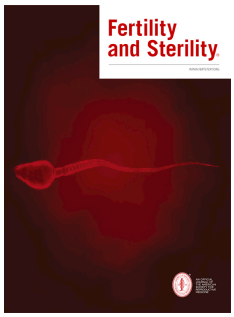

Educational gradients in the prevalence of medically assisted reproduction births in a comparative perspective

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The Danish data used in this study have been made available through a trusted third party, Statistics Denmark. Due to privacy concerns, the data cannot be made available outside the hosted research servers at Statistics Denmark. University-based and private Danish scientific organisations can be authorised to work with data within Statistics Denmark. Such organisations can provide access to individual scientists inside and outside of Denmark. Requests for data may be sent to Statistics Denmark: http://www.dst.dk/en/OmDS/organisation/TelefonbogOrg. aspx?kontor = 13&tlfbogsort = sektion or the Danish Data Protection Agency: https:// www.datatilsynet.dk/english/the-danish-data-protection-agency/contact/.

The French datasets are available from the French National Archive of Data from Official Statistics (ADISP): Enquête Nationale Périnatale (ENP) - 2016, DREES - Ministère de la Santé, INSERM - l'Institut national de la santé et de la recherche médicale (producteurs), ADISP (diffuseur). doi:10.13144/lil-1426. Enquête Nationale Périnatale (ENP) - 2010, DREES - Ministère de la Santé (producteur), ADISP (diffuseur). doi:10.13144/lil-0739. Enquête Nationale Périnatale (ENP) - 2003, DREES - Ministère de la Santé (producteur), ADISP (diffuseur). doi:10.13144/lil-0738. The data for Spain is freely accessible at the National Institute for Statistics' (INE) webpage (https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736177006&menu=resultados&idp=1254735573002#!tabs-1254736195425).

The data for the United Kingdom can be accessed via the UK Data Service.

The data for the United States are publicly available from the National Bureau of Economic Research (Natality Data from the National Vital Statistics System of the National Center for Health Statistics).

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Capsule: Institutional differences such as the level of public subsidization of treatments moderate the relationship between maternal educational level and the probability of giving birth after medically assisted reproduction.

Educational gradients in the prevalence of medically assisted reproduction births in a comparative perspective

Abstract

Objective

To study educational gradients in births after medical assisted reproduction across five countries with different institutional arrangements.

Design

We use logistic regression and compute predicted probabilities to estimate the association between education and giving birth after assisted reproduction, before and after adjustment for maternal age at delivery and marital/partnership status, using an overall sample of about 3.9 million live births in five countries.

Subjects

This study includes survey or register data containing information on births in five countries: N=61, 564 for Denmark, N= 37,533 for France, N=12,889 for Spain, N= 17,097 for the United Kingdom, and N=3,700,442 for the United States.

Intervention (for RCT) or Exposure (for observational studies)

None.

Main Outcome Measures

Probability of a child being born after medically assisted reproduction for mothers with a university degree relative to those having less than a university degree.

Results

University educated mothers are more likely to give birth after assisted reproduction compared to mothers with lower levels of education. After adjustment for socio-demographic characteristics, educational differences disappear in the United Kingdom and to some extent Spain, whilst they attenuate but persist in the other countries. The United States seems to show a larger educational gradient.

Conclusion

The results suggest that the institutional setting around assisted reproduction may moderate the gradient. A possible explanation may be access to treatments, as the United States – the context with the lowest subsidization – seems to show larger educational gradients than other contexts. In a context of global postponement of childbearing to older ages, mothers with lower levels of socioeconomic resources might find it more difficult to fully realise their fertility intentions in countries with a less generous subsidization of treatments.

Keywords

medically assisted reproduction; population-based studies; social inequality; educational gradient; comparative study

Introduction

In the last decades, a growing proportion of prospective parents have resorted to medically assisted reproduction (MAR) – broadly conceptualized as interventions, procedures, surgeries and technologies that treat fertility impairment and infertility (1) – to realize their fertility intentions. As fertility rates decline, due to a preference for a small(er) offspring, childbearing postponement or for other reasons, the recourse to medical assistance to conceive has increased markedly and it has intensified most notably in Europe, Australia, Asia and North America. (2)

The economic costs of accessing medically assisted reproduction – which depend on public coverage and vary substantially across countries (3) – as well as other barriers to access such as geographic distance and normative and cultural factors (4), suggest the existence of a socioeconomic gradient in usage and births. A handful of studies from single countries have consistently shown that parents of children conceived through medical assistance are more likely to have higher socioeconomic status (SES) relative to parents of naturally conceived (NC) children. Evidence thus far has been mostly focused on Finland (5, 6), the United States (7-9) and Norway (10).

