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Smoking in pregnancy and development into early adulthood

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SMOKING IN PREGNANCY AND DEVELOPMENT INTO EARLY ADULTHOOD

K.R.Fogelman

Abstract

Analyses of data from the 1958 Cohort (National Child Development Study) show only weak evidence for a relationship between mother's smoking in pregnancy and self-reported height at the age of twenty-three, once social class, family size, mother's height and birthweight for gestation are taken into account. However, when birthweight is omitted from the analyses, the average difference in height between those whose mothers did not smoke during the second half of pregnancy and those who smoked 20 or more cigarettes per day amounts to .93 cm for men and 1.83 cm for women. A strong association is also found with the level of the highest qualification achieved by the age of 23, suggesting a long-term relationship between smoking in pregnancy and the intellectual development of the offspring.

Introduction

The existence of a causal relationship of some kind between a mother's smoking in pregnancy and the survival and birthweight of her baby is now generally accepted. Among the main contributors to the evidence for this have been the national cohort studies, in particular the National Child Development Study (NCDS), of people born in 1958 (1,2), and more recently the 1970 Cohort, the Child Health and Education Study (3).

Early analyses of NCDS data, for example, demonstrated that smoking ten or more cigarettes per day in the second half of the pregnancy increased perinatal mortality by 28% and reduced birthweight by an average of 170 grams, compared with non-smokers (4); and that these results were not changed when allowance was made for possible mediating factors such as social class, maternal age and parity (5). Similar relationships have been reported for the cohort born twelve years later (6).

Subsequently, as the NCDS subjects have been growing up, there has been a series of papers examining the development of the surviving

children of those mothers who smoked. At the ages of seven and eleven associations were found between mother's smoking and the child's height, reading attainment and maths attainment (1,7,8). However, by contrast with the original perinatal findings, these relationships were much reduced when possible mediating factors were taken into account - although they were still statistically significant.

At the age of sixteen similar results were obtained for reading and maths attainment, but the association with height had decreased for girls and was no longer significant at the 5% level (9). For boys at 16 the mean difference in height between the children of non-smokers and those who had smoked 10 or more was just under one centimetre (.88 cm), very close to the comparable contrast at age eleven.

It was suggested that this sex difference could be compatible with an association between mother's smoking and the rate of children's growth or growth to puberty, but not eventual adult height (which is achieved by almost all girls by the age of sixteen). However, the main emphasis of these findings was on the relatively small differences in outcomes related to smoking in pregnancy, and the possibility that these might be explained by further, but unidentified, mediating factors.

Since these findings were reported, the next stage of the study has taken place at the age of twenty-three, and it is thus possible to examine these relationships further. In particular, the young men will have reached their adult height. If the hypothesis offered above is correct we should expect to find differences in height for neither sex at this age, when the mediating factors are taken into account.

Thus, in part, this paper describes analyses which up-date those carried out at the earlier ages. However there is an additional issue which is considered. Among the mediating factors taken into account in the past work was the child's birthweight for gestational age. This is justifiable if the underlying question is formulated as whether smoking in pregnancy has an effect on physical and intellectual development additional to its known effect on birthweight.

On the other hand, of at least equal interest is whether smoking in pregnancy has an effect on achieved development, even if this is no greater than would be predicted from the relationship with birthweight. In other words, is there evidence that those babies who were born lighter, in association with their mother's smoking, are

shorter or have poorer educational attainment in early adulthood? Or do the differences which existed at birth, as indicated by birthweight, disappear by early adulthood?

In order to address these issues, the results of two sets of analyses designed to assess the association between smoking in pregnancy and 23-year outcomes are reported below. The first replicates earlier analyses and takes into account the same potential mediating factors. The second is otherwise based on the same variables but excludes birthweight from the analyses.

The 1958 Cohort (NCDS)

As has been indicated the following analyses are of data collected for the National Child Development Study, a longitudinal study of all the people in this country who were born in the week 3-9 March, 1958. Originally studied at the time of their birth by the National Birthday Trust Fund (1,10), members of this cohort have been followed up at the ages of seven (1), eleven, sixteen (2) and twenty three (11). A fifth follow-up in their early thirties is now being planned (12).

