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**Birthweight and paternal involvement predict early reproduction in British women: Evidence from the National Child Development Study**

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## **Abstract**

There is considerable interest in the mechanisms maintaining early reproduction in the most socioeconomically disadvantaged groups in developed countries. Previous research has suggested that differential exposure to early-life factors such as low birthweight and lack of paternal involvement during childhood may be relevant. Here, we used longitudinal data on the female cohort members from the UK National Child Development Study (n=3014-4482 depending upon variables analysed) to investigate predictors of early reproduction. Our main outcome measures were having a child by age 20, and stating at age 16 an intended age of reproduction of 20 years or lower. Low paternal involvement during childhood was associated with increased likelihood of early reproduction (O.R. 1.79-2.25) and increased likelihood of early intended reproduction (O.R. 1.38-2.50). Low birthweight for gestational age also increased the odds of early reproduction (O.R. for each additional s.d. 0.88) and early intended reproduction (O.R. for each additional s.d. 0.81). Intended early reproduction strongly predicted actual early reproduction (O.R. 5.39, 95% CI 3.71-7.83). The results suggest that early-life factors such as low birthweight for gestational age, and low paternal involvement during childhood, may affect women's reproductive development, leading to earlier target and achieved ages for reproduction. Differential exposure to these factors may be part of the reason that early fertility persists in socioeconomically disadvantaged groups. We discuss our results with respect to the kinds of interventions likely to affect the rate of teen pregnancy.

Keywords: teenage pregnancy, reproductive development, life-history theory, birthweight, father absence, developmental plasticity

## Introduction

Whilst the majority of women in developed countries begin their reproductive careers relatively late, there is a persistent sub-group who become mothers in their teenage years. This early reproduction continues to attract research interest and public policy initiatives in the UK (Arai 2003; TPIAG 2008), due to its purported adverse health and socioeconomic consequences for mother and child (Fraser and others 1995; Furstenberg and others 1989; Hofferth 1987; Miller 2000), though it is unclear to what extent there are negative effects of young motherhood *per se*, once associated contextual factors are adequately controlled (see Geronimus and others 1994; Hoffman and others 1993; Shaw and others 2006; Smith and Pell 2001). Recently, an adaptive perspective on early reproduction has begun to develop. The overwhelming predictor of teenage motherhood is socioeconomic deprivation (Imamura and others 2007; McCulloch 2001), and socioeconomic deprivation in developed countries is associated with increased mortality and morbidity, particularly in mid-life (Geronimus and others 1999). By delaying reproduction, individuals run the risk of dying or becoming incapacitated before their offspring are adult (Geronimus 2003). Thus, we should expect females to match their timing of onset of reproduction to the prevailing mortality and morbidity schedule, starting earlier when these dangers are high (for a review, see Ellis and others 2009). This hypothesis is extremely successful at explaining differences in age at first birth across species (Promislow and Harvey 1990) and across human populations (Low and others 2008), as well as across socioeconomic groups within developed countries (Geronimus 2003; Geronimus and others 1999; Wilson and Daly 1997).

What are the proximate mechanisms which allow human females to alter their reproductive timing in different ecologies? In part, women may be responding to early-life cues that are predictive of their future prospects (Bateson and others 2004; Belsky and others 1991; Gluckman and others 2005). There are a number of lines of evidence of such developmental effects on female reproductive schedules in humans. Low birthweight, or thinness at birth, have been shown to predict early menarche in a number of studies (Adair 2001; Cooper and others 1996; Ibanez and others 2006a; Koziel and Jankowska 2002; Opdahl and others 2008; Sloboda and others 2007). Since small size at birth predicts increased risk of mortality, particularly from age 35 onwards (Andersen and Osler 2004), it makes adaptive sense that there should be calibration of reproductive strategy to size at birth. Note that slow growth after birth has the opposite effect to slow growth before birth, tending to delay menarche (Sloboda and others 2007). This explains the apparent paradox that at the population level, menarche becomes earlier as nutritional conditions improve, despite the fact that within

populations, girls with worse intrauterine growth have earlier menarche (Eveleth and Tanner 1990).

