

Medically assisted reproduction and parent–child relationships during adolescence: evidence from the UK Millennium Cohort Study

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STUDY QUESTION: Do the parent–child relationships of adolescents born after medically assisted reproduction (MAR) using the parents' own gametes differ from those of adolescents born after natural conception (NC)?

SUMMARY ANSWER: MAR and NC families have similar parent–child relationships in terms of closeness and conflict frequency, except that MAR mothers report being closer to their children than NC mothers.

WHAT IS KNOWN ALREADY: Prior work on parent–child relationships during childhood has reported mixed findings. While some studies have documented no differences between MAR and NC families, others have shown that MAR families have greater levels of warmth and positive feelings than NC families. Evidence on parent–child relationships during the adolescent period is generally positive but is limited because of the small number of existing studies and the reliance on small samples.

STUDY DESIGN, SIZE, DURATION: This work is based on the UK Millennium Cohort Study, whose study members were born in 2000–2002. The analyses focused on Sweep 6 which was collected when cohort members were around 14 years old. We also relied on variables collected in Sweep 1, when cohort members were aged around 9 months, to account for characteristics that could confound or mediate the relationship between MAR and our outcomes. The attrition rate between Sweeps 1 and 6 was 36.7%.

PARTICIPANTS/MATERIALS, SETTING, METHODS: The final sample consisted of 10 233 cohort members, 320 of whom were conceived with the help of MAR (3.1%). A total of six dependent variables were used to measure, when the cohort members were around 14 years old, levels of parent–child closeness and conflict, reported separately by the mother, the father and the cohort member. Linear models were used to analyse the association between parent–child relationships before and after adjustment for socio-demographic characteristics and mental health.

MAIN RESULTS AND THE ROLE OF CHANCE: Sweep 6 achieved a response rate of 76.3% of the eligible sample. The results show that, on average, MAR and NC families had similar parent–child relationships in terms of closeness and conflict frequency. The only difference was that MAR mothers reported being closer to their children than NC mothers both before ($\beta = 0.149$, $P < 0.05$) and after ($\beta = 0.102$, $P < 0.1$) adjustment for family socio-demographic characteristics and mental health.

LIMITATIONS, REASONS FOR CAUTION: The outcome variables are self-reported by each of the respondents and could be subject to social desirability bias. Second, some parents may have not reported they conceived through donor insemination, which could result in the analytical sample including a small subset of children who were not genetically related to their parents. Third, the data did not include information about whether the children were aware of their conception mode, since the Millennium Cohort Study did not collect information on MAR disclosure. Moreover, they did not allow us to study other aspects of parent–child relationships. Finally, as we observed parent–child relationships at only one moment in time; we were unable to test whether they changed over time.

WIDER IMPLICATIONS OF THE FINDINGS: The results suggest that the difficulties and the stress parents underwent to conceive through MAR did not translate into more difficult parent–child relationships during adolescence. Given the increasing number of children

conceived via MAR, the finding that MAR and NC families had similar parent–child relationships in terms of closeness and conflict frequency is reassuring.

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Introduction

In recent years, the number of children born through medically assisted reproduction (MAR: which covers a range of techniques, including ovulation induction, intrauterine insemination, IVF and ICSI) has increased markedly. Since 1978, when the first IVF-conceived baby was born, an estimated 8 million babies conceived through MAR have been born worldwide (Adamsson *et al.*, 2019). The rise in the use of MAR has resulted in a wealth of research on MAR-conceived children (Hart and Norman, 2013), which has largely focused on analysing their health and well-being (Zhan *et al.*, 2013; Spangmose *et al.*, 2017; Berntsen *et al.*, 2019).

The evidence on whether and, if so, how the conception mode affects parent–child relationships is less well developed and less conclusive, as the findings are mixed and tend to lack perspective from larger samples. There are multiple mechanisms with opposite and potentially offsetting effects that could determine how parents and children relate among MAR families, so it is difficult to predict whether, and if so, how, MAR is associated with family relationships. On the one hand, conception through MAR is associated with higher levels of parental stress than natural conception (NC), which could negatively influence parent–child relationships (Bernstein, 1990; Golombok *et al.*, 1995; Hahn, 2001; Colpin and Soenen, 2002; Wagenaar *et al.*, 2008). Moreover, scholars have argued that the experience of subfertility and of having made large investments in the child could lead MAR parents to be overprotective, and to have exaggerated expectations of their children and of their own parenting abilities (Hahn and DiPietro, 2001; McMahon *et al.*, 2003; Wagenaar *et al.*, 2009; Ilio and Golombok, 2015). On the other hand, MAR families tend to be socio-economically advantaged, which is, on average, positively associated with family relationships (Conger *et al.*, 2010).

