Paternal age, paternal presence and children's health: an observational study

Julian Gardiner,[1] Alastair G. Sutcliffe,[2] Edward Melhuish,[1,3] Jacqueline Barnes[1,4]

[1]Institute for the Study of Children, Families and Social Issues, Birkbeck University of London; [2]Institute of Child Health, University College London; [3]University of Oxford; [4]Tavistock and Portman NHS Foundation Trust, London, UK

Abstract

In an observational study of 31,257 children we investigated the effects of paternal age at the time of the child's birth, paternal absence and non-biological fathers on children's health. Results are per 5 year change in paternal age. Older fathers were associated with lower rates of unintentional injuries, odds ratio (OR)=0.966, P=0.0027. There was a quadratic association between paternal age and risk of hospital admission, β=0.0121, P=0.0109, with minimum risk at paternal age 37.7. Absent fathers were associated with increased risk of hospital admission, OR=1.19, $P<10^{-3}$, lower rates of complete immunizations to 9 months, OR=0.562, $P<10^{-3}$, higher Strength and Difficulties Questionnaire (SDQ) difficulties scores: β=0.304, P=0.0024 (3 year olds), β=0.697, $P<10^{-3}$ (5 year olds). Non-biological fathers were associated with increased risk of unintentional injury, OR=1.16, P=0.0319 and hospital admission, OR=1.26, P=0.0166; lower rates of complete immunizations to 9 months, OR=0.343, P=0.0309 and higher SDQ difficulties scores: β=0.908, $P<10^{-3}$.

Introduction

Recent years have seen a trend towards older parenthood in many developed countries, *e.g.*, the UK and the US.[1,2] Previous work by the present authors established that maternal age has a significant effect on a number of child health-related outcomes.[3] Where there were significant effects of maternal age, having an older mother was found to be beneficial to children in nearly all cases. We investigate the hypothesis that paternal age at the time of the child's birth may also affect the same child health outcomes with older fathers associated with more positive outcomes for their children. We also consider the effects of an absent father and of the presence of a non-biological father, both factors which have been shown to be associated with adverse child health outcomes in previous research.[4-10]

Materials and Methods

Sample selection

The sample consisted of children aged 9 months, 3 years and 5 years in the Millennium Cohort Study (MCS)[11] and in the National Evaluation of Sure Start (NESS) Impact Study.[12]

Eligible children for the MCS study were all those born over a period of 16 months starting in September 2000, living in 398 electoral wards selected to ensure adequate representation of wards with a high minority ethnic population (30+% Black or Asian in 1991 Census) and the most deprived 25% of wards using the Indices of Multiple Deprivation Child Poverty Index (IMDCPI).[13] The NESS sample was selected from areas chosen to receive a Sure Start Local Program, all in the 20% most disadvantaged areas in England based on the IMDCPI.[12] A random sample was selected from children born in 200 randomly chosen Sure Start areas during 29 months starting January 2002. Where multiple births occurred, only the firstborn child was included in analyses. The total sample consisted of: 31,257 children at 9 months old (18,552 from MCS; 12,705 from NESS); 24,781 children at 3 years old (15,590 from MCS; 9,191 from NESS); and 22,504 children at 5 years old (15,246 from MCS; 7,258 from NESS). Reductions in numbers in the NESS study were partly related to funding decisions. Further details of the sample are given in the paper on the effects of maternal age.[3]

Outcome variables

The child outcomes were chosen because they applied to the total population and were likely to predict later health and wellbeing. The following outcome variables were collected by parental report during home visits: child behavior total difficulties using the Strengths and Difficulties Questionnaire (SDQ),[14] child suffering an unintentional injury requiring medical treatment in the last year, child inpatient hospital admission in the last year, and child receipt of all recommended immunizations since the previous interview. The recommended immunizations (all free under the UK National Health Service) in terms of the age points in the studies were: at 9 months three doses of vaccines against diphtheria, tetanus, pertussis, polio and hemophilus influenza type b (hib); and by 3 years boosters for diphtheria, tetanus, pertussis, polio, and vaccinations against measles, mumps and rubella (typically delivered as combined MMR), hepatitis B, meningitis C and pneumococcal infection. Immunization uptake used only MCS data. The child's weight and height were measured by the researcher during home visits in order to calculate the child's body mass index (BMI). Whether children were overweight was assessed using reference data from the Centers for Disease Control and Prevention,[15] with *overweight* defined as *above the 85th percentile for child's sex and age*. Researchers also assessed the child's language development at 3 and 5 years using the British Ability Scales (BAS) Naming Vocabulary subscale.[16]

