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RESEARCH

Effect of pregnancy planning and fertility treatment on cognitive outcomes in children at ages 3 and 5: longitudinal cohort study

C Carson *researcher in statistics and epidemiology* [1], Y Kelly *professor of lifecourse epidemiology*[2 3], J J Kurinczuk *director*[1], A Sacker *research professor*[3], M Redshaw *social scientist*[1], M A Quigley *reader in statistical epidemiology*[1]

[1]National Perinatal Epidemiology Unit, University of Oxford, Headington, Oxford OX3 7LF, UK; [2]Institute of Social and Economic Research, University of Essex, Colchester, Essex CO4 3SQ; [3]Department of Epidemiology and Public Health, University College London, London WC1E 6BT

Abstract

Objective To investigate how pregnancy planning, time to conception, and infertility treatment influence cognitive development at ages 3 and 5.

Design Prospective population based cohort study.

Setting Millennium Cohort Study in the United Kingdom.

Participants 18 818 children recruited at 9 months and followed up at 3 and 5 years. 11 790 singletons with available data on pregnancy, cognitive outcomes, and confounders were included in analyses at age 3 and 12 136 at age 5.

Exposure measures Mothers reported whether the pregnancy was planned, and their feelings when first pregnant; those in whom the pregnancy was planned provided time to conception, and details of any assisted reproductive technologies. The population was divided into "unplanned" (unplanned and unhappy), "mistimed" (unplanned but happy), "planned" (planned, time to conception <12 months), "subfertile" (planned, time to conception ≥12 months), "induced ovulation" (received clomiphene citrate), and "assisted reproduction" (in vitro fertilisation or intracytoplasmic sperm injection). The "planned" group was the comparison group in all analyses.

Outcome measures Three components of the British Ability Scales (BAS II). Naming vocabulary assessed verbal ability at age 3; this test was repeated at age 5 with the picture similarities and pattern construction subscales, which measure non-verbal and spatial abilities.

Results In unadjusted analyses, the scores on all scales in children from unplanned pregnancies were significantly lower than in those from planned pregnancies—for example, the difference in mean verbal ability score at age 3 was −4.8 (95% confidence interval −6.0 to −3.7; P<0.05), equivalent to an average delay of four months. After adjustment for sociodemographic factors these differences were attenuated: −0.3 (−1.3 to 0.7), equivalent to no delay. Children born after assisted reproduction performed consistently better in verbal ability tests (3.8 (−0.2 to 7.9) at age 3 and 3.5 (0.2 to 6.8) at age 5), which suggests that on average these children are three to four months ahead; this difference did not completely disappear with adjustment for confounders. Children born after infertility treatment had lower mean scores in non-verbal tests (−1.2 (−4.1 to 1.6) after assisted reproduction and −1.5 (−3.5 to 0.4) after induced ovulation) and in spatial ability tests (−2.7 (−6.9 to 1.6) after assisted reproduction), though the differences were not significant.

Conclusions Pregnancy planning, subfertility, or assisted reproduction do not adversely affect children's cognitive development at age 3 or 5. The differences observed in the unadjusted analyses are almost entirely explained by marked inequalities in socioeconomic circumstances between the groups.

Introduction

In the United Kingdom, as many as 30-40% of pregnancies that end in childbirth are unplanned.[1-4] Meanwhile, the number of children born after assisted reproductive technologies is increasing annually.[5] These scenarios illustrate the variation in pregnancy planning, desire for a child, and the ability to conceive that could be viewed together as part of a "conception continuum."[6] At one extreme are those women whose pregnancy was an unwelcome surprise, through to those who consider the baby to be mistimed, to those who actively planned and conceived, and on to those who conceived only after a period of infertility or after assisted reproductive technology.

Children born after a prolonged time to conception or assisted reproduction, or both, are at greater risk of adverse health outcomes such as preterm birth, low birth weight, and congenital anomalies.[7 8] In addition, some researchers have reported lower cognitive scores in children born after assisted reproduction.[9-11] Unplanned pregnancies also have poorer perinatal outcomes,[12] but there is little epidemiological research assessing whether children's development is associated with pregnancy intention.