A second cue which has been intensively studied is paternal involvement. Girls whose fathers are absent or uninvolved in their development reach puberty earlier than average (see Alvergne and others 2008; Bogaert 2008; Ellis 2004; Quinlan 2003), have earlier sexual intercourse (Quinlan 2003), and are more likely than average to become mothers young (Chisholm and others 2005; Ellis and others 2003; Hogan and Kitagawa 1985; Vikat and others 2002). There is some debate about whether low paternal involvement is just one indicator of broad psychosocial adversity during childhood (Belsky and others 1991), or fathers have a specific causal effect (Draper and Harpending 1982). Both within and across human societies, men invest less in offspring as conditions become more harsh (Nettle 2008; Quinlan 2007), and therefore it is hard to adjudicate between low paternal involvement being a cause of accelerated development, and it being a consequence the same ecological factors as accelerated development. However, Ellis et al. (2003) find that father absence predicts early sexual activity and teenage pregnancy in two cohorts of girls even once a wide variety of other indicators of stress and adversity are controlled for, suggesting that paternal involvement might indeed have a special causal role.

Although the literature on early-life influences on reproductive development is large and well-developed, there are a number of gaps. Most studies use age at menarche as their outcome variable. Whilst this may be correlated with age at first reproduction, only a much smaller number of studies (e.g. Ellis and others 2003) have actually gone on to study early parenthood itself. In particular, none of the studies of the association with birthweight has gone beyond menarche to examine early reproduction. There is also relatively sparse information regarding adolescents' consciously held intentions about age at first reproduction. Young women in deprived areas state an earlier target age for reproduction than women in affluent ones (Jewell and others 2000), and may even make a conscious link between early reproduction and the mortality and morbidity in their environments (Chisholm and others 2005; Geronimus 1996). This raises the question of whether birthweight and paternal involvement will be associated with consciously-held desires for early reproduction. Finally, studies of the effects of birthweight have not generally tested for separate effects of short gestational age (preterm birth), as distinct from low birthweight for gestational age (intrauterine growth restriction).

This paper investigates the predictors of early reproduction in a large, nationally representative, longitudinally-studied British cohort, the National Child Development Study (NCDS). We concentrate on two outcome variables. The first is becoming a mother

before the age of 20. We chose the twentieth birthday (the end of the teenage years) as a cut-off point because it is earlier than the norm for this population, but still yields a sufficient number of cases for good statistical power. However, we have also repeated the main analysis using earlier and later cut-offs (see Supporting Information), and our results are generally similar.

Our second outcome variable concerns reproductive intentions. The NCDS girls were asked, when they were 16, what they felt the ideal age to start a family would be, and some gave an answer less than 20. We can thus examine the relationships between reproductive intentions at 16 and actual outcomes, as well as the relationships between early-life predictors and both intentions and behaviour. Our early-life predictor variables are gestational age (henceforth GA), birthweight for gestational age (henceforth BGA) and paternal involvement. Our hypothesis is that low BGA and low paternal involvement will predict both intended early reproduction at age 16, and actual early reproduction. Additionally, we hypothesise that short GA may have an accelerating effect on reproduction independently of the effect of low BGA, since short GA is independently associated with increased mortality and morbidity (Swamy and others 2008).

Our analytic strategy is three-stage. First, we test whether GA, BGA and low paternal involvement are associated with the outcome variables, with no other variables controlled. Second, we test whether they continue to have significant relationships with early reproduction once other predictors, such as socio-economic position (SEP) and own mother's age, are included in the model. This is a very conservative test, since SEP could be affecting early reproduction *via* low paternal involvement, and thus they may not both be significant when entered simultaneously in a multivariate model. However, if they are, it would be suggestive of causal importance. Third, we perform mediation analysis. Since socially deprived groups are characterised by lower birthweight babies and less paternal involvement with children than affluent ones (Mortensen and others 2008; Nettle 2008), birthweight and paternal involvement may be amongst the mechanisms by which low SEP affects reproductive timing.

## **Methods**

### *Study population*

The NCDS is an ongoing longitudinal investigation of all individuals born in Britain during one week in March 1958 (initial N=17,416). Extensive medical and sociological information gathered at the time of the cohort members' birth has been supplemented with questionnaires and interviews with parents, teachers and the cohort members

themselves. There have been 7 subsequent 'sweeps', or surveys of the cohort, most recently in 2004 at cohort age 46. Nearly two thirds of the original cohort members were still in contact at the most recent survey, though some individuals who are still in the study were missed for some intermediate sweeps. Loss to follow-up in this cohort is not random with respect to socioeconomic position at birth. For example, 35.7% of cohort members coming from the highest social class of origin have been lost from the study at age 42, whereas 44.1% of those from the lowest social class of origin have (Nettle 2003). However, these differences in retention are not dramatic, and the cohort remains large and representative enough for analyses to be robust even at the later ages.