Correspondence: Julian Gardiner, UCL Research Department of Epidemiology and Public Health, 1-19 Torrington Place, London WC1E 6BT, UK.
Tel.: +44.020.3108.3257 - Fax: +44.020.3108.3354.
E-mail: j.gardiner@ucl.ac.uk

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Key words: paternal age, child health, absent father, lone mother, non-biological father.

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Statistical modeling

Family type was classified as follows: i) child being raised by natural mother and natural father, ii) child being raised by natural mother and a male partner (*non-biological father*), iii) child being raised by natural mother alone (absent father), iv) child being raised by a carer/combination of carers excluding the natural mother. This last group was small and was excluded from the analysis (Table 1).

Paternal age at the child's birth was modeled as a continuous variable centered on age 35 years (approximately the center of the distribution, Figure 1) in families where natural father was present (type 1. families) and coded as zero where the father was not present. Dummy variables coded for families of type 2. (*non-biological father*) and type 3. (*absent father*). In this way the effects of families of these types were contrasted with that of a type 1. family (*two natural parents*) where the father was 35 years old.

The data were longitudinal, with two or three observations per child, depending on the outcome variable (Tables 1 and 2). The data were also geographically clustered. A mixed-effects modeling approach was adopted, fitting a random effect for cluster and for subject within cluster, producing a multilevel model.[17] A dummy variable was included for each time point.

Models were controlled for the following covariates: maternal age at child's birth, child's sex, child's age (modeled as the difference between the nominal ages of 9 months, 3 years and 5 years and the child's actual age at the time of the survey), number of siblings at the assessment time point, mother's parity at child's birth (a proxy for birth order), birth weight, child breast fed for at least 6 weeks, child's ethnic group, child in workless household, family income, mother's educational attainment, mother's social class (defined by habitual occupation), father's educational attainment and father's social class (defined by habitual occupation). Models of child's BMI and *child is overweight* included mother's BMI as an additional covariate. The covariates were selected a priori because they may be related to outcomes and may covary with paternal age. For each outcome, an initial model was fitted with linear terms in maternal and paternal age. Higher order polynomial terms in maternal and paternal age were added successively and retained if statistically significant ($P<0.05$). Because the effect of mother's and father's age on the child may vary in strength according to the child's age, *maternal age*/time and *paternal age*/time interactions were added to the resulting model and retained if statistically significant ($P<0.05$). For similar reasons *absent father*/time and *presence of non-biological father*/time interactions were also tested for in the same way. Finally, we tested for a *maternal age/paternal age* interaction.

Models were fitted in R 2.11.1.[18] Linear mixed-effects models were used for the continuous outcomes,[19] and logistic regression mixed-effects models for the binary outcomes.[20]

Missing data

Missing values occurred in the data for two reasons: i) non-response on items, ii) attrition of the sample, where a family dropped out of the study. Multiple imputation was used to handle missingness due to non-response and due to attrition.[21] We investigated sample attrition by fitting a logistic regression model with outcome *family dropped out of the study by 5 year survey*, using the same covariates as in the other models (evaluated at the 9 month survey). Subject to the assumption that dropout is dependent on the observed covariates and not on unobserved factors, models using multiply imputed data will not be subject to bias due to sample attrition.

The percentage of participants with complete data was 52.8% to 69.4%, depending on the outcome variable. Missing data were imputed using the Amelia II package.[22] The imputation model assumes a multivariate normal distribution for the complete data (missing and observed). Binary, categorical and ordinal variables are incorporated into this distribution using appropriate transformations.[23] Whilst the use of the multivariate normal distribution is inevitably an approximation, its effectiveness in missing data problems is well established.[24] All the outcome variables and covariates from all time points were included in the imputation model. Five imputations were generated, and models fitted to each imputed data set. Model results were consolidated using Rubin's Rules,[25] with degrees of freedom found using Hesterberg.[26]

Complete cases models were also fitted for comparison.