Correspondence to: C Carson claire.carson@npeu.ox.ac.uk

Supplementary table with description of population (see http://www.bmj.com/content/343/bmj.d4473/suppl/DC1)

The effects of pregnancy planning, a parent's desire for a child, and fertility on cognitive outcomes might act through many pathways including biological differences, health related behaviours in pregnancy,[13 14] uptake of antenatal care,[15] or parenting behaviours. A previous review highlighted the need for large scale population based studies with the capacity to examine possible causal pathways between pregnancy intention and markers of child development.[16]

We investigated the effects of pregnancy planning, time to conception, and fertility treatment on cognitive outcomes in the child up to the age of 5 using data from the Millennium Cohort Study.

Methods

Millennium Cohort Study

The Millennium Cohort Study is a nationally representative prospective cohort study of 18 552 families across the UK.[17] A random two stage sample of all infants born in 2000-2 and resident in the UK at 9 months was drawn from Department of Social Security Child Benefit Registers. The cohort study does not cover births where the infant died within the first 9-10 months after birth, but these constituted less than 1% of all births.[18] Ethnically diverse and disadvantaged areas were oversampled to ensure adequate representation.[19] Baseline interviews captured sociodemographic and health information, including questions about pregnancy and infertility treatment. Eighty per cent (14 898/18 552) and 79% (14 678/18 552) of families completed the follow-up interviews when the children were aged 3 and 5, respectively.

Pregnancy planning, time to pregnancy, and infertility treatments

Mothers were asked if they had planned to conceive and how they felt when they discovered they were pregnant. Those in whom the pregnancy was "planned" were then asked how long they took to conceive and if they had received fertility treatment. Women were grouped into the following categories:

- Unplanned (unplanned, unhappy about pregnancy)
- Mistimed (unplanned, happy about pregnancy)
- Planned (planned, time to conception <12 months)
- Subfertile (planned, time to conception ≥12 months)
- Induced ovulation (planned, used drugs such as clomiphene citrate to induce ovulation)
- Assisted reproductive technologies (planned, used technologies such as in vitro fertilisation or intracytoplasmic sperm injection).

Cognitive development measures

Cognitive development was assessed with three subscales of the British Ability Scales, second edition (BAS II). At age 3 children completed the naming vocabulary component, which assessed verbal ability. This was repeated at age 5 together with the picture similarities and pattern construction components, which measure non-verbal and spatial abilities, respectively.[20 21] The scales are adjusted for age (in three month bands) and indicate how a child's cognitive abilities have developed relative to his or her peers.

Inclusion criteria, exclusions, and losses to follow-up

The figure shows the number of children included in each analysis. Our analysis was restricted to singletons, for whom data on pregnancy was provided by their natural mother, and who were not conceived with donor gametes. Children who did not have adequate English language skills or had severe disabilities or behavioural problems did not complete the tests. Twenty four children had severe disabilities, 14 of whom had done the tests at age 3; to ensure consistency we excluded these children. In total, 18 114 children were eligible for the study at age 9 months, of whom 14 566 (80%) responded to the survey at 3 years. At this time, 11 790 (65% of those eligible at 9 months) had completed the tests, provided data on confounding factors, and were included in the analysis. The analysis at aged 5 was not dependent on participation in the survey at age 3. At this time, 14 346 (79% of those eligible at 9 months) children responded: 12 136 (67% of those eligible at 9 months) were included in the analysis of verbal abilities, 12 176 (67%) for non-verbal abilities, and 11 206 (62%) for spatial abilities.

Statistical analysis

We used linear regression to estimate the difference in mean ability score for each subscale across the pregnancy groups after adjustment for the child's sex, age, and other potential confounders and mediators. The "planned" group was the reference group in these analyses.

Adjustment was completed in stages because of the large number of potential confounders and mediators. Adjustment was made for the following variables:

A priori confounders or mediators (model 1)—Sex of child, age (in days), language spoken at home (English only, English plus another language).