Missing values are treated listwise, and thus degrees of freedom for analyses are smaller than the number of data points available for individual variables. Only female cohort members are considered here.

### *Measures*

The main measures considered in this study are outlined in table 1, including their date of gathering, NCDS variable number, and number of valid records. The first outcome variable is having a child before age 20 (*early reproduction*), derived from responses in 1981. Medical abortion is relatively rare in this cohort (6.4% of first pregnancies end in abortion, a figure which rises to 14.6% for first pregnancies below the age of 20), and so most teenage pregnancies not miscarrying lead to motherhood. The second outcome variable is stating, at age 16, a desire for a child before age 20 (*early intended reproduction*). This is derived from responses to the question, 'What is the ideal age to have a family?'. We also used a different variable, *age at first pregnancy*, derived from responses in 1991, to produce figure 1 (see Results).

The predictor variables of interest are the following. *Birthweight* in ounces was taken by weighing the baby immediately after birth. *Gestational age (GA)* was recorded at the time of birth from medical records, and is based on mother's last menstrual period. From these, we calculated *birthweight for gestational age (BGA)*. This is the standardised residual from the best-fitting regression relationship of birthweight on gestational age, which was a power function of the form  $y = Ax^b$  ( $A = 0.001$ ,  $B = 2.305$ ,  $F_{(1,7272)} = 4231.06$ ,  $p < 0.001$ ,  $r^2 = 0.37$ ). In other words, BGA represents residual variation in birthweight once the effects of gestational age have been partialled out. Its mean is zero, and positive values represent relative heaviness for gestational age, whilst negative values represent relative lightness for gestational age. Since we are interested in possible effects of both GA and BGA, we enter them both BGA and GA in all multivariate models.

*Paternal involvement* was assessed in an interview with the mother in 1969 (cohort age 11). Mothers were asked to state the father's role in the management of the child, with the response options '1. Plays an equal role', '2. Plays a significant role though less than mother', '3. Leaves it to the mother', and '4. Inapplicable'. The fourth response usually meant that the child had no contact at all with the father. The modal response to this item was '1. Plays an equal role'. It is implausible that fathers actually played an equal role to mothers in most British families of this generation. Nonetheless, the measure may be valid in a relative sense, in that fathers were doing less in the families where the mother gave a response other than '1. Plays an equal role'. There are also other reasons for trusting that the measure has some validity (see Nettle, 2008), for example that it correlates reasonably well with alternative measures of paternal involvement taken at age 7 (e.g. reading to the child and going on outings). In terms of effects on development, the scale reduces to a dichotomy between heavily involved fathers (responses 1 and 2) and uninvolved fathers (responses 3 and 4) (Nettle 2008). However, here we retain the full four-point scale, except for the mediation analyses and figure 2, and treat it as a categorical variable. Note that the paternal involvement measure is not exactly equivalent to co-residence, since some co-resident fathers scored 3, and some non-resident fathers scored 1 or 2.

For SEP, we include one measure based on the cohort member's family background, and based on the neighbourhood milieu, since there is some evidence for an effect of neighbourhood composition on timing of reproduction above and beyond to the effects of family SEP (Brooks-Gunn and others 1993; Smith and Elander 2006). The family SEP measure is *father's social class*, measured in 1958 on the basis of the father or male head of household's most recent job, using the Registrar General's typology of 1. Unskilled and routine occupations, 2. Partly-skilled occupations, 3. Skilled occupations, 4. Managerial and technical occupations, and 5. Professional occupations. We treat this as an ordered scale of increasing SEP. The neighbourhood measure is the proportion of children at the cohort member's current school in 1974 whose fathers are in non-manual occupations (which equates to class 4 and 5 and non-manual jobs in class 3). This proportion is coded in ten percentage point steps, and is henceforth referred to as *school socioeconomic composition*. Although there is an association between the two SEP measures ( $r=0.32$ ), this is not sufficient to cause problems of collinearity.

In addition to these variables, we include mother's age at cohort member's birth in the analyses, since there is evidence that women whose mothers were young at their birth are more likely to become young mothers themselves (Meade and others 2008).

### *Analysis*



As our main outcome variables (*early reproduction* and *early intended reproduction*) are dichotomous, we use logistic regression for our main analyses. Model 1 in each case contains paternal involvement as a factor, and GA and BGA as covariates. Model 2 additionally includes father's social class, school socioeconomic composition, and mother's age at birth as covariates. We considered main effects only in the models. For the mediation analyses, we perform Sobel mediation tests (Sobel 1982) using the procedures for scaling the coefficients from logistic regression models described in Mackinnon and Dwyer (1993). Since these procedures have only been developed for the case of dichotomous variables, the mediation analysis requires us to collapse our 4-category paternal involvement measure to the dichotomy of heavy (1 or 2) versus light (3 or 4). Both previous findings with this measure (Nettle 2008) and current results (see below) justify this dichotomisation. Ancillary analyses are described as they are presented.