The previous literature has studied parent–child relationships by focusing on warmth, rejection, control and respect for autonomy (Wang *et al.*, 2014). Existing studies have reported mixed findings. While some studies have uncovered no differences (Colpin *et al.*, 1995; McMahon *et al.*, 1997; McMahon and Gibson, 2002), others have found that MAR families show greater levels of warmth and positive feelings related to parenting than NC families (Golombok *et al.*, 1995; Hahn and DiPietro, 2001; Sydsjö *et al.*, 2002; Wagenaar *et al.*, 2008). Sydsjö *et al.* (2002) and Weaver *et al.* (1993) showed that MAR mothers reported more positively on their children than their NC counterparts. Although the small and non-nationally representative samples (between 20 and 100 MAR children) limit the generalizability of the findings, the picture is generally positive, as MAR families appear to function as well or better than NC families.

Research on parent–child relationships beyond childhood is less well developed. Colpin and Bossaert (2008), Golombok *et al.* (2001, 2009)

and Owen and Golombok (2009) used a sample of less than 30 IVF children between ages 12 and 18, and concluded that parent–child relationships, parenting behaviour, parenting stress and most parenting goals do not differ between IVF and NC families. Golombok *et al.* (2002) analysed 102 IVF children from the UK, Italy, Spain, and the Netherlands at ages 11–12, and obtained similar conclusions. In the few cases where differences existed, parents' self-reports indicated that the functioning of MAR families was more positive. In line with these findings for the childhood period, evidence on parent–child relationships during the adolescent period is generally positive but is limited because of the small number of existing studies and their reliance on small samples.

As the proportion of children who are conceived with MAR is increasing rapidly (Adamsson *et al.*, 2019), it is essential that we gain a better understanding of family relationships in adolescence within MAR families, and evaluate whether they differ from those of their NC counterparts for three main reasons. First, parent–child relationships remain vital for the development of autonomous and responsible individuals (Berk, 2004; Colpin and Bossaert, 2008) and have long-term implications for people's relationships with other adults, as well as for people's mental health, psychosocial adjustment, school performance and occupational choice and success (Laursen and Collins, 2009). Second, adolescence is a critical period of identity formation and of the development of autonomy from one's parents (Erikson, 1968). It is also a period when parent–child disagreements are more likely to surface, and the relationship shifts from being hierarchical to being more egalitarian (Steinberg, 1990; Jaffe, 1998). Therefore, the evidence available from studying parent–child relationships in MAR families during the childhood period may not fully apply to the adolescent period. Third, adolescence could represent a particularly challenging phase for MAR children, since the conception mode could affect the parent–child relationship during the stage of the life course when children become more independent, and start to develop their own identity (Golombok *et al.*, 2001; Colpin and Soenen, 2002; Hart and Norman, 2013; Barbuscia *et al.*, 2019).

In this study, we investigate parent–child relationships in adolescence in MAR families, and test whether these relationships differ from those of NC families. This paper contributes to the existing literature in several ways. First, we use a nationally representative dataset for the UK that allows us to overcome the issues of the findings' generalizability that have arisen in some of the previous studies on this topic. Second, the richness of the data allows us to control for a wide range of family characteristics that might confound or mediate the relationship between MAR treatment and parent–child relationships. Third, we evaluate family relationships by considering self-reported measures of all family members, and not just of the mothers, who tend to be the

main reporters on their children's and adolescents' behaviours and are considered to be the most accurate informants (Phares, 1997). Nonetheless, relying on only one informant would cause us to lose valuable information for evaluating children's and adolescents' behaviour (Renk, 2005). The only related studies that consider the views of mothers, fathers and adolescents are Colpin and Bossaert (2008) and Golombok *et al.* (2002).

Materials and methods

Data

The UK Millennium Cohort Study (MCS) is a nationally representative longitudinal survey that follows 19 244 children born in the UK in 2000–2002. The sample is geographically clustered, and is stratified to over-represent areas of England with relatively high proportions of ethnic minorities and high levels of child poverty, as well as areas in the three smaller countries of Wales, Scotland and Northern Ireland. Baseline interviews were conducted when the children were approximately nine months old, and follow-up interviews were conducted when the children were around 3, 5, 7, 11 and 14 years old. In this study, we focus on Sweep 6 which was collected when cohort members were around 14 years old. We also relied on variables collected in Sweep 1, when cohort members were aged around 9 months, to account for characteristics that could confound or mediate the relationship between MAR and our outcomes. The MCS includes detailed information about the demographic, health and socio-economic characteristics of the respondents and their families. The study also collects rich information on parenting, relationships and family life from resident parents.