Results

Sample characteristics are given in Tables 1 and 2. The distribution of paternal age at birth of child is shown in Figure 1.

The results from the models fitted to the imputed data and the complete cases models were similar. The results from the imputed data models are given as being more representative of the whole sample.

Results are from the final models, adjusted for maternal age and all other covariates. Regression lines from the final models in which there was a significant effect of paternal age at the time of the child's birth are shown in Figure 2.

Paternal age at child's birth

There was a significant association between paternal age at the time of the child's birth and the risk of the child having had an unintentional injury in the last 12 months, with older paternal age associated with lower risk of child's unintentional injury, OR=0.966 per 5 year increase in paternal age (95% CI: 0.945 to 0.988, P=0.0027). The model predicted risk of the child having had an unintentional injury in the last 12 months when the father was aged 20 was 21.3%, falling to 18.0% when the father was 50. There was a significant quadratic association between paternal age and the risk of the child having had a hospital admission in the last 12 months, β=0.0121 per 5 year change in paternal age (95% CI: 0.00295 to 0.0213, P=0.0109). The probability of hospital admission was at a minimum when paternal

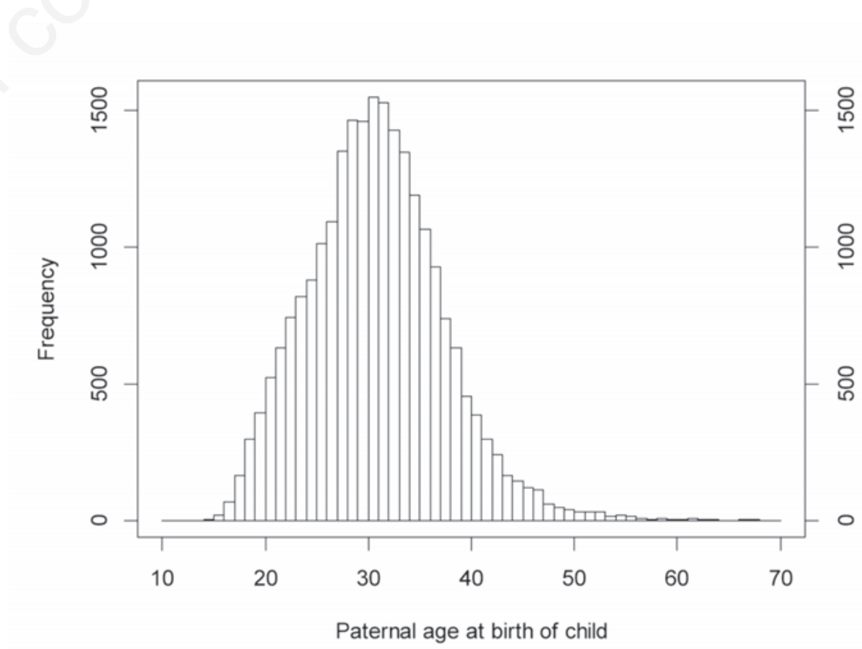

Figure 1. Histogram of paternal age at birth of child.

Table 1. Breakdown of sample at each survey by binary and categorical variables.