## Results

### *Association between early intended reproduction and early reproduction*

Fewer girls stated at 16 a desire to have a baby before 20 than actually did so (3.2% vs. 12.5%). However, early intended reproduction predicted actual early reproduction ( $\chi^2 = 95.90$ ,  $p < 0.01$ ), with those desiring teenage motherhood more likely to actually experience it (OR = 5.39, 95% CI 3.71-7.83). This conclusion is unaffected by excluding those small number of girls who had already given birth or could have been pregnant at the time of the interview at 16 (data not shown). Those who went on to have babies early tended to give low desired ages at parenthood. Of those girls who went on to have a baby before age 20, 29.4% had given an ideal age for first parenthood of 21 or less, whereas only 14.9% of those who did not go on to become teenage mothers did so. Indeed, the relationship between intended fertility pattern stated at age 16 and actual behaviour is strong in this cohort. Figure 1 illustrates this by showing the mean age of actual reproduction against the age stated at 16 as ideal, for all the women in the cohort who had had a child by 1991. If anything, those who desired early reproduction actually didn't manage to reproduce as early as they would have liked, on average.

### *Predictors of early reproduction*

Table 2 shows the outcomes of the logistic regression analyses with early reproduction as the outcome variable. In model 1, there is a significant effect of BGA (every extra s.d. reducing the odds, OR=0.88), but not of GA. Paternal involvement being rated as 'leaves to mother' or 'inapplicable' significantly raises the odds of early reproduction relative to father having a role 'equal to mother' (ORs 1.79 and 2.25 respectively). In model 2, SEP

variables and mother's age at birth are added. There are expected significant effects of father's social class (each class lower compared to professional occupations increasing the odds, OR=1.41) and school socioeconomic composition (every ten-percentage points fewer professional fathers increasing the odds, OR=1.21). Mother's age at birth does not significantly predict early reproduction. Even with the control variables in the model, paternal involvement remains a significant predictor of early reproduction, with the odds ratios remaining similar (ORs 1.87 and 1.79). BGA is near-significant ( $p=0.07$ ) in Model 2, though the OR is very similar to the significant OR of Model 1 (0.89 vs. 0.88).

We also tested whether the association between father's social class and teenage motherhood was mediated by either BGA or dichotomised paternal involvement (separate analyses). The dichotomisation of the paternal involvement variable, which is required for the statistical procedure, seems justified by the fact that the odds ratios for early reproduction never differ significantly between paternal involvement scores of 1 and 2, or between scores of 3 and 4, but they do differ between 1 and 3, and 1 and 4. Dichotomised paternal involvement was a significant mediator of the relationship between father's social class and early reproduction (Sobel test:  $z=3.77$ ,  $p<0.01$ ), as was BGA (Sobel test:  $z=1.99$ ,  $p<0.05$ ).

To explore how BGA and paternal involvement interact with one another to affect reproductive development, we created a synthetic variable with four values (1) above mean BGA and father involved; (2) below mean BGA and father involved; (3) above mean BGA and father uninvolved; and (4) below mean BGA and father uninvolved. We treated this synthetic variable as categorical. In a logistic regression model predicting early reproduction, containing this synthetic variable, and adjusting for GA, father's social class, school socioeconomic position, and mother's age at birth, the synthetic variable is significantly associated with early reproduction ( $\chi^2 = 17.66$ ,  $p<0.01$ ). Figure 2 shows the odds ratios associated with each value of the synthetic variable (reference category = above mean BGA and father involved). Below mean BGA and uninvolved father each increase the estimated odds (ORs 1.24 and 1.63 respectively), but the two combine more than additively to give an estimated odds ratio of 2.31 when BGA is low *and* father is uninvolved.