Medically assisted reproduction

The term MAR children refers to children who were conceived through ART, such as IVF and ICSI, or other kinds of fertility treatments, such as ovulation induction (OI) and IUI. At the baseline interview, respondents (the cohort member's mother in 99% of the cases) were asked whether they had used any fertility treatment to conceive. In the final sample ($n=10\,233$), 320 (3.1%) children who were conceived with the help of MAR were identified. The unequal representation of MAR and NC children aligns with the fact that we rely on a nationally representative survey (Andersen *et al.*, 2004). Of these, 135 (42%) were conceived through ART (either IVF, ICSI or frozen embryo transfer (FET)), 14 were conceived through IUI (4.4%), 132 (41.3%) were conceived with the aid of ovarian stimulation drugs not followed by any further treatment, and 39 (12.2%) were conceived with surgery involving the mother's womb, tubes or ovaries. In the main analyses, the different kinds of treatment are included in the same category because of the small numbers, so MAR is coded as a dummy variable that takes the value of 1 if the child was conceived through any type of MAR and the value is 0 otherwise.

Because of sample size issues, we were not able to analyse the associations separately for each MAR type. To partially overcome the sample size issues, we categorized the treatments according to how invasive they are. We divided respondents into two groups: more invasive procedures (IVF, ICSI, FET and surgery $n=174$) and less invasive

procedures (ovarian stimulation and IUI $n=146$) separately against NC.

Children conceived via donor insemination ($n=3$) were excluded from the analytical sample because their parent–child relationships might be distinct from those of other MAR children (Golombok *et al.*, 2002; Owen and Golombok, 2009). Given the small numbers, we would not be able to study this group separately. Some parents may have chosen not to disclose their children were conceived via donor insemination. However, because interviews were conducted separately for each family member and they were assured their answers were confidential, we expect the great majority of children included in our analytical sample to be genetically related to their parents.

Outcome variables

We relied on two questions related to closeness and quarrelling self-reported by mothers, fathers and cohort members at Sweep 6 (when the cohort members were around age 14). Closeness and conflict dimensions have often been used to describe parent–child relationships during adolescence (Laursen and Collins, 2009).

Both conflict and closeness are considered important predictors of children's development (Driscoll and Pianta, 2011). On the one hand, constructive conflict (as opposed to destructive conflict, which is a marker of dysfunctional relationships (Laible and Thompson, 2002)) may constitute an important aspect of children's socialization, as it involves high levels of negotiation, justification and resolution, and it is likely to enhance development (Kuczynski *et al.*, 1987; Dunn and Slomkowski, 1992). On the other hand, closeness clearly plays a role in children's development, as the children of warm and responsive parents have been described as socially competent, securely attached and successful in school (Field, 1987; Fiese *et al.*, 2000; Davies and Sturge-Apple, 2014) from the toddler years and the preschool period (Belsky *et al.*, 1996) to adolescence (Allen *et al.*, 1996). Colpin and Bossaert (2008), Golombok *et al.* (2009), Owen and Golombok (2009), and Peterson and Zill (1986), among others, have used constructs of warmth and conflict to evaluate parent–child and parent–adolescent relationships in MAR families. While closeness generally reflects positive aspects of a relationship, conflict could be interpreted as reflecting either positive or negative aspects of it.

In Sweep 6, the following questions were answered by the mother, the father and the cohort member. Several actions were taken to diminish the risk of self-reporting bias: the questions in the self-completion questionnaire were answered separately by each family member and the respondents were assured their answers would be treated as confidential.

Closeness: Parents were asked: 'Overall, how close would you say you are to [^Cohort member's name]?' The possible answers were coded in a Likert scale ranging from 1 'Not very close' to 4 'Extremely close'. Cohort members were asked the same questions regarding their mother and their father separately.

Frequency of quarrelling: Parents were asked: 'Most parents have occasional quarrels with their children. How often do you quarrel with [^Cohort member's name]?' The possible answers ranged from 1 'Most days' to 4 'Hardly ever'. Since this question is not specific on the type of conflict, it can reflect either positive or negative aspects of parent–child relationships. Similarly, the cohort members were asked about their mother and their father separately: 'Most young people

have occasional arguments with their parents. How often do you argue with your mother (father)? The possible answers ranged from 1 'Most days' to 5 'Never'. To ensure comparability between the parents' and the cohort member's responses, the answers 'hardly ever' and 'never' were classified in the same group.

