as impediments to brain development among infants (Wehby et al., 2011), poor visual-motor integration and verbal competence in young children (Heinonen et al., 2011), lower IQ, reduced scholastic achievement, and intellectual impairments in grade school children (Alloway and Alloway, 2010; Cornelius et al., 2012; Duckworth and Seligman, 2005; Kafouri et al., 2009; Pineles et al., 2014; Braun et al., 2009; Gilman et al., 2008; Huijbregts et al., 2006), and behavioral problems such as conduct disorders and attention deficit hyperactivity disorders (ADHD) in children aged from 6 to 16 years (Gaysina et al., 2013; Langley et al., 2007).

Several studies have identified a reduction in scholastic achievement among the offspring of mothers who smoked tobacco during pregnancy (Lambe et al., 2006; Martin et al., 2006; O'Callaghan et al., 2010). For instance, Lambe et al. (2006) examined over 400,000 15-year-old Swedish students and their school performance measured by grade-point summary scores in 16 subjects in relation to their prenatal

* Corresponding author at: Department of Social and Behavioral Sciences, School of Public Health, West Virginia University, Morgantown, WV 26505, USA.
E-mail address: alkristjansson@hsc.wvu.edu (A.L. Kristjansson).

https://doi.org/10.1016/j.ypmed.2018.05.017
Received 28 January 2018; Received in revised form 13 April 2018; Accepted 11 May 2018

cigarette smoke exposure. The results showed a deficit among those who were exposed to prenatal cigarette smoke. A Finnish study assessed the mean academic grades for all subjects among 12-year-old children, and found a reduction in scholastic achievement among children of smokers compared to non-smokers (Martin et al., 2006). Similar results were also reported in an Australian prospective study of over 7000 mothers and their children (O'Callaghan et al., 2010). Conversely, data from the US National Collaborative Project, which included a sample of ~50,000 participants, found no association between MSDP and scholastic achievement measured by standardized scores from reading, spelling and arithmetic (Gilman et al., 2008). This result was consistent with a Swedish quasi-experimental study using a sibling-comparison approach among 15-year-old students; there were no differences in school grades and math proficiency among the exposed and unexposed siblings (D'Onofrio et al., 2010).

In addition to the inconsistency in current knowledge regarding the relations between MSDP and academic outcomes in the offspring, few studies have sought to assess the impact of MSDP on scholastic outcomes at multiple time points, despite the need and calls for such studies (Martin et al., 2006). The few studies that have included an assessment of academic outcomes at more than one time period have not employed statistical models that account for the linked time structure in the data and hence the potential for a cumulative effect over time. For example, Gilman et al. (2008) assessed the relations between prenatal smoke exposure and academic achievement in 4- and 7-year-old children respectively, but found no association after controlling for potential confounders, and Kristjansson et al. (2017) found negative relations between MSDP and academic achievement in the offspring at ages 10, 13 and 15. Thus, in order to understand the cumulative, long-term impact of MSDP on academic achievement, studies need to employ consistent measures that capture academic achievement over several developmental periods, and analytic methods that tests them simultaneously in one coherent model.

Another related problem with previous assessments has been the variation in covariates studied. These include both birth-related factors such as birth weight and familial characteristics that may contribute to the relationship between MSDP and cognitive outcomes (e.g., Gilman et al., 2008; Lawlor et al., 2006), while other studies have indicated that familial factors such as mother's education are more likely than birth related measures to explain cognitive outcomes (Batty et al., 2006; Breslau et al., 2005; Clifford et al., 2012; Wehby et al., 2011). At the same time, a few studies have included an extensive range of birth-related outcomes, but have omitted familial and social factors at time of assessment (Lambe et al., 2006), and others have included social and familial characteristics at the time of assessment but have failed to include birth-related factors (O'Callaghan et al., 2010). Given the relative importance of these two sets of covariates and appeals for more consistency in the selection of covariates (Clifford et al., 2012; Inamdar et al., 2015; Ion et al., 2015; Ko et al., 2014; Lanting et al., 2009; Roelands et al., 2009), studies that incorporate both while simultaneously controlling for social and familial factors at different assessment periods could better illuminate the relationship between MSDP and academic achievement.

The aim of this study was to improve the current understanding of the potential long-term impact of MSDP on academic achievement. We examined the impact of MSDP on standardized academic scores at the age of 10–11 (4th grade), 13–14 (7th grade), and 15–16 (10th grade), with data collected at birth, during the neonatal period, and at each grade level. We hypothesize that maternal smoking would lead to both lower baseline achievement scores, as well as cumulative lower scores over time.

2. Methods

2.1. 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 (Sigfusdottir et al., 2017). 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 for the investigation comprised a combination of official registry data from several national data banks assembled from 2014 to 2016. 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 Mother care registry at 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 (ETI) overseen by the Ministry of Education, Science, and Culture, and iv) the Statistical Bureau of Iceland. 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.

2.2. Measures

2.2.1. Achievement

Achievement score data in mathematics and the Icelandic language in 4th (aged 10–11), 7th (age 13–14), and 10th (age 15–16) grades came from the ETI database. Grading in Iceland is given on a numerical scale from 0 to 10 with 5 and above as “passed” and 7.25 and above regarded as first-class grade. For the purpose of this assessment, the ETI delivered standardized grades on a scale from 0 to 60 for each subject, with mean scores fixed at 30, and a combined scale for the two subject ranging from 0 to 120.

2.2.2. Annual household income

Data on the total income for the household were available by year, and calculated in the survey as the additive combination of income from employment, capital, and any other income revenue. Explorative analysis of all year's data revealed that the final available year of income, 2013, had the strongest statistical relationship to the achievement variables. This variable, ranging from 0 to 172 million ISK, was further split into deciles, with 10% in each group, in order to account for excess 0's and very strong positive skew.

2.2.3. Maternal smoking

Maternal smoking during pregnancy was assessed during the first antenatal visit which usually takes place towards the end of the first trimester in Iceland. Expecting mothers were asked whether they currently smoke tobacco or if they did so before knowing about becoming pregnant. Smoking status was initially coded as (0) no, (1) yes, sometime during pregnancy, and (2) yes, before knowing about pregnancy. Previous work (Kristjansson et al., 2017) demonstrated that those endorsed the final option (10% of the population) were more similar to those who said no than to regular cigarette smokers. Thus, we recoded this variable into (1) yes, sometime during pregnancy and (0) no smoking or smoking prior to knowing about pregnancy.

2.2.4. Cohabitation at birth

Maternal cohabitation with the father at time of birth data came from the birth registry database, and was recoded into (1) yes, (0) no.