At birth information was obtained from medical records and from an interview with the mother. For the stages during the school years information was obtained by parental interviews, medical examinations, personal questionnaires, school questionnaires, and tests of educational attainment. At 23, lengthy interviews were carried out by professional interviewers.

Variables

Dependent variables:

Height at age 23 was self-reported in the course of the interview.

Highest qualification obtained by 23 is based on the answers to a number of questions about qualifications obtained in the course of education and training. These have been grouped to form a 16 point scale from no qualifications (=16) to higher degree (=1) (for fuller detail, see (13)).

Independent variables:

Sex

Mother's smoking after the fourth month of pregnancy, grouped as: no cigarettes per day; 1-9 per day; 10-19; 20+.

Social Class of the father's occupation at the time of the subject's birth, grouped as: professional and intermediate; skilled non-manual; skilled manual; semi and unskilled manual; no male head of household.

Family size, i.e. the number of children under 21 in the household when the subject was eleven, grouped as: 1 or 2; 3 or 4; 5 or more.

Birthweight for gestation, calculated as centiles of the total distribution, and entered as a continuous variable.

Mother's height, reported by the mother at the perinatal interview and entered as a continuous variable.

Response

The sample in these analyses, approximately 8,200 individuals, represents just over half the known survivors from the original birth cohort, and some two-thirds of those who were successfully interviewed at the twenty-three year follow-up. The reduction results from the requirement to have data on all the variables in the analyses, and is due to a combination of refusals, failure to trace and partial information.

General analyses of response patterns within the study have been reassuring, but do show a slight tendency for the responding sample to be more middle class and to under-represent certain disadvantaged groups (14,15). The one more serious bias is an under-representation of ethnic minority groups. Perhaps more relevant is the finding that repeating earlier general analyses omitting later non-respondents does not affect the underlying relationships (14).

More specific checks on the characteristics of those included in the analyses reported here show that the contrasts with the original birth cohort are small. For example, 67.8% of the analysis sample had mothers who did not smoke during their pregnancy compared with 66.5% of the full cohort. Similarly, of the analysis sample 18.7% had fathers in professional and intermediate occupations and 20.1%

in semi- or unskilled occupations, compared with 17.0% and 21.3% in the original week's births. A more troubling comparison is in the proportions born into families with no male head (1.8% and 3.0%), but the small size of this group makes it extremely unlikely that this would affect our conclusions.

Statistical Methods

As in the earlier NCDS analyses, the method used is analysis of covariance. Two dependent variables have been investigated: height at 23 and the highest qualification obtained by the same age. There are three other important differences from the earlier analyses. Firstly, for the reasons given above, additional analyses have been carried out to assess the effect of omitting birthweight for gestation from the independent variables. Secondly,mother's age did not prove to be related to either outcome and so has been omitted from the multivariate analyses. Thirdly, an extra category has been introduced into the variable which describes smoking in pregnancy, so that a group of heavier smokers (20 or more per day) can be identified.

Two-way interactions were tested for these analyses. None proved to be significant in relation to height, so main effects only are fitted in those analyses. Two- way interactions are included in the analyses of highest qualifications, but only the interaction between social class and family size was in fact significant at the 5% level. Separate analyses have been carried out for each sex.

Tables I and II present, for height and the highest qualification obtained respectively, three sets of deviation coefficients for each sex. The first represent the unadjusted deviation from the overall mean associated with each category of smoking in pregnancy. The second give the deviations adjusted for social class, family size, birthweight for gestation and mother's height (and also two-way interactions among these for the qualifications analyses only). The third column of deviations is from analyses which adjust for the same variables, but with the exception of birthweight for gestation.

Height at 23

The figures for the analyses of 23-year height in Table I can be interpreted straightforwardly as they are in centimetres: the difference between any pair of deviations represents the average difference in height in centimetres between those two categories. Thus the unadjusted contrast in the average height of those men

whose mothers did not smoke and those who smoked twenty or more cigarettes per day is 1.42 cms. Adjusting for all the independent variables reduces this contrast to less than half a centimetre, and this is not significant at the 5% level. Omitting birthweight from the analysis produces an intermediate picture, with an adjusted difference of .93 cms which borders on the 5% probability level.