Covariates

To control for family and child characteristics that could confound or mediate the relationship between the mode of conception and parent–child relationships, we included a set of variables that have been widely used by the existing literature (Ilio and Golombok, 2015). First, we included the basic characteristics of the cohort member: namely, the child's sex (bivariate), whether she/he was the first-born, and whether she/he was delivered in a multiple birth. We also included adjustments for a number of parental background characteristics collected in the first sweep (collected when the cohort member was around nine months old): the mother's age at birth (continuous), the parents' marital status at birth (categorical: married, cohabiting, single), the highest educational level in the household (categorical: National Vocational Qualification (NVQ) level 1/2, NVQ level 3 and NVQ level 4/5), and the household's income quintile (categorical: obtained using the modified OECD scale, which adjusts family income by household size).

Finally, we controlled for parental characteristics measured in sweep 6; i.e. when the parent–child relationships were measured: the number of siblings (continuous), the parental household structure (categorical: one biological parent, two biological parents, one biological parent and other parent) and mental health variables for all family members because previous research shows an association between MAR and mental health and an association between mental health and parent–child relationships (Buist *et al.*, 2004; Reitz *et al.*, 2006; Verhaak *et al.*, 2007; Milazzo *et al.*, 2016) (continuous: Kessler scales for parents ranging from 0 to 24 and the parent's reported total difficulty score from the Strength and Difficulties Questionnaire (SDQ) for children, ranging from 0 to 38. In both scales, higher values signal more psychological distress).

Inclusion and exclusion criteria

Analytical samples included cohort members who lived with at least one biological parent in Sweeps 1 and 6, and for whom information on parent–child relationships and covariates at Sweeps 1 and 6 was available. As shown in Table I, sample sizes vary across the outcome variables: the largest analytical sample is the one used to analyse the mother's report, followed closely by the cohort's member report on the mother. Sample sizes reflect the more common absence of the natural father from the household. The final analytical sample for the question on closeness answered by the cohort member about his/her mother includes 10 023 children, of whom 317 (3.2%) were conceived through MAR. The sample for the child's answer on his/her father includes 7014 children (of whom 3.7% were conceived through MAR). Finally, 9748 and 5727 responses are included in the analytical sample for the estimation on how close the mother and the father reported being to their child, respectively; of these 3.2% and 3.9% were conceived through MAR. Sample sizes for the frequency of quarrelling follow a similar pattern of variation.

Table I Main outcomes descriptive statistics.

	Natural conception			MAR			T-Stat for differences between NC and MAR
	Mean	SD	n	Mean	SD	n	
How close?							
Mother with CM	3.32	0.73	9438	3.48	0.66	310	-3.81***
Father with CM	3.11	0.73	5504	3.07	0.74	223	0.80
CM with mother	3.22	0.8	9706	3.30	0.75	317	-1.76*
CM with father	3.08	0.86	6758	3.15	0.81	256	-1.28
How often do you quarrel?							
Mother with CM	2.96	0.96	9406	3.03	0.96	309	-1.26
Father with CM	3.09	0.89	5482	3.05	0.83	223	0.66
CM with mother	3.10	0.96	9826	3.05	0.96	318	0.91
CM with father	3.38	0.87	9226	3.32	0.88	302	1.18

CM, cohort member; MAR, medically assisted reproduction.

Mean and SD Weighted. n unweighted. Sample sizes vary across outcomes depending on who answered the question and the family members living in the household during the interview. *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$.

Methodology/statistical analysis

We estimated a set of Ordinary Least Square (OLS) models to obtain the linear association between the mode of conception and our outcome variables. The baseline model reports the descriptive (or unadjusted) association between MAR and each of the outcomes. We then added covariates to test whether, and if so, how, the unadjusted association changed after we took the confounders/mediators into account. Model 1 controls for family background characteristics (parental education, parental marital status and income quintile at Sweep 1) and birth variables (maternal age, child's sex, whether the child was first-born, whether the child was part of a multiple birth); Model 2 controls for household composition and number of siblings in Sweep 6; and Model 3 introduces parents' and cohort members' mental health. In Model 4, we replicated the unadjusted models excluding those respondents whose pregnancies were unplanned (between 30% and 40% of the analytical sample according to the outcome and respondent). Excluding unplanned pregnancies allows us to compare MAR families with NC families who are more alike, as all MAR pregnancies are planned, and unplanned pregnancies are associated with lower socio-economic status and differences in family structure and parent–child relationships (Gipson *et al.*, 2008; Carson *et al.*, 2011). All the analyses were estimated using Stata 16. We estimated each of the models separately for the mothers', the fathers' and the cohort members' reports. When analysing the relationship between the mother and the cohort member, parental controls such as education and mental health refer to the mother. Similarly, when estimating the relationship between the father and the cohort member, parental controls refer to the father.