Variable	9 months, n (%)	3 years, n (%)	5 years, n (%)
Types of family			
Natural mother and natural father	23,682 (75.8)	18,680 (75.4)	16,816 (74.7)
Natural mother and no father figure	7433 (23.8)	5342 (21.6)	4539 (20.2)
Natural mother and non-biological father	112 (0.4)	588 (2.4)	917 (4.1)
Other family	30 (0.1)	171 (0.7)	232 (1.0)
Child has had unintentional injury in last 12 months	2669 (8.5)	8069 (32.8)	6216 (27.8)
Child has had hospital admission in last 12 months	4583 (14.7)	6153 (26.0)	3295 (14.7)
Child has had recommended immunizations	17,553 (96.0)	10,178 (65.3)	-
Child is overweight	-	6832 (32.7)	6531 (30.0)
Child's sex (% female)	15,245 (48.8)	12,147 (49.0)	11,067 (49.2)
Child was breast fed for at least 6 weeks	12,413 (39.9)	10,248 (41.4)	9470 (42.1)
Child living in workless household	8709 (27.9)	5992 (24.2)	4648 (20.7)
Child's ethnicity			
White	24,882 (79.6)	19,857 (81.3)	18,176 (81.8)
Mixed ethnicity	1235 (4.0)	891 (3.6)	771 (3.5)
Indian	634 (2.0)	505 (2.1)	466 (2.1)
Pakistani/Bangladeshi	2393 (7.7)	1740 (7.1)	1573 (7.1)
Black	1405 (4.5)	929 (3.8)	805 (3.6)
Other ethnic group	691 (2.2)	492 (2.0)	440 (2.0)
Mother's parity at birth of child			
1	11,913 (47.3)	11,654 (47.0)	10,710 (47.6)
2	8173 (32.4)	8044 (32.5)	7290 (32.4)
≥3	5107 (20.3)	5083 (20.5)	4504 (20.0)
Number of siblings			
0	13,044 (41.7)	6218 (25.1)	3714 (16.6)
1	10,387 (33.2)	10,703 (43.2)	10,118 (45.1)
2	4894 (15.7)	4829 (19.5)	5379 (24.0)
≥3	2932 (9.4)	3010 (12.2)	3227 (14.4)
Mother's highest qualification			
None	5050 (16.2)	3407 (13.8)	2827 (12.6)
GCSE or equivalent	12,683 (40.6)	10,143 (41.0)	9500 (42.3)
A level or equivalent	7273 (23.3)	6022 (24.4)	5456 (24.3)
Degree or higher degree	5092 (16.3)	4272 (17.3)	3957 (17.6)
Other qualification	1112 (3.6)	877 (3.5)	717 (3.2)
Mother's socio-economic status, defined by habitual employment			
Management and professional	6720 (22.4)	6113 (25.8)	4933 (22.7)
Intermediate	4986 (16.6)	3668 (15.5)	4929 (22.7)
Small employer/self-employed	1107 (3.7)	1559 (6.6)	1808 (8.3)
Low supervision and technical	1808 (6.0)	1630 (6.9)	2106 (9.7)
Semi-routine and routine	13,233 (44.0)	9353 (39.5)	7071 (32.6)
Non-working	2212 (7.4)	1376 (5.8)	839 (3.9)
Father's highest qualification			
None	3074 (15.1)	2760 (15.5)	2208 (14.2)
GCSE or equivalent	8898 (43.8)	7472 (41.8)	6706 (43.0)
A level or equivalent	3432 (16.9)	3049 (17.1)	2666 (17.1)
Degree or higher degree	3860 (19.0)	3552 (19.9)	3239 (20.8)
Other qualification	1039 (5.1)	1029 (5.8)	778 (5.0)
Father's socio-economic status, defined by habitual employment			
Management and professional	5926 (31.6)	5341 (31.6)	4930 (33.1)
Intermediate	1652 (8.8)	1594 (9.4)	1355 (9.1)
Small employer/self-employed	3339 (17.8)	3148 (18.6)	2724 (18.3)
Low supervision and technical	2466 (13.1)	2042 (12.1)	1811 (12.2)
Semi-routine and routine	5384 (28.7)	4776 (28.3)	4075 (27.4)
Household income			
< £11,000 per year	11,629 (39.2)	5941 (24.6)	4459 (20.0)
£11,000-£22,000 per year	11,423 (38.5)	8641 (35.8)	7233 (32.4)
> £22,000 per year	6594 (22.2)	9536 (39.5)	10,612 (47.6)
Total number of participating families at survey	31,257	24,781	22,504

GCSE, General Certificate of Secondary Education; A level, Advanced level.

age was 37.7 (95%CI: 32.1 to 54.4). The model predicted risk of hospital admission had a minimum of 17.2% when paternal age was 37.7, with a predicted risk of 20.1% when paternal age was 20 years above or below this value.

There were no significant maternal age/paternal age interactions in any of the models.