For women, the comparable contrasts are somewhat larger: 2.53 cms, 1.57 cms and 1.83 cms respectively. This may seem surprising, given that, as was described above, at the age of sixteen it was boys' height which showed the stronger relationship with their mothers' smoking. However it can be seen that at 23 the main contrast for women, in the full model, is between those whose mothers had smoked 20 or more and the remainder. This group is relatively small and was not examined separately at 16. Given also the borderline statistical significance, at a level which is hardly demanding for a sample of this size, it seems reasonable to conclude from these analyses that the evidence for a relationship between smoking in pregnancy and adult height, when birthweight is among the factors taken into account, is weak.

When birthweight is not included in the analyses, the remaining association between smoking in pregnancy and adult height is stronger, especially for women.

Highest Qualification by 23

Table II presents the results for the second dependent variable examined: the highest qualification obtained by the age of twenty-three. It is less easy to give a clear meaning to the figures in this table, but, broadly, a difference of one point around the overall mean represents the contrast between having 1-4 O-level (in Scotland O-grade) passes at grades A-C and having five or more such passes (but no higher level qualification).

The relationships reported in Table II are generally stronger than those found for height, and remain highly statistically significant after allowing for the other independent variables. As might be expected, birthweight plays a smaller part in explaining the association between smoking in pregnancy and educational qualifications than it did in the analysis of height. The contrast between the two sets of adjusted deviations is slight, and mainly due to the somewhat strange results for the sons of the heaviest

smokers, a relatively small group. In general, for both sexes, there is only a small difference between the two heavier smoking groups but then a steady gradient to the non-smokers.

Discussion

As was predicted from the results at the age of sixteen (9), the evidence examined in this paper provides little support for a continuing relationship into adulthood between physical growth and mother's smoking in pregnancy, when social class, family size, birthweight for gestation and mother's height are taken into account. This finding contrasts with those reported in early childhood, despite the fact that the analyses reported here were designed to be comparable with those which produced the earlier findings. One difference which must be considered is in the height measure. At the NCDS follow-ups at 7, 11 and 16, height was measured by examining doctors. At 23 it was self-reported. It is likely that the latter will be less accurate, but there is evidence that self-reported height is sufficiently valid for epidemiological analysis of this kind (16,17). Furthermore the NCDS height data have been checked and amended for inconsistencies and improbable values (19).

These findings may imply the absence of a causal relationship, but, in conjunction with the results at earlier ages, they appear more compatible with the suggestion either that mother's smoking affects rate of growth, but not total growth, or that it has a small affect until puberty which disappears in the course of the far greater changes then taking place.

It should be clear however that this conclusion is limited to the question of whether smoking in pregnancy has an effect on height which is additional to its association with birthweight. If we ask whether there are differences in eventual height, once social background and the mother's own height have been allowed for, then the evidence for that is stronger, particularly for women. It does not appear that the possible initial impact of smoking in pregnancy on the development of the child, as indicated by its birthweight, has evaporated by adulthood, as indicated by height.

The relationship of smoking in pregnancy with the offspring's educational achievement, as measured by the highest qualification obtained by the age of twenty-three, remains quite strong, even

after allowing for social class, family size, birthweight for gestation and mother's height; and is not substantially affected by the omission of birthweight from the analyses. It is difficult to give a precise meaning to the differences on the qualifications scale associated with smoking, but they clearly do represent a shift into a distinguishable level of qualification. Such differences are certainly of significance when fine decisions are being made about job selection or entry into further or higher education.

It was to be expected that some difference would persist, since there were differences at earlier ages in reading and maths test scores, and these could be expected to predict subsequent qualifications. It is however a little surprising that the relationship is so strong and of such potential practical importance. As far as it is possible to judge, the relationship at 23 may be a little stronger than it was at sixteen. The contrasts in reading and maths test scores between the extreme smoking categories represented .12 and .18 of the population standard deviation. The equivalent figures for the qualifications scale at 23 are .22 for men and .31 for women (this is not explained by the inclusion of the additional smoking category at 23).