#### *Predictors of early intended reproduction*

Table 3 shows the outcomes of the logistic regression analyses with early intended reproduction, stated at age 16, as the outcome variable. Model 1 found significant effects of BGA (every extra s.d. decreasing the odds of desiring a family before 20, OR 0.81), but not GA. Paternal involvement also affected early intended reproduction in the predicted direction (a rating of 'leaves it to mother' increasing the odds of desiring a

family before 20, OR 2.50, though the difference between the 'Inapplicable' group and the 'Equal to mother' group is not significant). In Model 2, where control variables are added, there is a significant effect of father's social class on early intended reproduction, but no effect of school socioeconomic composition or mother's age at birth. The effects of BGA and paternal involvement are largely unchanged from Model 1 to Model 2. The BGA age effect persists, with a similar odds ratio (ORs 0.74 vs. 0.81), and, whilst the paternal involvement effect overall becomes marginally significant ( $p=0.06$ ), the contrast between the 'Equal to mother' and 'Leaves it to mother' groups remains significant with a similar odds ratio (ORs 2.31 versus 2.50). Results are not qualitatively different if girls who might already have been pregnant or have given birth at time of interview at 16 are excluded, and in fact the effects of BGA and paternal involvement are strengthened (data not shown).

The mediation of the relationship between father's social class and early intended reproduction by BGA age was not quite significant (Sobel test,  $z=1.80$ ,  $p=0.07$ ), but there was a significant mediation effect of paternal involvement (Sobel test,  $z = 2.60$ ,  $p<0.01$ ). Thus, part of the association between family SEP and early intended reproductions is explained by lower paternal involvement in low SEP families.

## **Discussion**

The comparison of intended and realised early reproduction suggests that teenage motherhood is often not unanticipated. Ten percent of women who would go on to have babies by age 20 already stated at age 16 that they wished to do so, whilst almost 40% gave a target age for first reproduction of 21 or lower. As our figure 1 shows, young people's stated intentions in the domain of life history bear considerable relationship to their actual later behaviour, and those who become mothers early are generally women aiming for early reproduction.

We found that low BGA and low paternal involvement in childhood predicted early reproduction. Low paternal involvement was associated with odds of early reproduction increased by 79-125% relative to high paternal involvement, a substantial effect. The BGA effects were weaker (see also Supporting Information), with a standard deviation's reduction in BGA associated with odds around 14% higher. In absolute terms, with no other factors controlled for, girls who went on to reproduce before 20 were on average one and a half ounces (45g) lighter at birth than those who did not (113.73 oz versus 115.25 oz). Our figure 2 suggests that each of the factors has an independent association with early reproduction, but that they combine at least additively, so that

girls with low BGA and also fathers who are uninvolved are most liable to reproduce early.

The effects remained around the same size when socioeconomic factors were controlled for, although a substantial reduction in sample size meant that some comparisons moved outside the level of statistical significance. However, more importantly, the data show that both BGA and paternal involvement mediate the relationship between family SEP and early reproduction. Thus, part of the reason for more early reproduction in daughters of lower-SEP families may be that those daughters are differentially likely to be of low BGA, and to receive low paternal involvement.

We also found that these same two factors predicted a *desire* (stated at age 16) for early reproduction, again with non-trivial effect sizes, which did not change substantially when other variables were controlled for. This is significant, as it suggests that early-life factors might induce changes not just in the schedule of physiological development, but also in motivational characteristics that are accessible at the explicit, conscious level by the time women are 16 years old. Mediation analysis suggest that part of the reason young women in low-SEP families desire earlier reproduction is that they have been differentially exposed to low paternal involvement.

This is the first reported association between low birthweight for gestational age and teenage parenthood later in life. However, it is consistent with findings in other studies that low birthweight or thinness at birth predict early menarche (Adair 2001; Cooper and others 1996; Ibanez and others 2006a; Koziel and Jankowska 2002; Opdahl and others 2008; Sloboda and others 2007). Our study confirms that it is lightness for a given gestational age, rather than being born preterm, which appears to be relevant. Gestational age has no effect on the odds of reproducing young. Why this should be the case is not clear. However, girls born preterm have a reduced probability of ever reproducing, probably due to increased rates of developmental disorders (Swamy and others 2008). It may be that significantly preterm birth in the ancestral environment was not often enough survived for it to have been employed as a calibrational cue in reproductive development.

Low BGA may thus act as a cue to the developing female to follow a 'fast' life history strategy of relatively early maturation and reproduction. Part of this strategy, as these data show, is the development of a conscious motivation to reproduce early. The hormonal mechanisms relating low BGA to accelerated reproductive development are partly understood. Small size at birth predicts increased circulating levels of the oestrogen precursor dehydroepiandrosterone in childhood and adolescence (Opdahl and others 2008). Low BGA leads to increased adiposity in childhood (Ibanez and others

2006b), and adiposity increases oestrogen functioning in a number of ways (Frisch 1987). Low BGA is also associated with hyperinsulinemia and insulin resistance (Ibanez and others 2006b), and insulin appears to play a major role in pubertal tempo (Ibanez and others 2006c).