Absent fathers

Living in a household with no father was associated with an increased risk of the child having a hospital admission in the last 12 months, OR=1.19 (95%CI: 1.08 to 1.31, P<10^{-3}). In the remaining cases where there were significant main effects of *absent father* there were also significant interactions between the main effect and time. Separate effects by time point are therefore reported. An absent father was significantly associated with a lower probability of the child having had complete immunizations up to 9 months of age, OR=0.562 (95%CI: 0.447 to 0.707, P<10^{-3}). There was also an association between an absent father household and a higher SDQ difficulties scores: at 3 years old β=0.304 (95%CI 0.109 to 0.500, P=0.0024), at 5 years old β=0.697 (95%CI: 0.511 to 0.882, P<10^{-3}).

Non-biological fathers

The presence of a non-biological father figure was associated with an increased risk of the child having had an unintentional injury in the last 12 months, OR=1.16 (95%CI: 1.01 to 1.33, P=0.0319), and an increased risk of hospital admission in the last 12 months, OR=1.26 (95%CI: 1.05 to 1.51, P=0.0166). The presence of a non-biological father figure was also associated with the child having a significantly higher SDQ difficulties score: β=0.908 (95%CI: 0.581 to 1.23, P<10^{-3}).

In the model of immunization uptake, there was a significant interaction between the effect of the presence of a non-biological father and time. The presence of a non-biolog-

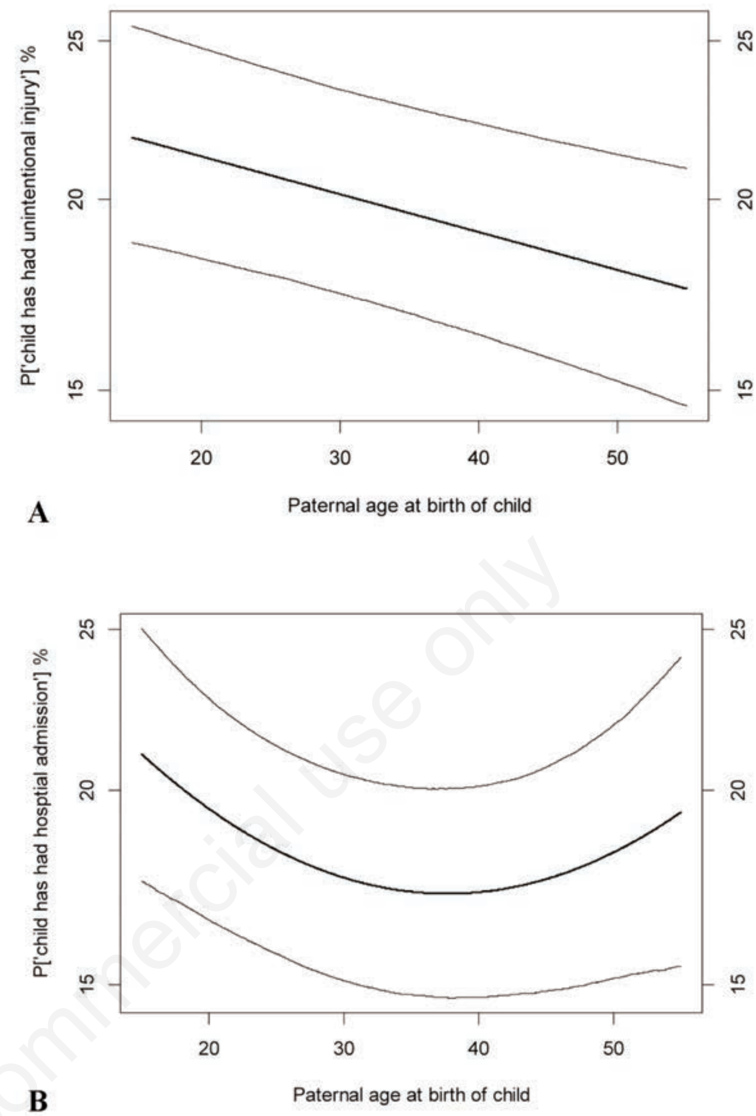

Figure 2. Regression line with 95% confidence interval for the final model of the outcome variable Child has had unintentional injury (A) or hospital admission (B) in last 12 months. The y-axis indicates the probability that the child has had an unintentional injury (A) or a hospital admission (B).

Table 2. Summary statistics for continuous variables.

