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Maternal cigarette smoking during pregnancy and the trajectory of externalizing and internalizing symptoms across childhood: Similarities and differences across parent, teacher, and self reports

Angelina R. Sutin, Heather A. Flynn, and Antonio Terracciano

Florida State University College of Medicine

Abstract

Maternal smoking during pregnancy (MSDP) has been associated with symptoms of externalizing (e.g., hyperactivity) and internalizing (e.g., emotional) disorders in childhood. The present research addresses two new questions about the nature of this relation: (1) Do the associations between MSDP and externalizing and internalizing symptoms vary by who reports the symptoms? and (2) Is MSDP associated with changes in symptomatology across childhood? We address these questions with two cohorts from the Longitudinal Study of Australian Children (LSAC). Parents and teachers completed the Strengths and Difficulties Questionnaire up to six times every two years between child ages 4 and 14 in the older cohort ($N=3,841$) and up to four times between child ages 4 and 10 in the younger cohort ($N=3,714$); the study children also completed the same questionnaire up to three times starting at age 10. Across the two cohorts, MSDP was associated with more externalizing symptoms as reported by parents, teachers, and self. MSDP was also associated with increases in externalizing symptoms across childhood when teachers assessed the symptoms but not when parents assessed them. Finally, MSDP was not consistently associated with the average level of internalizing symptoms, but it was associated with increases in these symptoms across childhood. The present research indicates a robust association between MSDP and the average level of externalizing symptoms in childhood regardless of who reports the symptoms. It also indicates that whether MSDP is associated with the trajectory of externalizing symptomatology depends on who reports on the symptoms.

Keywords

Maternal smoking during pregnancy; internalizing behavior; externalizing behavior; teacher reports

Maternal smoking during pregnancy (MSDP) is associated with the emotional and behavioral health of the child (Button *et al.*, 2007). There is consistent evidence that children of mothers who smoked during pregnancy have more symptoms of attention deficit hyperactivity disorder (ADHD) (Kovess *et al.*, 2015, Melchior *et al.*, 2015) and are more

likely to receive a diagnosis of ADHD (Zhu *et al.*, 2014) than children of mothers who did not smoke during pregnancy. MSDP has likewise been associated with other externalizing behaviors, such as symptoms of conduct disorders (Hutchinson *et al.*, 2010). The relation with internalizing symptomatology in childhood is less clear (Moylan *et al.*, 2015); some research finds a positive relation between MSDP and internalizing symptoms (McCrary and Layte, 2012) and some research finds no association (Melchior *et al.*, 2015). The present research expands on this evidence base by addressing two fundamental questions about the nature of the relation between MSDP and offspring symptoms of behavioral and emotional disorders: (1) Do these associations vary by who reports the symptoms? and (2) Is MSDP associated with change in symptomology across childhood? To address these questions, we examine whether MSDP is associated with differences in symptoms reported by parents, teachers, and the children themselves measured up to six times across childhood, from ages 4 to 14. To ensure that results are replicable, we test these associations in two independent samples of children and their families.

Method

Participants and Procedure

The two cohorts from the Longitudinal Study of Australian Children (LSAC) (Australian Institute of Family Studies, 2015) were used in this study. The younger cohort included families recruited into the study when the study child was an infant. The older cohort included families recruited into the study when the study child was 4–5 years old. In both cohorts, families were re-interviewed every two years. A total of 3,714 and 3,841 families from the younger and older cohorts, respectively, had the relevant measures (see below) to be included in the analysis. Children were assessed on the SDQ measure from ages 4 to 10 in the younger cohort and from ages 4 to 14 in the older cohort. This research adhered to the Declaration of Helsinki, was reviewed by appropriate ethics committees, and informed consent of the participants was obtained (consent from the adults, assent from the children).

Measures

Maternal smoking—At entry into LSAC, mothers were asked about their cigarette smoking behavior during pregnancy. Smoking was coded as (0) mother reported no smoking during pregnancy or (1) mother reported any cigarette smoking during pregnancy.