Results

Table I presents descriptive statistics for the outcome variables. Overall, the differences between the NC and the MAR families were

small, and generally not statistically significant. The mothers of MAR children reported being closer to their children than the mothers of NC children, and MAR cohort members reported being closer to their mothers than NC children; these differences are statistically significant. Although it was observed that the fathers of MAR children reported being less close to their children than the fathers of NC children, these differences were not statistically significant. For the reports on the quarrelling frequency, a similar pattern emerged, but the differences were smaller and also not statistically significant: MAR mothers reported quarrelling less with their children and MAR children reported arguing less with both of their parents compared to their NC counterparts, but MAR fathers reported quarrelling more than the NC fathers.

Table II presents descriptive statistics for NC- and MAR-conceived children and their families. Consistent with previous literature showing that MAR families tend to be socio-economically advantaged (Carson et al., 2011; Barbuscia and Mills, 2017), the results indicate that compared to the NC parents, the MAR parents were, on average, more educated, had higher levels of income, and were more likely to be married at the time of birth. In addition, compared to the NC children, the MAR children were more likely to be born to an older mother, to be first-born, and to be born in a multiple birth.

The MAR children had a smaller number of siblings and were more likely to be living with both biological parents at age 14 than the NC children. Both the MAR mothers and fathers reported having lower scores on the Kessler scales, indicating lower levels of psychological distress (Kessler et al., 2003). Finally, the MAR parents also reported that their children had lower average total difficulty scores on the SDQ questionnaire, which indicates lower levels of socio-emotional problems.

Table III presents a summary of the MAR coefficient for the estimations on the six outcome variables. The full model results are presented in *Supplementary Tables SIII, SIV, SV, SVI, SVII, SVIII, SVIX and SX*. MAR was positively and significantly associated with the mothers' reports on 'how close' they are to their children (0.149 with 95% CI: 0.033 to 0.266). The magnitude of the association (computed by a log transformation of the dependent variable) suggests that mothers who conceived through MAR reported 5% more positively on how close they are to their children than mothers who conceived naturally. The association was attenuated in magnitude and was no longer statistically significant after adjustments for the parents' and cohort members' socio-demographic characteristics around the time of birth (Model 1). Including adjustments for socio-demographic variables measured at age 14 (Model 2) did not change the results. In Model 3, which additionally

Table II Covariates descriptive statistics.

	Natural conception		MAR	
	Mean	SD	Mean	SD
Parental education (Sweep 1)				
Mother education: none, overseas, NVQ level 1/2	0.45	0.5	0.34	0.48
Mother education: NVQ level 3	0.14	0.35	0.12	0.33
Mother education: NVQ level 4/5	0.41	0.49	0.53	0.5
Father education: none, overseas, NVQ level 1/2	0.39	0.49	0.28	0.45
Father education: NVQ level 3	0.16	0.36	0.16	0.37
Father education: NVQ level 4/5	0.45	0.5	0.55	0.5
Income weighted quintiles (Sweep 1)				
	3.29	1.36	3.95	1.09
Parental relationship at the time of birth				
Married	0.64	0.48	0.88	0.33
Cohabiting	0.24	0.43	0.09	0.29
Non-cohabiting	0.11	0.32	0.03	0.16
Maternal age at CM's birth				
	29.56	5.54	32.89	4.84
Multiple birth				
	0.02	0.13	0.24	0.43
CM is mother's first child				
	0.42	0.49	0.67	0.47
CM sex				
	0.50	0.50	0.46	0.5
Number of siblings in the household (Sweep 6)				
	1.52	1.09	0.95	0.92
Household structure (Sweep 6)				
I Biological parent only	0.27	0.44	0.18	0.39
I Biological parent + other	0.14	0.34	0.07	0.25
2 Biological parents	0.60	0.49	0.75	0.43
Father Kessler K6 Scale (Sweep 6)				
	3.57	3.52	3.00	3.13
Mother Kessler K6 Scale (Sweep 6)				
	4.53	4.37	4.19	3.8
Parent-reported CM SDQ total difficulties (Sweep 6)				
	8.30	6.14	7.16	4.95

CM, cohort member; MAR, medically assisted reproduction.