Variable	9 months		3 years		5 years	
	Mean	SD	Mean	SD	Mean	SD
Child's BMI (kg/m^2)			16.8	2.12	16.3	1.92
Child's BAS naming vocabulary score			48.1	11.6	52.0	11.5
Child's SDQ total difficulties score			11.1	5.11	9.10	4.87
Mother's age at birth of child (years)	27.9	6.09	28.3	6.07	28.4	6.01
Father's age at birth of child (years)	31.7	6.42	31.9	6.40	32.0	6.32
Mother's pre-pregnancy BMI (kg/m2)	24.2	4.92	24.4	4.99	24.3	4.94
Child's age (years)	0.795	0.0574	3.16	0.192	5.21	0.251
Birth weight (kg)	3.31	0.598	3.33	0.594	3.33	0.593

SD, standard deviation; BMI, body mass index; BAS, British ability scales (higher scores indicate greater language ability); SDQ, strength and difficulties questionnaire (higher scores indicate greater social difficulties).

ical father figure was associated with a lower probability of the child having had complete immunizations up to 9 months of age, OR=0.343 (95%CI: 0.130 to 0.905, P=0.0309).

Model of drop out

A number of factors affected the probability of dropout by the 5 year survey. Families were less likely to drop out where the mother was older, OR=0.86 per 5 year increase in maternal age (95%CI: 0.84 to 0.89, $P<10^{-3}$); where the mother was a lone parent, OR=0.73 (95%CI: 0.64 to 0.83, $P<10^{-3}$); where the child was breast fed, OR=0.81 (95%CI: 0.76 to 0.86, $P<10^{-3}$); where the child was female, OR=0.94 (95%CI: 0.89 to 0.99, P=0.0294); where family income exceeded £11,000 per year, OR=0.83 (95%CI: 0.77 to 0.90, $P<10^{-3}$) and where the father's habitual occupation was *self-employed/small employer*, OR=0.89 (95%CI: 0.85 to 0.94, $P<10^{-3}$). Families were more likely to drop out by the 5 year survey where the child was older at the 9 month survey, OR=1.15 per 1 month increase in child's age (95%CI: 1.10 to 1.19, $P<10^{-3}$); where the child's ethnic group was *mixed*, OR=1.37 (95% CI: 1.19 to 1.57, $P<10^{-3}$), *black African or Caribbean*, OR=1.85 (95%CI: 1.59 to 2.15, $P<10^{-3}$), or *other*, OR=1.25 (95%CI 1.04 to 1.50, P=0.0205); where the family was without work at the time of the 9 month survey, OR=1.49 (95%CI: 1.38 to 1.61, $P<10^{-3}$) and where the mother had no formal educational qualifications, OR=1.50 (95%CI: 1.40 to 1.62, $P<10^{-3}$).

Discussion

Previous studies have established a link between advanced paternal age and the risks of autism and schizophrenia among offspring.[27-33] Advanced paternal age has been associated with poorer neurocognitive outcomes for younger children.[34] Lower IQ in adolescents has been associated both with older (>40 years) and younger (<20 years) fathers.[35] Poorer social functioning in male adolescents has also been associated with both older (>45 years) and younger (<20 years) fathers.[36] More positively, older fathers have been shown to be more involved in their children's health care.[37] Although we found two statistically significant effects of paternal age on the outcome variables, bearing in mind the large sample size which will show statistical significance for small effects, the conclusion of this study is essentially a negative one with regards to any large or practically important effects of paternal age on these child health related outcomes. This conclusion contrasts sharply with that of an analysis of the effects of maternal age on these outcomes using the same data, where much larger and more widespread effects were found.[3]

There is a large body of evidence to suggest that paternal involvement is important for children's health and development;[4] higher rates of low birth weight, preterm birth, babies small for gestational age, and infant mortality have been found where the father was absent.[5] Children from single parent (father absent) households have been found to be more likely to have psychiatric illness, attempt suicide and have alcohol and drug-related conditions than their counterparts from two parent households,[6] and to be more likely to be overweight, to have poorer health and to have psychological problems.[7] These results are not explained by poorer socio-economic conditions in single parent households, although other authors have suggested that the problems suffered by children with absent fathers can largely be explained by socio-economic factors.[8,9] Fathers' interaction with their children has also been shown to enhance children's psychosocial wellbeing.[10] Our findings of greater risk of hospital admission, lower probability of complete immunizations and more behavioral problems are in accord with previous findings of adverse effects associated with an absent father on children's health and wellbeing. Our results are net of the socio-economic covariates, supporting the view that socio-economic disadvantage may not explain all the differences observed between single and two parent families.