SDQ—Parents, teachers, and the study child completed a 25-item version of the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997). The SDQ had five subscales with five items each that measured Prosociality (e.g., “considerate of other people’s feelings”), Hyperactivity (e.g., “restless, overactive, cannot stay still for long”), Emotional Symptoms (e.g., “often unhappy, depressed or tearful”), Peer Problems (e.g., “rather solitary, prefers to play alone”), Conduct Problems (e.g., “often lies or cheats”), and a Total Score (the sum of all subscales except Prosociality). Participants responded to each item using a three-point scale from 0 (*not true*) to 2 (*certainly true*). Parents and teachers completed this scale when the study child was 4, 6, 8, 10, 12 and 14 (12 and 14 in the older cohort only). In the older cohort, most teachers were female (82%), with a mean of 15.40 ($SD=10.88$; range=0–55) years in teaching, and 27% had an advanced degree. In the younger cohort, most teachers

were female (88%), with a mean of 15.48 ($SD=10.88$; range 0–60), and 21% had an advanced degree in the younger cohort. Study children self-reported on themselves with this same scale at age 10 (younger cohort) and at ages 10, 12, and 14 (older cohort).

Covariates—Covariates included child sex, indigenous status, mother's age, mother's education (coded from 1=never attended school to 6=year 12 or equivalent), family income (coded from 1 = <\$2,600 per year to 15 = >\$124,800 per year), and single parent households. Bivariate correlations between the covariates and SDQ scores are shown in Supplementary Tables 1 (older cohort) and 2 (younger cohort).

Statistical Approach

Hierarchical Linear Modeling (HLM) (Raudenbush and Bryk, 2002) was used to model the trajectory of SDQ scores in both cohorts across the three different reporters (parent, teacher, self) using all available data. A quadratic model was fit at Level 1 for each scale to model non-linear changes across childhood; age was centered on the grand mean. At Level 2, MSDP was entered as a predictor of the intercept and slope to test whether the mean-level and trajectory of the SDQ dimensions differed by prenatal exposure to cigarette smoking. The covariates were included at Level 2 to control for their potential confounding effects. HLM models the trajectory of the SDQ scores on age, which accounts for changes in symptoms with age.

Results

Table 1 shows the descriptive statistics for the study variables. Across the two cohorts, a total of 740 mothers in the older cohort (18%) and 709 mothers in the younger cohort (16%) reported having smoked during their pregnancy with the study child.

MSDP was associated with the intercept (i.e., mean-level) of several SDQ dimensions, with similar effects across the two cohorts and the three reporters (i.e., parent, teach, and self; Table 2). MSDP had the strongest association with the Hyperactivity scale: The children of mothers who had smoked during their pregnancy were more restless, fidgety, distracted, and acted without thinking than children of mothers who had not smoked during pregnancy. MSDP was also associated with higher scores on Peer Problems, Conduct Problems, and Total Problems. The associations between MSDP and the mean-level of Emotional Symptoms and Prosociality were generally stronger for the older cohort than the younger cohort.

The relation between MSDP and change in the externalizing dimensions was more complex (Table 2). MSDP was not associated consistently with change as reported by parents across the two cohorts but it was associated consistently with change as reported by teachers: MSDP was associated with increases in the tendency to be easily distracted, to have difficulties with peers, and to lie, and decreases in the tendency to help others, as reported by teachers. MSDP was associated with increases across childhood in Emotional Symptoms reported by both parents and teachers in both cohorts; MSDP was unrelated to self-reported increases in these symptoms in the older cohort.

Discussion

The present research addressed questions about the nature of the relation between MSDP and internalizing and externalizing behavior in childhood. The most consistent results were found between MSDP and the mean-level of externalizing behavior: Compared to the children of mothers who had not smoked during pregnancy, the children of mothers who had smoked during pregnancy were, on average, more hyperactive and had more difficulties with their peers and with their behavior as rated by parents, teachers, and the children themselves. These results support previous findings that MSDP is associated with symptoms of ADHD and other externalizing disorders (Hutchinson *et al.*, 2010, Kovess *et al.*, 2015, Zhu *et al.*, 2014) and indicate that the results do not depend on who reports the symptomatology; similar differences emerged from three respondents who had access to information about the child across different settings.