This table is computed for the analytical sample of 'how close' reported by mothers, which is composed of 9443 observations.

Table III MAR coefficient in linear model estimations of parent–child relationships.

MAR coefficient	Full analytical samples				Excluding unplanned pregnancies*	n
	M0 Unadjusted	M1 Adjusts for family background and birth characteristics	M2 M1 + household composition and number of siblings in Sweep 6	M3 M2 + parent and cohort members' mental health		
How close						
Mothers' report	0.149** (-0.0591)	0.0871 (-0.0596)	0.0824 (-0.059)	0.102* (-0.0556)	0.128** (-0.0584)	9433
Fathers' report	0.0256 (-0.0655)	-0.00794 (-0.0682)	-0.0194 (-0.0676)	-0.0193 (-0.0661)	0.0137 (-0.0653)	4877
Cohort members' report on mother	0.0939 (-0.0617)	0.0209 (-0.0599)	0.0182 (-0.0596)	0.029 (-0.0594)	0.0627 (-0.0611)	9144
Cohort members' report on father	-0.000892 (-0.0692)	-0.0334 (-0.0679)	-0.0374 (-0.0682)	-0.0331 (-0.0684)	-0.026 (-0.0695)	4787
How often quarrel / argue						
Mothers' report	0.0875 (-0.0661)	0.0199 (-0.0656)	0.021 (-0.0657)	0.0633 (-0.0641)	0.0308 (-0.0672)	9402
Fathers' report	-0.00465 (-0.0714)	0.0075 (-0.0763)	0.00298 (-0.0761)	0.0116 (-0.07)	-0.0276 (-0.0719)	4861
Cohort members' report on mother	-0.0226 (-0.0646)	-0.0239 (-0.0633)	-0.0249 (-0.0642)	-0.00632 (-0.0626)	-0.0611 (-0.0643)	9130
Cohort members' report on father	-0.0704 (-0.0757)	-0.0311 (-0.0797)	-0.0389 (-0.0786)	-0.0295 (-0.076)	-0.0653 (-0.0761)	4786

*The sample size reported in the table corresponds to the number of observations in the full analytical sample. Sample sizes for the estimations that exclude unplanned pregnancies correspond to 5653 (mothers' report), 3451 (fathers' report), 5501 (CMs' report on the mother) and 3398 (CMs' report on the father) in the 'how close' estimations; and to 5635 (mothers' report), 3438 (fathers' report), 5493 (CMs' report on the mother) and 3397 (CMs' report on the father) in the quarrelling estimations. CM, cohort member.

** $P < 0.05$, * $P < 0.1$.

adjusts for the parents and cohort members' mental health, MAR mothers reported 3.2% more positively on how close they are to their children (0.102 with 95% CI: -0.007 to 0.212).

The association between MAR conception and the parent–child relationship reported by the father or by the cohort member was not statistically significant and was smaller in magnitude than that reported by the mother, both before and after adjustments for family and child characteristics. In all models, the adjustment for parents and cohort members' mental health explained the highest percentage of the variance in the dependent variable, but there was still a high percentage of variance left unexplained by the covariates included in our models.

When excluding unplanned pregnancies, the unadjusted effect of MAR conception was positive and statistically significant, albeit slightly smaller than the unadjusted effect in the overall sample (Model 4). Additional analyses, not shown in the paper, revealed that the MAR coefficient behaved similarly to Models 1–3 after adjustment for socio-demographic and mental health variables. The remaining mothers', fathers' and cohort members' reports were, like in the analyses on the full sample, not statistically significant. When excluding unplanned

pregnancies, we dropped between 30% and 40% of the analytical sample depending on the outcome and respondent.

When analysing the sign and statistical significance of the covariates, it could be seen that the number of siblings was negatively associated with closeness for all family members but not with quarrelling. The cohort member being a male was positively associated with closeness for mothers, but negatively associated with closeness in all other reports. For quarrelling, the cohort member being a male was negatively associated with the maternal report and the cohort member's report on the mother, but positively associated with the father's report on his child. Adolescent mental health was negatively associated with both closeness and quarrelling for all family members. Also, the highest level of parental education (NVQ level 4 and 5) was negatively associated with closeness and quarrelling for both parents, but only with quarrelling in the adolescent's view.