Cross-country research drawing on comparable measurements is still scarce. Heterogeneity across studies regarding the methodologies, socioeconomic indicators, and outcome variables used makes it difficult to compare the results of existing studies based on individual countries. As a result, evidence on whether context moderates the social gradient in MAR births is still limited; i.e. whether the gradient is more marked in settings with lower subsidization of MAR treatments.

In this paper, we investigate whether educational gradients in births differ across countries with diverse institutional settings around MAR access and use. Using harmonized data from five high-income countries – Denmark, France, Spain, the UK, and the US – with diverse institutional frameworks facilitating or hindering access to MAR, we provide a comprehensive assessment of educational disparities in MAR births from a comparative perspective.

Materials and methods

Data sources and samples

We draw on high-quality representative national datasets, coming from either administrative registers, cohort studies, or fertility surveys, where information on social background, births, and the use of MAR is available. We use the latest available data or several data points in the case of countries with a small sample size, which results in the years analysed being slightly different across contexts. Supplemental Table 2 in Supplemental Material A synthetises the main features of all datasets. Supplemental Material B provides a detailed description of how we harmonized both the outcome variable (MAR birth) and the main predictor (maternal education).

For Denmark, we use data from the Danish Population Register together with data on all births from the Danish Fertility Database (11) and information on MAR treatments from the Danish National Register of Assisted Reproduction Techniques (12), which included in vitro fertilization (IVF), Intracytoplasmic Sperm Injection (ICSI), Frozen embryo replacement (FER), Vitrified-warmed blastocyst replacement (WBR), Oocyte donation (OD) and Intrauterine insemination (IUI). The Danish sample includes all live births to individuals residing in Denmark occurring in 2018, and a MAR birth is defined as that resulting from the mother receiving any type of treatment within 10 months before giving birth. From the Population Registers we also obtain information on mother's age, living arrangement at the start of 2018, and the level of education.

For France, we use three waves of the National Perinatal Survey (*Enquête Nationale Périnatale* or ENP) – 2003, 2010, 2016 – which samples all live births occurring in or later transferred to any public or private maternity unit in France (13, 14). Since less than 0.5% of births occur outside a hospital, the data is close to complete and consist of linked survey and medical records. The survey samples all children who were born

13-19 October 2003, 15-21 March 2010, and 14-20 of March 2016. The dataset contains information on whether the mother received a MAR treatment through IVF, IUI, or OD leading to the conception.

For Spain, we draw on the Spanish Fertility Survey (*Encuesta de Fecundidad*) for 2018, which is based on a representative sample of the non-institutionalized population of Spain aged between 18 and 55. The definition of MAR in these data includes IVF, ISCI, IUI, surrogate gestation, programmed intercourse, and other medical treatments. For this country, no direct information is provided on the use of fertility treatments for specific births, so we only know whether mothers ever underwent treatment with MAR prior to giving birth at a specific parity. Nevertheless, since there is information on the date and month during which a woman pursued her first MAR treatment and the number of live births resulting from this treatment or subsequent ones, most MAR births can in practice be identified. Cases where a given live birth cannot be unequivocally traced back to either MAR treatment or a natural conception have been excluded from the analysis. Different aggregate estimations based on the representative Spanish Fertility Survey – including the proportion of births due to MAR treatments – have shown a reasonable degree of coincidence with estimations based on the Spanish Fertility Society's register after discounting treatments for patients residing abroad (15). This indicates that the Spanish Fertility Survey provides reliable figures on Medically Assisted Reproduction treatments resulting in (live) births in Spain. We could not use the Spanish Fertility Society's register in this study as it does not contain socioeconomic information from individual-level patient data.

For the UK, we use data from the Millennium Cohort Study (MCS) (16, 17), a nationally representative survey of children born in the U.K. 2000-2 and their parents. Measures of MAR include self-reported information from mothers on conception following use of OD, gamete intrafallopian transfer (GIFT), IUI, ICSI, IVF, FER/WBR, and laparoscopic surgery (LS). Despite being maternal reports, the UK data are reliable and they closely match hospital records (18). We used weights to account for the complex sampling design and non-response and overrepresentation of disadvantaged and ethnically diverse areas and the survey command to account for the clustering of samples within strata.

For the US, we use administrative public data files from the CDC-National Vital Statistics System (NVSS) covering all US birth certificates for children born in 2019 (19). MAR data are gathered for all US states except for Tennessee and South Carolina, representing 96.3% of all births, as reported in the NVSS user guide. MAR births are defined as pregnancies resulting from MAR treatment according to the birth certificate, and cover OD, ICSI, IUI, IVF, GIFT, FER/WBR, and zygote intrafallopian transfer (ZIFT) procedures. We acknowledge that the US data underreport children born with assisted reproductive technologies (ART) (20, 21) and we provide several sensitivity analyses using subgroups to rule out that this has a major effect on the results.