The results for paternal involvement are consistent with a long list of previous studies on age at menarche (for a review, see Ellis 2004), and a smaller number on teenage childbearing or pregnancy (Ellis and others 2003; Hogan and Kitagawa 1985; Vikat and others 2002). Effects sizes were just as large, or larger, for the 'leaves to mother' group of fathers, many of whom were coresident, as for the 'Inapplicable' group, where the father had no contact at all with the child by age 11. This supports the contention that the quality of the paternal relationship, not only its mere existence, may be significant (Ellis and others 1999). Our paternal involvement measure is relatively crude, having only four categories, and our data unfortunately do not allow us to discriminate between fathers who became uninvolved at different ages. Other studies have suggested that father absence before the age of 5 has much stronger effects than father absence beginning later (Ellis and others 2003), and that there might be different critical periods for age at menarche and age at first sexual activity (Alvergne and others 2008). Nor can our study shed any light on whether low paternal involvement is just a symptom of general psychosocial adversity, which is the causal factor, or whether there are specific mechanisms responsive to paternal behaviour, since we did not have independent measures of psychosocial adversity (but see Ellis and others 2003).

We found, unsurprisingly, substantial effects of socio-economic position on teenage motherhood. Both our measure of family SEP and that of neighbourhood composition had significant effects on teenage motherhood. This is consistent with the idea that neighbourhood characteristics have effects on reproduction above and beyond the effects of family SEP (Brooks-Gunn and others 1993; Smith and Elander 2006). However, another possibility is that the neighbourhood measure, which was measured at a finer scale than the family one, picked up additional variation in family socioeconomic characteristics, and is predictive for that reason. Our results did not confirm mother-to-daughter intergenerational transmission of early age at reproduction, as reported by Meade et al. (2008). Although maternal age at cohort member's birth does predict cohort members becoming teenage mothers in the NCDS data when no other variables are controlled for, this association disappears as soon as either of the measures of SEP is included in the model (see Supporting Information). Thus, any tendency for young women whose mothers had them whilst young to reproduce young themselves is explained by shared socio-economic position, and there is no evidence for cultural transmission of age at reproduction.

The major limitation of this study is that the design is not genetically informative. Birthweight and paternal involvement could be linked to early reproduction either via developmental plasticity, as we have suggested, or via a genetic correlation between these traits. For example, age at first reproduction might be genetically heritable, and the association with birthweight then simply a side effect of the fact that young mothers are more likely to have low birthweight babies (Borja and Adair 2003). The lack of a predictive effect of maternal age in our analyses suggests that account is unlikely, but cross-sectional evidence of the kind presented here cannot generally adjudicate between genetic and developmental induction accounts of the same associations. However, we note evidence from a study with a genetically informative design suggesting that at least part of the paternal involvement effect is due to developmental induction rather than genetic heritability (Tither and Ellis 2008).

The results of this study can be interpreted as suggesting that factors operating early in life induce a motivation for early reproduction, by cuing evolved mechanisms for regulating life-history strategy. If this is the case, current public policy interventions, which aim to reduce teenage pregnancy by educating adolescents about reproduction and contraception, may be of limited effectiveness. For example, Henderson et al. (2007) review the results of a large-scale randomised trial of a programme of high-quality sex education for 13-15 year old students, and find that the programme had no effect on the rate of teenage conceptions. Evidence is lacking that teenage parents are in fact undereducated about reproduction or contraception (for a discussion, see Arai 2003), and our data suggest that deep motivational schedules and patterns of expectation may have been set up much earlier in life, including even *in utero*. Such schedules would in all likelihood remain plastic into adolescence and adulthood, but we don't know how plastic, or to which cues they respond. What is clear, though, is that the long-term route to reducing teenage parenthood is to reduce exposure to the cues of environmental hazard to which young people in deprived areas are disproportionately exposed.

Table 1. Description and descriptive statistics of the main measures included in the analyses.