Sociodemographic, health, and health related behaviours in pregnancy (model 2)—Maternal age, socioeconomic position (higher of mother or father using UK national statistics socioeconomic class, four categories); equivalised family income at baseline[22]; maternal qualifications (NVQ or equivalent groups); firstborn child; alcohol consumption in pregnancy (never, low, moderate, high[23]); smoking habits in pregnancy (non-smoker, gave up while pregnant, continued to smoke); mother's own health (such as asthma, diabetes, etc); family structure (married, cohabiting, or lone parent at appropriate sweep); father's age and qualifications (categorical variables that included a "no father"' category for lone parent families).

Early life course (model 3)—Gestational age (in weeks); birth weight; breast feeding (none, less than four months, four months and more); maternal depression at 9 months (indicated by malaise inventory score[24]); Condon maternal postnatal attachment score.[25]

Later early life course (model 4)—Maternal and paternal depression (indicated by a Kessler score ≥9[26]); maternal and paternal parenting involvement scores (derived from reported frequency of reading, counting, learning alphabet, singing and drawing with the child, a higher score indicating greater involvement[27]); type of childcare (none, informal (other family, friends or au pair), formal (childminder or nursery)) and hours a week in childcare at appropriate sweep. The analysis at age 3 also included an indicator of positive parent-child relationship (based on the Pianta score[28 29]).

At each stage variables were included if they were significantly associated with the outcome at a 5% level, after adjustment for

other factors in the model. The results are reported as difference in mean score (regression coefficient) and converted into the equivalent of the progress one would expect over a month in a child of this age. Existing age equivalents derived for the cohort study population were used. For example, in a one month period, we would expect the test scores of a typical 5 year old to increase by 0.83 for naming vocabulary, 0.62 for picture similarities, and 1.81 for pattern construction.[17 30]

All analyses took the clustered stratified study design into account by using the survey commands in Stata version 10.[31] All reported estimates are weighted by sampling and non-response weights to account for missing data because of non-response at later sweeps.[32]

Results

Descriptive characteristics of study population

Forty one per cent (5149/12 136) of children were born after an unplanned pregnancy; 15% of mothers reported that they felt unhappy or ambivalent about the pregnancy ("unplanned" n=1822), while 26% of mothers were happy ("mistimed" n=3327). Fifty three per cent of mothers (6244/12 136) reported a planned pregnancy, conceived in less than 12 months ("planned group"); a further 4% (480) conceived after 12 months or longer ("subfertile group"), while 1.4% (167) had ovulation inducing drugs and 1% (96) were born after assisted reproduction.

Table 1 describes the study population, indicating marked trends across the conception continuum. Table A on bmj.com provides further details. Babies conceived after assisted reproduction were, on average, born at an earlier gestation and lower birth weight than the children from other groups. We observed consistent patterns across the groups in terms of sociodemographic characteristics, timing of antenatal care, and health related behaviours in pregnancy. Compared with the planned fertile group the unplanned children were generally born to younger mothers, who were less likely to be in a stable relationship, had lower educational attainment, a lower family income, and a more disadvantaged socioeconomic position. Mothers in the unplanned groups were also more likely to smoke and drink heavily in pregnancy. The reverse was true for the mothers in the induced ovulation and assisted reproduction groups.

Association between pregnancy planning and BAS scores

Table 2 shows the results of the linear regression models exploring the effect of pregnancy planning, fertility, and infertility treatment on the separate BAS subscales. In unadjusted analyses, the "unplanned" children have lower scores than their planned counterparts. For example, the difference in verbal ability score at age 5 is −4.6 (−5.5 to −3.6), which equates to an average developmental delay of more than five months. After adjustment for sociodemographic factors these differences almost entirely disappear, and further adjustment for early and later life course factors has little effect (fully adjusted difference in mean score −0.1 (−1.0 to 0.8) or no delay).

Association between subfertility, fertility treatment, and BAS scores

The picture is less clear cut for the subfertile and fertility treatment groups, and the results differ across the BAS subscales. In unadjusted analyses, the children who were born after assisted reproduction had higher scores in the verbal ability tests than the planned children: 3.8 (−0.2 to 7.9) and 3.5 (0.2 to 6.8) at ages 3 and 5, respectively. These differences suggest that they are on average three to four months ahead in development compared with the planned group. The differences were attenuated when we adjusted the models for confounding factors, particularly sociodemographic covariates: 1.6 (−1.6 to 4.7) and 2.2 (−0.6 to 5.0) at ages 3 and 5, respectively.