As a robustness check, we estimated ordered probit models using the same structure of adjustments. The results in *Supplementary Table SI* show that the coefficients have a direction and a statistical significance similar to those of the main results presented in the paper.

When estimating the associations using the sub-categories of MAR (Supplementary Table SII), the association was more nuanced, although because of small numbers, these results should be interpreted cautiously. Mothers who conceived through less invasive treatments (clomid/IUI) tended to report higher levels of closeness with their adolescent son/daughter than mothers who conceived naturally. The association for mothers who conceived through more invasive methods went in the same direction, but it was not statistically significant. Also, mothers who conceived through more invasive MAR methods (IVF/ICSI/FET/Surgery) reported higher quarrelling frequency than NC mothers, but this report was not echoed by the cohort member's report. The remainder of the coefficients were small and not statistically significant.

Discussion

This article contributes to the existing literature on comparisons of parent-child relationships in MAR and NC families. The results showed that, on average, MAR and NC families had similar parent-child relationships in terms of closeness and conflict frequency. Most family members' reports indicated that there were no differences between MAR and NC families in parent-child closeness or frequency of quarrelling.

The only report in which we observed differences by conception mode was in the maternal report on closeness with the child, as the MAR mothers reported being closer to their children before adjustment for family characteristics. We attempted to unpack this association by taking advantage of the high level of detail of the MCS. First, when we considered the family socio-demographic characteristics, we found that the association was partially attenuated in size and was no longer statistically significant (Model 1 and Model 2). MAR families were selected and more advantaged, and these characteristics, which are positively associated with parent-child relationships, confounded the association between MAR and mothers' reports on closeness with the cohort member. Conversely, after adjustment for the mother's and the child's mental health (Model 3), the association increased its size and regained its statistical significance. This could suggest that mental health could act as a mediator in the association between MAR and parent-child relationships. The results obtained by excluding unplanned pregnancies confirm these arguments. In the unadjusted models, the MAR coefficient was smaller than it was in the overall sample, which was consistent with the fact that we were comparing groups that are alike in terms of pregnancy planning (Gipson *et al.*, 2008; Carson *et al.*, 2011). However, the results clearly showed that MAR mothers had a pattern of closeness to their children that differed even from that of couples who, like them, had planned their births, which may be explained by the relatively advantaged socioeconomic composition of people who undergo MAR to conceive (Carson *et al.*, 2011).

The mothers' reports that they have closer relationships with their children was not echoed by the children's or the fathers' reports, which could suggest that MAR mothers perceive their relationships to be closer. This finding may be consistent with previous evidence that family members experience family relationships differently (Olson, 1977), and that MAR mothers see their children as being particularly precious (Wagenaar *et al.*, 2009). Alternatively, it could reflect a

tendency among MAR mothers to over-report how close they are to their children because of social desirability bias; i.e., because of the difficulties a MAR mother had in conceiving her child, she may feel pressure to report having a positive relationship with her child, and to come across as a competent mother (McMahon and Gibson, 2002). However, since we rely on a large nationally representative dataset social desirability bias is less likely to occur in our sample compared to previous studies. Previous studies analysing parent-child relationships considering the views of all family members have reached mixed findings on the discrepancies in reports: while Golombok *et al.* (2002) found discrepancies in the report of mothers and their 11- to 12-year old child, Colpin and Bossaert (2008) found no discrepancies in the reports of mothers, fathers or adolescents.

The sign of the association between the covariates and our outcomes is consistent with previous literature on parent-child relationships. The negative association between the number of siblings and closeness has been explained by larger families providing less supportive environments and attention for children than smaller families and straining parent's emotional, physical and economic resources (Scheck and Emerick, 1976; Kidwell, 1981; Richardson *et al.*, 1986). The different associations between gender and closeness or quarrelling for each respondent also aligns with earlier work (Richardson *et al.*, 1986; Starrels, 1994). The association between adolescent's mental health and the report of higher levels of both closeness and quarrelling frequency for all family members is consistent with a negative relationship between parent-adolescent attachment and internalizing and externalizing adolescent behavioural problems (Buist *et al.*, 2004; Reitz *et al.*, 2006). Finally, the finding of highly educated parents reporting lower levels of closeness and higher levels of quarrelling with their children than less educated parents is partly consistent with the findings of Zhang (2012), where maternal education negatively predicted conflict and positively predicted closeness in mother relationships with children aged 3–5. It could be related to more educated mothers having higher commitments to work regardless of how they conceived their children, even in the early life of their children (Barnes *et al.*, 2004). Since we were controlling simultaneously for parental education and household income quintile, we did not interpret the negative effect of education as though socioeconomic advantage had a negative effect on parent-child relationships.