Measure	NCDS Variable number	Type	Number of valid records	Descriptive statistics
Early reproduction	Derived from ageatfch (1981)	Dichotomous	6270	No = 5485 Yes = 785
Early intended reproduction	Derived from n2809 (1974)	Dichotomous	5242	No = 5073 Yes = 169
Age at first pregnancy	Derived from n502023 (1991)	Continuous	4592	Mean 24.04 (s.d. 4.42)
Father's social class	Derived from n492 (1958), 'other' values excluded	5-point scale	7947	I = 359 II = 1032 III = 4798 IV = 998 V = 760
School socioeconomic composition	n2115 (1974)	10-point scale	5311	Mean 4.09 (s.d. 2.37)
Mother's age at birth	n553 (1958)	Continuous	8404	Mean 27.50 (s.d. 5.74)
Birthweight (oz)	n574 (1958)	Continuous	8143	Mean 113.76 (s.d. 19.99)
Birthweight for gestational age (BGA)	Derived from birthweight	Continuous	7274	Mean 0.00 (s.d. 1.00)
Gestational age (GA)	n497 (1958)	Continuous	7502	Mean 280.19 (s.d. 14.71)
Paternal involvement	n1147 (1969)	4 categories	6705	1 = 3993 2 = 1613 3 = 694 4 = 405

Table 2. Results from logistic regression models predicting early reproduction. p-values are based on the  $\chi^2$  log-likelihood ratios for variables overall, and the Wald statistic for individual odds ratios.

Variable	Model 1 (n=4482)		Model 2 (n=3014)	
	$\chi^2$	Odds ratios	$\chi^2$	Odds ratios
Model overall	42.21**	-	110.41**	-
Paternal involvement	35.80**	Equal to mother 1 Significant 0.88 Leaves it to mother 1.79** Inapplicable 2.25**	14.51**	Equal to mother 1 Significant 1.15 Leaves it to mother 1.87** Inapplicable 1.79*
Birthweight for gestational age	6.13*	One s.d. more 0.88*	3.24§	One s.d. more 0.89§
Gestational age	0.17	-	0.01	-
Father's social class	-	-	23.38**	One class lower 1.41**
School socioeconomic composition	-	-	38.17**	One scale-point fewer 1.21**
Mother's age at birth	-	-	1.02	-

\*  $p < 0.05$

\*\*  $p < 0.01$

§  $p = 0.07$



Table 3. Results from logistic regression models predicting early intended reproduction. p-values are based on the  $\chi^2$  log-likelihood ratios for variables overall, and the Wald statistic for individual odds ratios.

Variable	Model 1 (n=3729)		Model 2 (n=3020)	
	$\chi^2$	Odds ratios	$\chi^2$	Odds ratios
Model overall	16.06**	-	29.47**	-
Paternal involvement	11.87**	Equal to mother 1 Significant 1.07 Leaves it to mother 2.50** Inapplicable 1.38	7.48§	Equal to mother 1 Significant 1.11 Leaves it to mother 2.31** Inapplicable 1.51
Birthweight for gestational age	4.06*	One s.d. more 0.81*	6.72**	One s.d. more 0.74**
Gestational age	0.30	-	1.05	-
Father's social class	-	-	8.73**	One class lower 1.46**
School socioeconomic composition	-	-	1.19	-
Mother's age at birth	-	-	0.25	-