Children born after infertility treatment seem to perform less well on the non-verbal tests, with adjusted difference in means of −1.2 (−4.1 to 1.6) and −1.5 (−3.5 to 0.4) for the assisted reproduction and induced ovulation groups, respectively, which is equivalent to more than two months' delay on average. Children born after assisted reproduction also have lower spatial ability scores: −2.7 (−6.9 to 1.6) or a 1.5 month delay. These results, however, are not significant. There is no evidence that subfertility has a strong effect on cognitive ability scores.

Discussion

Summary of findings

Children born after unplanned and mistimed pregnancies perform poorly in verbal ability tests at ages 3 and 5 compared with children born after a planned pregnancy, while children conceived after assisted reproduction perform better. After adjustment for confounders, particularly sociodemographic variables, however, these differences disappear for the unplanned and mistimed groups and are attenuated in the assisted reproduction group. There is some suggestion that children born after induced ovulation or assisted reproduction have lower non-verbal ability scores, and the assisted reproduction group also has lower spatial ability scores. Subfertility alone is not associated with cognitive test scores.

Comparison with other studies

Direct comparisons with other studies of children born after assisted reproduction and cognitive development are difficult because researchers have used a wide range of cognitive measures and have sampled different groups of children, and there is great variation in methodological quality.[33] We found that children born after assisted reproduction outperform their peers in verbal ability tests; a pattern that, though reduced, remains after adjustment for other factors. Yet these children seem to perform less well in the spatial and non-verbal tests. Previous studies have also identified delays in children born after assisted reproduction.[9-11 34] Other studies, generally those with a larger sample size, have found no evidence of an effect on overall ability.[35-37] We found no evidence of an adverse effect in the "subfertile" group, while Zhu et al described a modest increase in psychomotor delay with increasing time to conception among children aged 18 months.[34] It could be that any effect seen at 18 months is no longer detectable at age 3 or 5 or that, in our population, prolonged time to conception per se had no adverse effects on cognitive outcome.

The epidemiological literature that examines the effects of pregnancy intention on cognitive outcomes in the child is sparse. Our findings are similar to those reported by Joyce et al, who found that unwanted or mistimed children in a large American cohort performed less well in maths, reading, and picture vocabulary tests, but that this was because of "family background and parental characteristics."[38] Both studies found that the strength of pregnancy intention was important, with unplanned and unhappy groups achieving lower scores than the mistimed groups.

Potential mechanisms

The influences on cognitive ability might be subtle, and it is plausible that the effects of pregnancy intention, fertility, and infertility treatment on verbal, non-verbal, and spatial skills vary. Children born after assisted reproduction (and to a lesser extent those born after induced ovulation and in the subfertile group) benefit from a generally advantageous socioeconomic position. The associated advantages, such as more highly educated parents or more parental involvement, might have the greatest effect on language skills,[39 40] perhaps explaining some of the variation in the findings for the different aspects of cognition. At the other end of the spectrum, children born after mistimed or unplanned pregnancies might have access to fewer educational resources (such as books, puzzles, trips to library), which could mediate the association between pregnancy intention and cognitive outcome.[41] Though our findings suggest that parenting behaviour has little additional effect once economic circumstances are accounted for, it is important to consider that the mechanism that drives these differences could act through parenting behaviours, maternal wellbeing, and the resources available in the family to facilitate experiential learning.[29]