When estimating separately for MAR categories according to their level of invasiveness, we found that mothers who conceived through more invasive MAR procedures (IVF/ICSI/FET/surgery) reported higher levels of quarrelling with their children than mothers who conceived naturally. This could suggest that IVF/ICSI/FET/surgery families have more quarrelling dynamics but since this report is not echoed by the cohort members' reports, it could also be related to the mother's perception of the relationship. Moreover, more quarrelling does not necessarily mean that the relationship is worse since it could reflect constructive as well as destructive conflict (Laible and Thompson, 2002). Because of small numbers, these results should be interpreted cautiously and point to the need for more data on specific types of treatments to fully unpack potential differences in the association between different MAR types and parent-adolescent relationships.

Our findings confirm those of previous studies, which showed that there were few differences in the family relationships of MAR and NC families, and that when such differences existed, parents self-reports reflected more positive functioning in MAR families (Golombok *et al.*,

2001, 2002, 2009; Colpin and Bossaert, 2008; Owen and Golombok, 2009). They also align with the literature that has analysed parent–adolescent relationships for other MAR types: Golombok *et al.* (2017) documented no differences in parent–child relationships between donor insemination, surrogate and NC family types at age 14. The results suggest that the difficulties and the stress parents underwent to conceive through MAR did not translate into more difficult parent–child relationships during adolescence. Given the increasing number of families formed through MAR, these results present a positive and reassuring picture around the functioning of MAR families during the adolescent period.

The study has a number of limitations. First, our interest variables were self-reported by each of the respondents and despite the precautions taken to avoid self-report bias, they could still be subjected to it. Second, some parents might have not reported their child was conceived through donor insemination, which could affect the proportion of adolescents biologically linked to their parents in our sample. But because interviews were conducted separately on each family member and all respondents were assured their answers were confidential, we expect underreporting to only affect a small number of cases and that the great majority of MAR children in our analytical sample to be genetically linked to their parents. Third, the dataset did not include information on MAR disclosure. Nonetheless, this might not be as relevant here, considering that (because of their small numbers) we excluded from the analytical sample families who reported to have conceived via donor insemination, for whom disclosure might be especially relevant (Ilioi and Golombok, 2015; Golombok *et al.*, 2017). Fourth, although the dimensions of closeness and conflict have been widely used to study parent–child relationships, there are other aspects of parent–child relationships (emotional involvement, supportive presence, respect for the child's autonomy, structure and limit-setting, among others (Colpin *et al.*, 1995; Golombok *et al.*, 1995)) that we were not able to analyse using the MCS. Although we cannot generalize the results to other dimensions of family functioning, the dimensions (of closeness and quarrelling) we have analysed in this study matter because they are important predictors of children's development and socialization. Finally, we analysed parent–child relationships in one moment in time only, which prevented us from observing stability and change over time. Future research could build and expand on this work by shedding light on whether, and if so, how, parent–child relationships change during and after adolescence (Laursen and Collins, 2009).

Despite these limitations, this article makes a significant contribution to the literature on parent–child relationships in MAR families. Its main strength lies in our use of a nationally representative dataset, which allowed us to overcome the issues of the generalizability of the findings encountered in previous studies. Moreover, careful adjustments allowed us to isolate from the association between MAR conception and the parent–child relationship family characteristics that could confound or mediate it. Finally, by considering the views of all family members (and not just of the mother), we were able to present a comprehensive view of parent–child relationships in MAR families. Future work using different data will enable us to test whether these findings persist over the longer term and when looking at different dimensions of parent–child relationships.

Supplementary data

Supplementary data are available at *Human Reproduction* online.

Data availability

The University of London Centre for Longitudinal Studies owns the copyright for the Millennium Cohort Study (MCS) data used in this study. The MCS data are held/curated by the UK Data Service. Anyone wishing to use the MCS data (found at: <https://discover.ukdataservice.ac.uk/series/?sn=2000031>) must register and submit a data request to the UK Data Service at <http://ukdataservice.ac.uk/>. Additional terms and conditions of access are outlined here: <https://www.ukdataservice.ac.uk/get-data/how-to-access/conditions>.

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Authors' roles

Substantial contributions were made by A.G., including devising the idea, contributing statistical advice, making critical comments, and revising the paper. M.P. constructed and analysed the data and wrote the first draft. Both authors finally approved the version being submitted.

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Conflict of interest

None declared.

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