The relation between MSDP and change in externalizing symptomatology was less consistent. Across the two cohorts, MSDP was associated with increases in Hyperactivity, Conduct Problems, and Total Problems and declines in Prosociality as reported by teachers but not as reported by parents. There may be several reasons for this divergence. Teachers and parents have different relationships with children and interact with them in different contexts. As such, informants have access to different information about the child (Renk, 2005). In addition, as children grow, parents may become habituated to their children's behavior and may not be able to detect how the child changes year to year. Teachers, in contrast, are more likely to make comparisons to other children in the class. In general, children tend to increase in their prosocial behaviors and decline in their more problematic behaviors across middle childhood (Mellor, 2005). For those children whose mothers smoked during pregnancy, their problematic behavior may become more visible with age as they may be less likely to show the typical age-related change toward greater maturity. And, in some domains, teacher reports are better predictors of future behavior/disorders than parent reports, presumably because they are less biased than parent reports (Rudasill *et al.*, 2014).

MSDP was associated with the mean-level of Emotional Symptoms for the older cohort but not the younger cohort. Across both parent and teacher reports, however, MSDP was associated with worsening of these symptoms across childhood. Previous research has been relatively mixed on the relation between MSDP and symptoms of internalizing disorders (Moylan *et al.*, 2015). The association tends to be more apparent in later childhood and adolescence than in early childhood (Dolan *et al.*, 2016, Dürr *et al.*, 2015, Ellingson *et al.*, 2014, McCrory and Layte, 2012, Melchior *et al.*, 2015). The present research is consistent with these findings from studies that measured symptomatology at a single point in time and suggests that the association between MSDP and internalizing symptoms may not be apparent until relatively later in childhood. It may be more difficult for adults to perceive symptoms that are experienced internally for young children (e.g., whether the child is worried or nervous) than external symptoms that are more clearly visible (e.g., hyperactivity, fighting) (Renk, 2005). Internalizing symptoms may also be more apparent to parents and teachers as the child gets older and the symptoms are more visible and/or the child can better express his/her feelings.

The present research has several strengths, including two samples and longitudinal assessments by three different reporters. There are also some limitations that need to be taken into account. For example, maternal smoking was a retrospective self-report at entry into the study and thus this behavior was not directly measured during pregnancy. A second limitation is that we did not have information on whether the mother quit smoking at some point during pregnancy or the amount of cigarettes smoking throughout pregnancy. Future research could address these limitations and include a biological marker of nicotine use during pregnancy instead of retrospective self-reports and detailed information on smoking patterns during pregnancy to identify potential sensitive periods. In addition, we could not test alternative explanations for the association between MSDP and the internalizing and externalizing symptoms, such as shared genetics or mother's commitment to having children. There is evidence, for example, that supportive parenting is associated with better offspring outcomes (Chevalier and Marie, 2016). In supplemental analyses, we did account for parent-reported supportive parenting in the HLM models. The associations between MSDP and the SDQ dimensions were virtually identical controlling for this parenting dimension (data not shown). Still, other aspects of the parent-child relationship may contribute to the association between MSDP and internalizing and externalizing behaviors that could be addressed in future research. Overall, the present research is consistent with previous research and adds that mean-level differences in externalizing symptoms by MSDP do not depend on who reports the symptoms whereas whether the difference in symptoms increases or decreases across childhood does depend on who reports them.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Descriptive Statistics for the Two Cohorts

Demographic Factor	Cohort	
	Older	Younger
Child Sex (female)	49% (1865)	49% (1812)
Indigenous (yes)	2% (86)	2% (73)
Mom age	34.75 (5.13; 19–52)	31.38 (5.10; 16–48)
Mom education	5.27 (1.03; 1–6)	5.49 (.89; 1–6)
Family income	10.59 (2.63; 1–15)	10.44 (2.56; 1–15)
Single parent (yes)	12% (473)	7% (266)
Smoked during pregnancy (yes)	18% (740)	16% (709)
Number of SDQ assessments		
Parent report ¹	5.16 (1.39; 1–6)	3.56 (.81; 1–4)
Teacher report ²	4.29 (1.39; 1–6)	3.04 (.92; 1–4)
Self report ³	2.71 (.59; 1–3)	1

Note. $N=3,841$ for the older cohort and $N=3,714$ for the younger cohort. Numbers are either percentages (n) or means (standard deviations; range). SDQ=Strengths and Difficulties Questionnaire. Education ranges from 1 (never attended school) to 6 (Year 12 or equivalent). Income ranges from 1 (<\$2600/year) to 15 (>\$124,800).