Strengths and limitations

We used data from a large population based UK cohort, with sufficient power to allow an investigation of the full range of conception states rather than focusing on one group alone. In contrast with previous studies, data were available on many potential confounding and mediating factors. Our study, however, included only small numbers of children born after infertility treatments, so findings for these groups should be interpreted with caution. Unfortunately, the number of children born after specific forms of fertility treatment (such as intracytoplasmic sperm injection) was insufficient to allow separate analyses to be conducted. Missing data because of loss to follow-up can result in bias in cohort studies. We used non-response weights, which take into account factors associated with response, in the analysis to minimise the effects.[19] The original protocol for the Millennium Cohort Study excluded from the cognitive tests children with severe behavioural problems and disabilities, children whose parent refused consent, and children who were too tired, ill, or overwhelmed to complete the tests. Unfortunately, it is not possible to separate out the reasons for missing test results. The proportion missing was small: 2.4-5.2% at age 3 and 0.3-1.8% at age 5 (table 2). We believe any adverse effect is unlikely to remove the large increase in cognitive scores observed in the unadjusted results for the assisted reproduction children. Reports of pregnancy intention could be problematic because women might later rationalise an unintended pregnancy as a wanted birth, though others have found recall to be reliable.[42] Given that the proportion reporting an unplanned pregnancy is consistent with previous reports, we believe that the classification is reliable.[1 4] Educational attainment and occupation reflect a complex nexus of influences including IQ, temperament, and opportunity. The links between these influences and pregnancy planning, however, are likely to be complex and driven by personal and social resources rather than cognitive ability, thus reducing the risk of residual confounding.

Future research and implications

Further work is needed to define "unplanned" and "unintended" pregnancy[43 44] as it is an issue where labels are emotive for many parents. Research examining the specific pathways between pregnancy planning, parenting behaviours, and cognitive outcomes would add to our understanding. Work is needed to investigate whether there are real differences in verbal and non-verbal cognitive development in children born after assisted reproduction and, if so, why that might be the case.

Conclusion

In conclusion, we found no evidence that pregnancy planning, subfertility, or assisted reproduction per se adversely affect children's cognitive development at age 3 or 5. Unadjusted analyses show that children born after unplanned pregnancy score poorly in cognitive tests compared with their planned counterparts, while children conceived after assisted reproduction do significantly better in tests of verbal ability. These differences are almost entirely explained by confounding by socioeconomic factors, providing further evidence of the influence of socioeconomic inequalities on the lives of children in the UK. To help children achieve their full potential, policy makers should continue to target social inequalities.

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Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval: This research involved secondary analysis of the MCS and therefore did not require ethical approval. Ethical approval for the Millennium Cohort Study was granted from the multi-centre research ethics committee.

Data sharing: The datasets are available on the UK Data Archive. Further information about the study and data can be found at www.cls.ioe.ac.uk/.

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What is already known on this topic

Children born after a prolonged time to conception and assisted reproduction are at greater risk of some adverse health outcomes, and some researchers have reported lower cognitive scores in such children

Unplanned pregnancies also have poorer perinatal outcomes, but there has been little epidemiological research to assess whether child development is associated with pregnancy planning

What this study adds

Unadjusted test scores at ages 3 and 5 indicate that children born after an unplanned pregnancy are four to five months behind planned children in verbal abilities, while children born after assisted reproduction are three to four months ahead

These findings are almost entirely because of differences in socioeconomic circumstances, highlighting the strong influence of social inequality on cognitive outcomes

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Tables

Table 1| Description of population at analysis at age 5 (n=12 136) in study of effect of pregnancy planning and fertility treatment on cognitive development in children. Figures are percentages unless otherwise specified