Increased behavior problems, as measured by the SDQ Difficulties Score, have been found in *re-constituted families* including a non-biological parent, a result not explained by socio-economic factors.[8] Our findings confirm this result, and also suggest more widespread adverse effects of having a non-biological father figure instead of a natural father, with higher risks of unintentional injury and hospital admission, and lower probability of complete immunizations. These results were not explained by socio-economic differences between families with natural fathers and non-biological fathers.

This study is subject to the usual limitation of observational studies, that causality cannot be assumed from association. Much of the data analyzed, apart from child weight and height and naming vocabulary measurements, were based on parental report although the fact that the data were collected in an optimal manner by direct parental interview with highly trained interviewers would seem to obviate this limitation somewhat. There will be some degree of measurement error, but the measures used were the best available, and there is no reason to assume systematic bias. Under these conditions the effect of measurement error will be to weaken the observed associations rather than to lead to finding spurious ones. The results from the models fitted to multiply imputed data depend to some extent on the model used for the imputation. However, the results from the complete cases models were found to be similar, so we believe it is unlikely that our results are an artefact of the imputation model. As with all longitudinal studies, there was attrition of participants over time. However, the rates of attrition compared favorably with other studies, and the use of multiple imputation should largely correct any resulting bias.

Conclusions

The health and well-being related outcomes studied here show little association with paternal age at child's birth once demographic and socio-economic confounders have been controlled for. This contrasts with the stronger associations found between these outcomes and maternal age using the same data, where older mothers were generally associated with better outcomes for children.[3] Both absent fathers and the presence of non-biological fathers were associated with poorer outcomes for children in some cases.

References

1. Office for NAtional Statistics. Births and deaths in Englandand Wales. London: ONS; 2009. Available from: http://www.ons.gov.uk/ons/rel/vsob1/birth-summary-tables--england-and-wales/2009/birth-summary-tables--england-and-wales---births-and-deaths--england---wales-statistical-bulletin---2009--final-.pdf
2. Martin JA, Hamilton BE, Ventura SJ, et al. Births: final data for 2009. Available from: http://www.cdc.gov/nchs/data/nvsr/nvsr60/nvsr60_01.pdf
3. Sutcliffe AG, Barnes J, Belsky J, et al. The health and development of children born to older mothers in the United Kingdom: observational study using longitudinal cohort data. BMJ 2012;345:e5116.
4. Sarkadi A, Kristiansson R, Oberklaid F, Bremberg S. Fathers' involvement and children's developmental outcomes: a systematic review of longitudinal studies. Acta Paediatr 2008;97:153-8.
5. Alio AP, Kornosky JL, Mbah AK, et al. The impact of paternal involvement on feto-infant morbidity among Whites, Blacks and Hispanics. Matern Child Health J 2010;14:735-41.
6. Weitoft GR, Hjern A, Haglund B, Rosen M. Mortality, severe morbidity, and injury in children living with single parents in Sweden: a population-based study. Lancet