¹Total parent assessments = 19,833 ($n=3,841$) and 13,239 ($n=3,714$) for the older and younger cohort, respectively.

²Total teacher assessments = 16,028 ($n=3,734$) and 11,282 ($n=3,714$) for the older and younger cohort, respectively

³Total self assessments = 9,267 ($n=3,424$) and 3,034 ($n=3,034$) for the older and younger cohort, respectively; the younger cohort only had a single self assessment on the SDQ

Table 2

The Association Between Maternal Smoking During Pregnancy and the Mean-level and Trajectory of Parent, Teacher, and Self-reported Externalizing and Internalizing Symptomatology

	Older Cohort		Younger Cohort	
	Intercept	Slope	Intercept	Slope
	<u>Parent Report</u>		<u>Parent Report</u>	
Hyperactivity	.47 (.08; .31, .63)**	.01 (.01; -.01, .03)	.42 (.09; .24, .60)**	.02 (.02; -.02, .06)
Peer Problems	.26 (.05; .16, .36)**	.01 (.01; -.01, .03)	.22 (.06; .10, .34)**	.03 (.01; .01, .05)*
Conduct Problems	.36 (.05; .26, .46)**	-.01 (.00; .00, .00)*	.25 (.06; .13, .37)**	.00 (.01; -.02, .03)
Emotional Symptoms	.13 (.06; .01, .25)*	.02 (.01; .00, .04)**	.11 (.07; -.03, .25)	.04 (.01; .02, .06)**
Total Problems	1.22 (.19; .85, 1.59)**	.03 (.02; -.01, .07)	1.00 (.21; .59, 1.41)**	.09 (.03; .03, .15)**
Prosociality	-.20 (.06; -.32, -.08)**	.01 (.01; -.01, .03)	-.03 (.07; -.11, .11)	.01 (.01; -.01-.03)
	<u>Teacher Report</u>		<u>Teacher Report</u>	
Hyperactivity	.55 (.09; .37, .73)**	.05 (.01; .03, .07)**	.49 (.10; .29, .69)**	.06 (.02; .02, .10)*
Peer Problems	.26 (.05; .16, .36)**	.01 (.01; -.01, .03)	.19 (.06; .07, .31)**	.05 (.02; .01, .09)**
Conduct Problems	.33 (.05; .23, .43)**	.03 (.01; .01, .05)**	.30 (.06; .18, .42)**	.04 (.01; .02, .06)*
Emotional Symptoms	.18 (.05; .08, -.18)**	.03 (.01; .01, .05)**	.08 (.06; -.04, .20)	.07 (.02; .03, .11)**
Total Problems	1.34 (.19; .97, 1.71)**	.12 (.03; .07, .17)**	1.06 (.22; .63, 1.49)**	.21 (.05; .11, .31)**
Prosociality	-.39 (.07; -.53, -.25)**	-.05 (.01; -.07, -.03)**	-.30 (.08; -.46, -.14)**	-.08 (.02; -.12, -.04)**
	<u>Self Report</u>		<u>Self Report¹</u>	
Hyperactivity	.41 (.09; .23, .59)**	.03 (.03; -.03, .09)	.33 (.12; .09, .56)**	–
Peer Problems	.36 (.06; .24, .48)**	.06 (.02; .02, .10)*	.34 (.09; .16, .52)**	–
Conduct Problems	.38 (.06; .26, .50)**	.01 (.02; -.03, .05)	.38 (.09; .20, .56)**	–
Emotional Symptoms	.41 (.08; .25, .57)**	.06 (.03; .00, .12)	.15 (.12; -.08, .38)	–
Total Problems	1.57 (.23; 1.12, 2.02)**	.16 (.07; .02, .30)*	1.20 (.31; .59, 1.81)**	–
Prosociality	-.22 (.06; -.34, -.10)**	-.05 (.02; -.09, -.01)*	-.08 (.09; -.26, .10)	–

Note. $N=3,841$ for the older cohort and $N=3,714$ for the younger cohort. Estimates are from hierarchical linear models controlling for the demographic and social covariates.

¹The estimates for the self-reports from the younger cohort are unstandardized beta coefficients (standard errors) from linear regression, controlling for the demographic and social covariates.