	Unplanned (n=1822, 15%)	Mistimed (n=3327, 26%)	Planned (n=6244, 53%)	Subfertile (n=480, 4%)	Induced ovulation (n=167, 1.4%)	ART (n=96, 1%)
Male child	51	50	51	48	49	47
Non-white	13	14	10	10	4	13
Mean age (years) at 3 year questionnaire	3.13	3.14	3.11	3.12	3.11	3.10
Mean age (years) at 5 year questionnaire	5.21	5.21	5.20	5.21	5.19	5.15
Parents' characteristics						
Family structure (married)	32	48	77	80	84	90
Family structure (lone parent)	36	19	4	3	2	2
Mean annual income at 9 months (£)	16 040	17 780	27 250	27 090	31 550	30 220
Household social class (professional/ managerial)	26	36	58	57	66	66
Mean age of mother at birth of child (years)	26.8	27.7	30.0	31.6	31.7	33.7
Mother's educational attainment (with degree)	22	29	45	43	52	49
Cohort member is mother's first child	36	45	40	52	61	70
Mother has ever suffered depression	26	17	12	12	10	10
Father interviewed	52	66	82	82	85	81
Mean age of father at birth of child (years)	35.9	36.9	37.8	39.5	39.8	41.1
Father's educational attainment (with degree)*	27	32	46	44	49	53
Pregnancy related variables						
Mean gestation at pregnancy confirmation (weeks)	8.7	7.9	6.8	6.5	5.9	3.9
Mean gestation at received antenatal care (weeks)	13.3	12.8	11.4	11.3	10.0	10.1
Continued to smoke in pregnancy	37	27	13	18	12	5
Moderate/high alcohol intake in pregnancy	11	7	7	7	7	2
Mean gestational age (weeks)	39.1	39.1	39.3	39.2	39.0	38.4
Mean birth weight (g)	3330	3340	3430	3320	3310	3200
Breast feeding (% breast fed at all)	58	70	79	80	82	88
Parenting variables						
Weak postnatal attachment at 9 months†	28	20	24	23	19	21
Mother's positive relationship with child at age 3 (mean)	33.0	33.5	33.8	33.9	34.0	33.6
Mother's involvement score at 5 years (mean)‡	16.2	16.8	16.8	16.9	17.4	17.3
Father's high involvement score at 5 years‡	34	33	33	32	38	36
Childcare and schooling						
Start childcare aged <1 year	54	54	61	59	71	58
Mean hours/week in childcare at age 3	12.5	13.2	15.0	14.3	16.5	14.6
Formal childcare at age 3	22	22	31	29	39	35
Mean hours/week in childcare at age 5	8.2	7.0	5.6	5.2	5.2	5.7
Formal childcare at age 5	4	4	6	4	6	4
At school full time at age 5	97	97	97	97	98	99
British Ability Scale II						
Mean verbal ability score at age 3	71.8	73.8	76.4	77.6	77.4	81.3
Mean verbal ability score at age 5	105.9	107.1	110.5	112.0	115.0	114.0
Mean non-verbal ability score at age 5	81.1	81.2	83.1	82.7	81.9	82.5
Mean spatial ability score at age 5	85.9	86.9	90.0	90.4	90.6	86.1

Table 1 (continued)

	Unplanned (n=1822, 15%)	Mistimed (n=3327, 26%)	Planned (n=6244, 53%)	Subfertile (n=480, 4%)	Induced ovulation (n=167, 1.4%)	ART (n=96, 1%)

ART=assisted reproductive techniques.

*% shown is % among fathers who responded (n=8905).

†Score in lowest 25% of population is considered clinically relevant.[25]

‡Mother's score treated as continuous variable and mean score reported. Father's score is categorised as low/medium/high so that non-responders and missing can be included.

Table 2| Difference in mean (95% confidence interval) scores on British Ability Scales (BAS) with accumulating additional adjustment in study of effect of pregnancy planning and fertility treatment on cognitive development in children