2003;361:289-95.
7. Scharte M, Bolte G, GME Study Group. Increased health risks of children with single mothers: the impact of socio-economic and environmental factors. Eur J Public Health 2013;23:469-75
8. McMunn AM, Nazroo JY, Marmot MG, et al. Children's emotional and behavioural well-being and the family environment: findings from the Health Survey for England. Soc Sci Med 2001;53:423-40.
9. Spencer N. Maternal education, lone parenthood, material hardship, maternal smoking, and longstanding respiratory problems in childhood: testing a hierarchical conceptual framework. J Epidemiol Community Health 2005;59:842-6.
10. Coleman WL, Garfield C. Fathers and pediatricians: enhancing men's roles in the care and development of their children. Pediatrics 2004;113:1406-11.
11. Dex S, Joshi H, eds. Millennium cohort study, first survey: a user’s guide to initial findings. Centre for Longitudinal Studies, University of London; 2004. Available frm: http://www.cls.ioe.ac.uk/library-media%5Cdocuments%5CMCS1_A_Users_Guide_To_Initial_Findings.pdf
12. Melhuish E, Belsky J, Leyland AH, et al. Effects of fully-established Sure Start Local Programmes on 3-year-old children and their families living in England: a quasi-experimental observational study. Lancet 2008;372:1641-7.
13. Noble M, Wright G, Smith G, et al. Measuring multiple deprivation at the small-area level. Environment Planning 2006;38:169-85.
14. Goodman R. The strengths and difficulties questionnaire: a research note. J Child Psychol Psychiat 1997;38:581-6.
15. Centers for Disease Control and Prevention. Percentile data files with LMS values. Available from: http://www.cdc.gov/growthcharts/percentile_data_files.htm.
16. Elliott CD, Smith P, McCulloch K. British ability scales. 2nd ed. Windsor: NFER-Nelson; 1996.
17. Hruschka DJ, Kohrt BA, Worthman CM. Estimating between- and within-individual variation in cortisol levels using multilevel models. Psychoneuroendocrinol 2005;30:698-714.
18. R Development Core Team. R: a language and environment for statistical computing. Vienna: R Foundation for Statistical Computing; 2010. Available from: http://www.R-project.org/.
19. Pinheiro J, Bates D. nlme: linear and nonlinear mixed effects models. Available from: http://cran.r-project.org/web/packages/nlme/index.html
20. Ripley BD. MASS: support functions and datasets for venables and ripley's MASS. Available from: http://cran.r-project.org/web/packages/MASS/index.html.
21. Goldstein H. Handling attrition and non-response in longitudinal data. Longit Life Course Stud 2009;1:63-72.
22. Honaker J, Joseph A, King G, et al. Amelia II (R Package). 2011. Available from: http://cran.r-project.org/web/packages/Amelia/index.html.
23. Honaker J, King G, Blackwell M. Amelia II: a program for missing data. Available from: http://cran.r-project.org/web/packages/Amelia/vignettes/amelia.pdf
24. Schafer JL. Analysis of incomplete multivariate data. Boca Raton: CRC Press; 1997.
25. Rubin DB. Multiple imputation for nonresponse in surveys. Philadelphia: Wiley & Sons; 1987.
26. Hesterberg T. Combining multiple imputation t, chi-square, and F inferences. Seattle, WA: MathSoft; 1998.
27. Lauritsen MB, Pedersen CB, Mortensen PB. Effects of familial risk factors and place of birth on the risk of autism: a nationwide register-based study. J Child Psychol Psychiatry 2005;46:963-71.
28. Reichenberg A, Gross R, Weiser M, et al. Advancing paternal age and autism. Arch Gen Psychiatry 2006;63:1026-32.
29. Kolevzon A, Gross R, Reichenberg A. Prenatal and perinatal risk factors for autism: a review and integration of findings. Arch Pediatr Adolesc Med 2007;161:326-33.
30. Malaspina D, Harlap S, Fennig S, et al. Advancing paternal age and the risk of schizophrenia. Arch Gen Psychiatry 200158:361-7.
31. Torrey EF, Buka S, Cannon TD, et al. Paternal age as a risk factor for schizophrenia: how important is it? Schizophr Res 2009;114:1-5.
32. Croen LA, Najjar DV, Fireman B, Grether JK. Maternal and paternal age and risk of autism spectrum disorders. Arch Pediatr Adolesc Med 2007;161:334-40.
33. Zammit S, Allebeck P, Dalman C, et al. Paternal age and risk for schizophrenia. Br J Psychiatry 2003;183:405-8.
34. Saha S, Barnett AG, Foldi C, et al. Advanced paternal age is associated with impaired neurocognitive outcomes during infancy and childhood. Plos Med 2009;6:e1000040.
35. Malaspina D, Reichenberg A, Weiser M, et al. Paternal age and intelligence: implications for age-related genomic changes in male germ cells. Psychiatr Genet 2005;15:117-25.
36. Weiser M, Reichenberg A, Werbeloff N, et al. Advanced parental age at birth is associated with poorer social functioning in adolescent males: shedding light on a core symptom of schizophrenia and autism. Schizophr Bull 2008;34:1042-6.
37. Moore T, Kotelchuck M. Predictors of urban fathers' involvement in their child's health care. Pediatrics 2004;113:574-80.