Of course these are observational data and we should not claim that we have unequivocally demonstrated a causal relationship. Nevertheless, the evidence does appear strong enough to justify warnings against smoking in pregnancy because of the possibility of implications for the long-term physical and intellectual development of the child, in addition to the other known dangers.

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Table I Cigarettes smoked by mother in second half of pregnancy and height at 23

No of cigarettes smoked	N	Overall Mean (s.d)	Unadjusted Deviation(cms)	Adjusted Deviation (full model)	Adjusted Deviation (excl. b'weight)
MEN	4094	177.5 (6.96)			
None	2774		.27	.07	.17
1-9	703		-.66	-.20	-.38
10-19	539		-.37	-.06	-.26
20+	75		-1.15	-.41	-.76
F				0.494(p>.05)	2.566(p=.053)
WOMEN	4179	162.5 (6.62)			
None	2821		.35	.08	.20
1-9	756		-.50	.10	.04
10-19	506		-.88	-.34	-.76
20+	79		-2.18	-1.49	-1.63
F				2.662(p=.047)	7.108(p<.001)

Table II Cigarettes smoked by mother in second half of pregnancy and highest qualification obtained by 23

No of cigarettes smoked	N	Overall Mean (s.d)	Unadjusted Deviation	Adjusted Deviation (full model)	Adjusted Deviation (excl. b'weight)
MEN	4126	9.01 (4.68)			
None			-.41	-.25	-.27
1-9			.54	.18	.28
10-19			1.25	.93	.89
20+			1.07	.77	1.03
F				28.474(p<.001)	33.590(p<.001)
WOMEN	4179	9.73 (4.62)			
None			-.54	-.35	-.39
1-9			.89	.55	.64
10-19			1.43	.98	.95
20+			1.63	1.09	1.06
F				51.715(p<.001)	56.402(p<.001)

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N A T I O N A L C H I L D D E V E L O P M E N T S T U D Y

The National Child Development Study (NCDS) is a continuing longitudinal study which is seeking to follow the lives of all those living in Great Britain who were born between 3 and 9 March, 1958.

It has its origins in the Perinatal Mortality Survey (PMS). This was sponsored by the National Birthday Trust Fund and designed to examine the social and obstetric factors associated with the early death or abnormality among the 17,000 children born in England, Scotland and Wales in that one week.

To date there have been four attempts to trace all members of the birth cohort in order to monitor their physical, educational and social development. These were carried out by the National Children's Bureau in 1965 (when they were aged 7), in 1969 (when they were aged 11), in 1974 (when they were aged 16) and in 1981 (when they were aged 23). In addition, in 1978, details of public examination entry and performance were obtained from the schools, sixth-form colleges and FE colleges.

For the birth survey information was obtained from the mother and from medical records by the midwife. For the purposes of the first three NCDS surveys, information was obtained from parents (who were interviewed by health visitors), head teachers and class teachers (who completed questionnaires), the schools health service (who carried out medical examinations) and the subjects themselves (who completed tests of ability and, latterly, questionnaires). In addition the birth cohort was augmented by including immigrants born in the relevant week in the target sample for NCDS1-3.

The 1981 survey differs in that information was obtained from the subject (who was interviewed by a professional survey research interviewer) and from the 1971 and 1981 Censuses (from which variables describing area of residence were taken). Similarly, during the collection of exam data in 1978 information was obtained (by post) only from the schools attended at the time of the third follow-up in 1974 (and from sixth-form and FE colleges, when these were identified by schools). On these last two occasions case no attempt was made to include new immigrants in the survey.

All NCDS data from the surveys identified above are held by the ESRC Data Archive at the University of Essex and are available for secondary analysis by researchers in universities and elsewhere. The Archive also holds a number of NCDS-related files (for example, of data collected in the course of a special study of handicapped school-leavers, at age 18; and the data from the 5% feasibility study, conducted at age 20, which preceded the 1981 follow-up), which are similarly available for secondary analysis.

Further details about the National Child Development Study can be obtained from the NCDS User Support Group.