Model	Unplanned (n=1822, 15%)	Mistimed (n=3327, 26%)	Planned (n=6224, 53%)	Subfertile (480, 4%)	Induced ovulation (n=167, 1.4%)	ART (n=96, 1%)
Verbal abilities at age 3 (n=11 790)*						
% missing data†	4.5	52	3.5	3.4	2.4	4.0
Unadjusted model	−4.8‡ (−6.0 to −3.7)	−2.4‡ (−3.4 to −1.5)	Reference	1.1 (−0.7 to 2.9)	0.2 (−2.8 to 3.1)	3.8 (−0.2 to 7.9)
Plus a priori confounders§	−5.3‡ (−6.4 to −4.3)	−2.8‡ (−3.7 to 2.0)		0.7 (−1.0 to 2.5)	−0.3 (−3.2 to 2.5)	4.1‡ (0.8 to 7.5)
Plus sociodemographic factors	−0.9 (−1.9 to 0.2)	−0.4 (−1.2 to 0.4)		0.3 (−1.5 to 2.1)	−2.3 (−5.0 to 0.5)	1.2 (−2.0 to 4.4)
Plus early life course factors	−0.8 (−1.8 to 0.3)	−0.3 (−1.1 to 0.5)		0.4 (−1.3 to 2.2)	−2.0 (−4.7 to 0.7)	1.7 (−1.5 to 4.9)
Plus later life course factors	−0.3 (−1.3 to 0.7)	−0.2 (−1.0 to 0.5)		0.3 (−1.5 to 2.0)	−2.4 (−5.0 to 0.2)	1.6 (−1.6 to 4.7)
Verbal abilities at age 5 (n=12 136)¶						
% missing data†	1.7	1.0	1.1	0.6	1.0	1.2
Unadjusted model	−4.6‡ (−5.5 to −3.6)	−3.4‡ (−4.2 to −2.5)	Reference	1.5‡ (0.1 to 3.0)	4.5‡ (2.2 to 6.8)	3.5‡ (0.2 to 6.8)
Plus a priori confounders§	−4.9‡ (−5.8 to −4.0)	−2.9‡ (−3.7 to −2.2)		1.4 (0.0 to 2.8)	4.0‡ (1.7 to 6.3)	4.8 (2.1 to 7.4)
Plus sociodemographic factors	−0.2 (−1.2 to 0.7)	−0.2 (−0.9 to 0.6)		1.0 (−0.4 to 2.4)	2.0‡ (−0.1 to 4.2)	2.0 (−0.7 to 4.8)
Plus early life course factors	−0.2 (−1.1 to 0.7)	−0.2 (−0.9 to 0.5)		1.2 (−0.2 to 2.6)	2.2‡ (0.1 to 4.3)	2.3 (−0.5 to 5.1)
Plus later life course factors	−0.1 (−1.0 to 0.8)	−0.2 (−0.9 to 0.5)		1.1 (−0.3 to 2.5)	2.1 (0.0 to 4.2)	2.2 (−0.6 to 5.0)
Non-verbal abilities at age 5 (n=12 176)**						
% missing data†	1.4	1.0	0.9	0.6	1.0	0.3
Unadjusted model	−1.9‡ (−2.7 to −1.1)	−1.8‡ (−2.4 to −1.6)	Reference	−0.1 (−1.2 to 1.1)	−1.1 (−3.1 to 0.9)	−1.2 (−4.1 to 1.8)
Plus a priori confounders§	−2.0‡ (−2.8 to −1.2)	− 1.8‡ (−2.4 to −1.2)		−0.2 (−1.3 to 1.0)	−1.1 (−3.1 to 0.9)	−0.8 (−3.7 to 2.1)
Plus sociodemographic factors	−0.3 (−1.1 to 0.5)	−0.6‡ (−1.2 to 0.0)		0.0 (−1.2 to 1.1)	−1.6 (−3.6 to 0.3)	−1.4 (−4.2 to 1.5)
Plus early life course factors	−0.2 (−1.0 to 0.6)	−0.6 (−1.2 to 0.0)		0.1 (−1.1 to 1.2)	−1.5 (−3.5 to 0.4)	−1.2 (−4.1 to 1.6)
Plus later life course factors	−0.2 (−1.0 to 0.6)	−0.6 (−1.2 to 0.0)		0.1 (−0.1 to 1.2)	−1.5 (−3.5 to 0.4)	−1.2 (−4.1 to 1.6)
Spatial abilities at age 5 (n=11 206)††						
% missing data†	1.8	1.3	1.2	0.6	1.0	0.3
Unadjusted model	−4.5‡ (−5.8 to −3.1)	−2.7‡ (−3.7 to −1.8)	Reference	0.5 (−1.4 to 2.3)	0.7 (−2.9 to 4.3)	−3.3 (−7.9 to 1.3)
Plus a priori confounders§	−4.7‡ (−6.0 to −3.3)	−2.9‡ (−3.9 to −2.0)		0.2 (−1.6 to 2.0)	0.5 (−2.9 to 4.0)	−2.7 (−7.1 to 1.7)
Plus sociodemographic factors	−1.0 (−2.3 to 0.3)	−0.7 (−1.6 to 0.2)		0.6 (−1.1 to 2.4)	−0.2 (−3.7 to 3.3)	−3.2 (−7.3 to 1.0)
Plus early life course factors	−0.9 (−2.2 to 0.4)	−0.6 (−1.5 to 0.3)		1.0 (−0.8 to 2.7)	0.2 (−3.2 to 3.5)	−2.5 (−6.7 to 1.8)
Plus later life course factors	−0.8 (−2.1 to 0.5)	−0.6 (−1.6 to 0.3)		0.9 (−0.9 to 2.7)	0.0 (−3.4 to 3.3)	−2.7 (−6.9 to 1.6)