\*  $p < 0.05$

\*\*  $p < 0.01$

§  $p = 0.06$

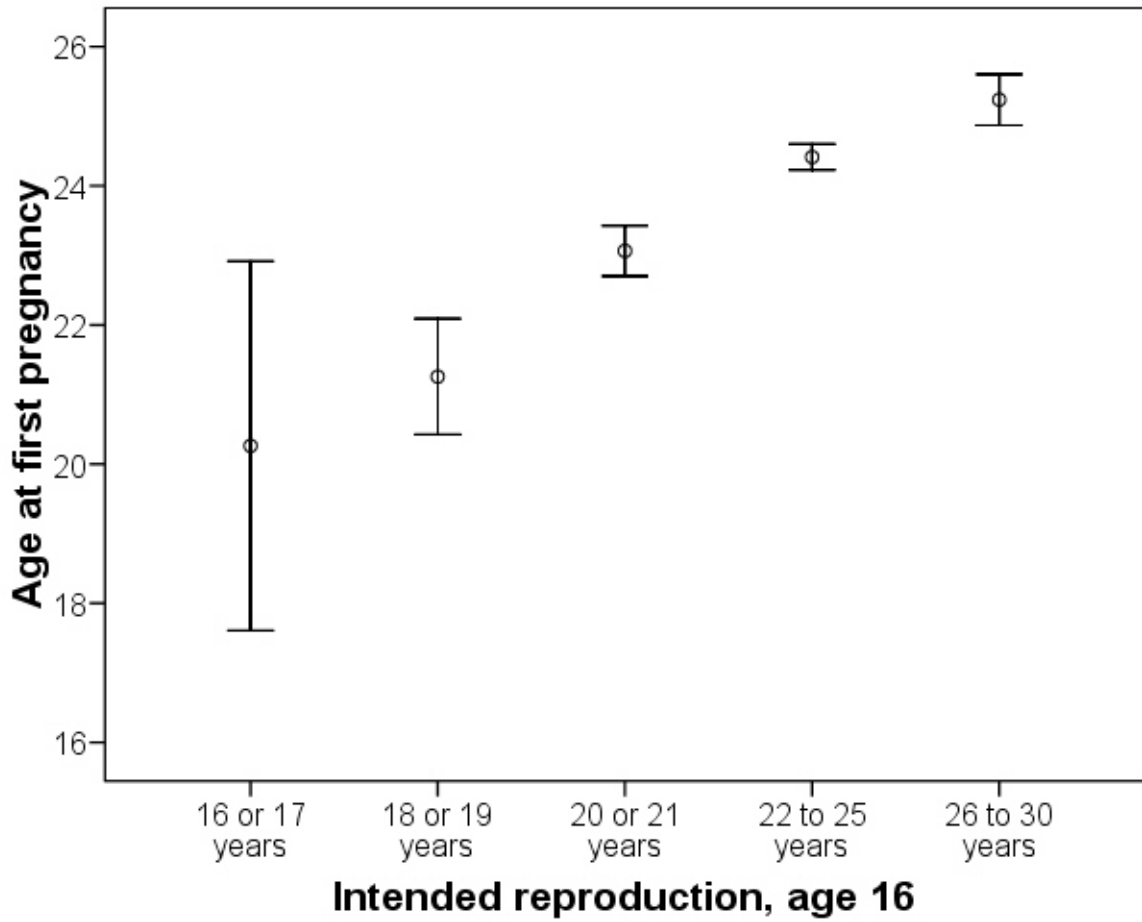


Figure 1. Actual age of first pregnancy (mean and 95% confidence interval), against intended age at reproduction stated at 16, for women who had been pregnant by age 33. Women who gave an intended age of reproduction of over 30 are excluded.

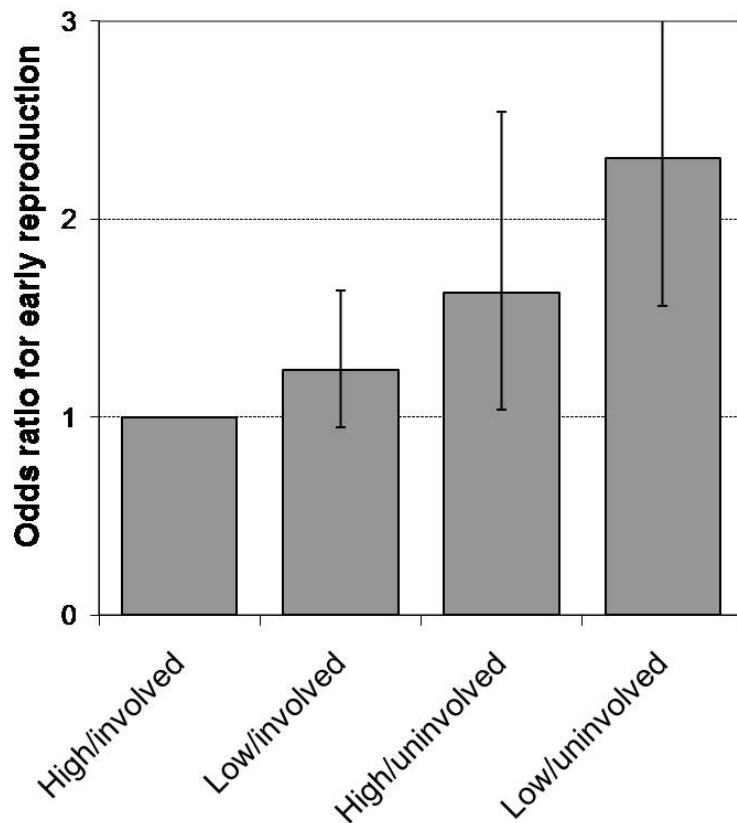


Figure 2. Odds ratios for early reproduction for all combinations of high and low birthweight for gestational age, and father involved or uninvolved. High and low birthweight for gestational age are defined as above and below the mean respectively, and paternal uninvolved is defined as the responses 'Leaves it to mother' or 'Inapplicable'. Results are adjusted for gestational age, father's social class, school socioeconomic position, and mother's age at birth.

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