Variables and definitions

The dependent variable is a binary indicator of whether the birth resulted from a MAR or natural conception. In order to make results as comparable as possible across countries, we neither distinguish between specific MAR techniques nor consider the number of cycles undergone. We focus on MAR rather than ART as its broader definition allows for a more direct comparison across data sources.

The main independent variable is maternal level of education, which we use as an indicator of women's/families' socioeconomic status since other measures such as occupation or income were not systematically available across all five countries. To facilitate the comparison across countries, we dichotomise this variable by distinguishing mothers having a university degree – International Standard Classification of Education (ISCED) level 5 or higher – from any below-tertiary level of education (for the US, we also include a category for unknown level of education). The ISCED classification allows for rigorous harmonization of the education indicator across countries (see Supplemental Material B for details on the harmonization procedure). We also provide sensitivity analyses using income categories for all countries except the US, for which this information is not available.

In the adjusted models, we control for maternal age at birth (in five categories: ≤24, 25-29, 30-34, 35-39, ≥40) to account for the higher resort of older women to MAR, and because of the more stable occupational

situation and higher socioeconomic status of older individuals accessing fertility treatments in these countries. Partnership status at birth – distinguishing between married, cohabiting with partner, and single (for the US, married, unmarried, and unknown) – is controlled for to account for the unequal access requirements across the five national settings. Finally, we only include live births in the sample to allow comparability across all national data sources.

Statistical analyses

Separately for each country, we estimate logistic regression and we compute the predicted probability of having a live birth after MAR for women with university education (vs. those with lower qualifications) compared with the probability of having a NC child. This result constitutes the baseline quantification of the extent to which an educational gradient is present. In a second set of models, we control for maternal age and partnership status. In all models, we also adjust for year of birth when more than one year of data is used. Because MAR births are disproportionately more likely to be first births (22, 23) the models were conducted on all births and then separately for first and second or higher order births. We estimate and comment predicted probabilities, as comparing odds ratios has a number of pitfalls related to coefficients rescaling in comparing results across groups and models (24, 25).

Ethical approval

Approval for the analyses was granted by national data producers. As all analyses were carried out on de-identified secondary data, they are considered exempt from IRB approval.

Results

Descriptive statistics

First, we provide an assessment on the number of infants born after the use of ART – a subset of MAR treatments entailing in vitro handling of gametes or embryos (1) – across all five countries since 2000 (Figure 1). Overall, the share of ART conceived children increased across all countries considered. Denmark had the highest proportion of ART-conceived live births at the start of the period (slightly below 4%) and experienced a moderate increase over time. In recent years, Denmark has been surpassed by Spain, where the proportion of ART births underwent the greatest increase and exceeded 9% in 2018. In the remaining three countries – France, the UK and the US – the increase in ART births was sustained but moderate, and by the end of the period considered they still exhibited relatively low levels (3% in 2017 in France and the UK, 2% in the US). In the supplemental online material, we also provide a description of the institutional context around MAR by country (26).

[FIGURE 1 ABOUT HERE]

Second, in Table 1 we report the descriptive statistics of the analytical samples by country and mode of conception: NC vs. MAR – here we use the broad definition including all procedures and not only those entailing in vitro handling of gametes or embryos; column percentages are displayed. Denmark shows the largest total proportion of children born after being conceived through MAR (9.1%), followed by France (5.5%), Spain (3.8%), the UK (3.4%) and finally the US (2%). Overall, we observe four patterns across all the countries considered. First, MAR-conceived children are more likely to be born to older mothers. Between 24% and 45% of MAR-conceived children are born to mothers in the 35-39 age group, while only between 15% and 23% of NC children are born to mothers within this age group. This difference is larger among mothers above 40 years of age; only 2% to 4% of the NC are born to this age group compared to 6% to 19.5% within the MAR group. Second, MAR-conceived children are more likely to be born to mothers with a university degree, with the gap varying between about 10 percentage points in the UK to as much as 40 percentage points in the US. Third, MAR-conceived children are disproportionally likely to be born within a marriage, with wide variations by country – Denmark has a gap of about a mere 3 percentage points and the US of 33 percentage points. Fourth, MAR-conceived children are systematically more likely to be

first born. This pattern is consistent across all countries, with the difference between MAR and NC ranging between around 11 percentage points in Spain and 27 percentage points in the UK.

[TABLE 1 ABOUT HERE]

Regression results

Figure 2 below displays, for each of the five countries, the predicted probabilities [with 95% confidence intervals (CIs)] of having a child born following a MAR conception for mothers with a university degree (blue markers) and those having less than a university degree (orange markers). Full results are presented in Supplemental Material A: Supplemental Tables 3-7. Within each country panel, the point estimates on the left refer to baseline models and those on the right to adjusted models, as defined above. The upper panel reports predicted probabilities by maternal educational status for the whole sample of births; the middle panel only for first births; the lower panel for second or higher-order births.