*Additional adjustments: sociodemographic—maternal age, social class, income, qualifications, first born; early life course—birth weight, breast feeding; later life course—maternal positive relationship score, maternal involvement score, age started childcare.

†% of children eligible for inclusion in analysis who do not have BAS score. % weighted for design effects only, not for non-response.

‡P<0.05 (significant).

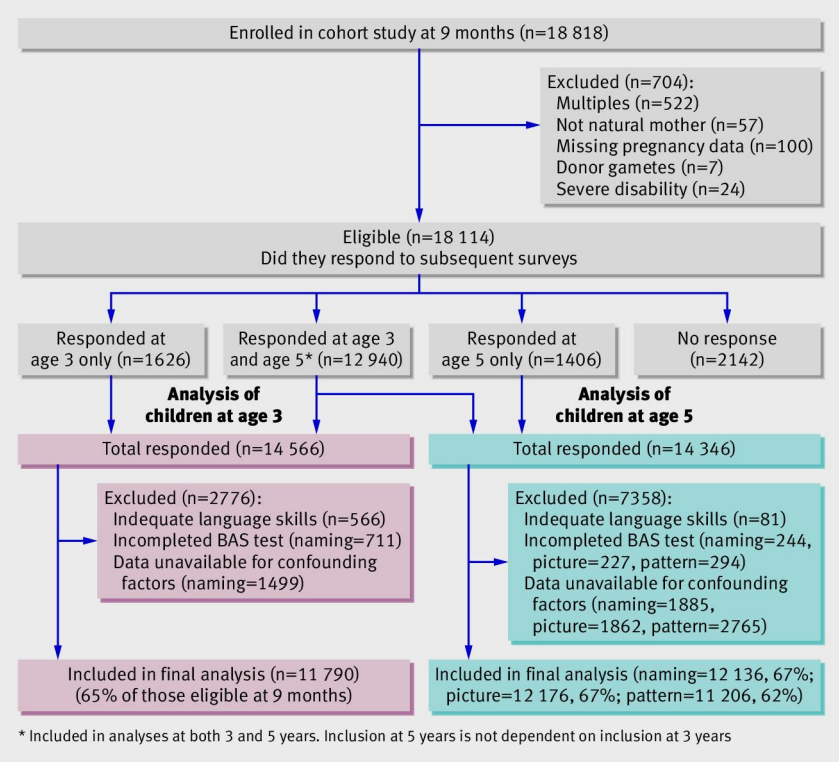
§A priori confounders were age at sweep, language (English only, English and another), sex of cohort member.

¶Additional adjustments: sociodemographic—maternal age, social class, income, family structure, qualifications, first born, alcohol in pregnancy, smoking in pregnancy, father's qualifications; early life course—birth weight, breast feeding; later life course—maternal involvement.

**Additional adjustments: sociodemographic—social class, income, qualifications, father's age, father's qualifications; early life course—birth weight, breast feeding; later life course—maternal involvement, childcare (any, informal, formal).

††Additional adjustments: sociodemographic—social class, income, qualifications, alcohol in pregnancy, father's qualifications; early life course—gestation, birth weight, breast feeding; later life course—maternal involvement, maternal discipline, schooling (full time, part time).

Figure



Flow of participants though study of pregnancy planning on cognitive outcomes in child, showing numbers available for analyses at ages 3 and 5. Naming=naming vocabulary (verbal ability). Picture=picture similarities (non-verbal ability). Pattern=pattern construction (spatial ability)