Among all live births (upper panel) and across countries, mothers having a university degree have a higher chance to give birth after MAR, and this result holds in both unadjusted and adjusted models. The exception is the UK, where after adjusting for covariates we do not find educational differences in women's likelihood of giving birth to a MAR child. Among firstborns (middle panel, adjusted models), mothers having a university degree have a higher chance to give birth after MAR. Yet, this pattern loses statistical significance when we adjust for the basic covariates in France (Less than university $\beta = 0.086$, 95% CI 0.093, 0.078; University $\beta = 0.077$, 95% CI 0.082, 0.072), Spain (Less than university $\beta = 0.015$, 95% CI 0.18, 0.003; University $\beta = 0.015$, 95% CI 0.022, 0.009), and the UK (Less than university $\beta = 0.067$, 95% CI 0.079, 0.055; University $\beta = 0.050$, 95% CI 0.059, 0.041). Among second or higher-order births (lower panel), university educated mothers are more likely to have a MAR child in all countries except for the UK and France, where we observe no meaningful statistical differences after covariate adjustment.

[FIGURE 2 ABOUT HERE]

To provide an alternative scale of the disparities in births due to MAR, Figure 3 displays bars reporting the relative overrepresentation of university educated mothers giving birth after MAR relative to those mothers having less than a university education. Over each pair of bars, a horizontal line illustrates whether the unadjusted (purple bars) and adjusted (yellow bars) relative overrepresentation estimates are statistically different from each other.

In the unadjusted models, all countries display a gradient in MAR births, with university educated mothers more likely to give birth after MAR (all births: Denmark 55%; France 53%; Spain 79%; UK 44%; US 465%). After adjustments, three distinct country patterns emerge. First, even after adjusting for the basic controls, the US shows a remarkable amount of overrepresentation of highly educated mothers giving birth after MAR (175% for all births, 48% for firstborns, 208% for second or higher-order born; adjusted models). Second, the UK and France show no clear pattern of overrepresentation. Differences tend not to be statistically significant in the UK if we compare across parities, while in France the overrepresentation observed among all births becomes negligible or non-significant when we stratify the analyses by parity. Third, the remaining countries lay somewhere in the middle. In both Denmark (30% for all births, 24% for first births, 16% for second or higher-order births) and Spain (39% for all births, 9% for first births, 73% for second or higher-order births), MAR children are significantly (only all births and second or higher-order parity) and substantially more likely to be born to university educated mothers.

[FIGURE 3 ABOUT HERE]

Supplementary analyses

We performed a number of supplementary analyses. First, since education may be correlated with maternal age – especially among younger mothers – leading to the null educational gradient after adjustment in some countries, we replicated our analyses using an indicator of income. We performed these analyses in all the countries but the US, where the information was not available. For the UK and Denmark, we used income

quintiles; for Spain we had to dichotomize the quintiles due to sample size limitations; and for France we used survey-specific income bands. For Spain and France, we performed the analyses for a subset of observations for which income data were available. We find that families with a higher income are more likely to have a MAR child, and that the association persists after adjustment for covariates. The findings corroborate the notion of a robust socio-economic gradient in MAR across all contexts. Regression results are reported in Supplemental Tables 8-11 in Supplemental Material A. For the US, we replicated the analyses for mothers over 30 years of age – as after this age it is very unlikely for a woman to gain additional educational qualifications. The results are fully consistent and they are reported in Supplemental Table 12 in Supplemental Material A.

Second, there is evidence that the US data underreports births from assisted reproductive technologies (21), which we found support for in our study. When we compared the number of ART born in the NVSS with those from the National ART Surveillance System (NASS) 2019 report (27), we found an underrepresentation in line with previous studies (9) (58.32% report rate). Given the underreporting of births from ART, we conducted sensitivity analyses similar to Tierney and Cai (9), for subgroups for which there is evidence of a better ART reporting: infants with birth weight under 1,500 grams; infants born below the 32nd week of gestation; triplets or higher multiple births; and deliveries from mothers 45 years or older (20). We replicate the analyses using as an outcome both whether the mother had a child after MAR – as in the main analyses – as well as if the mother had a child after ART – a more restrictive definition including only births from treatments entailing in vitro handling of gametes or embryos. Supplemental Table 13 in Supplemental Material A reports the results across all these subgroups, and they are fully consistent with those reported on the full sample.

Third, since we use disparate data sources and the US data have a degree of underreporting of ART, we combine results from Figure 3 with the same ratios computed for results displayed in Supplemental Table 13 in Supplemental Material A. We observe that the US, regardless of the sample or subsample considered, systematically shows the highest overrepresentation of university educated mothers in giving birth to MAR children (Supplemental Figure 1 in Supplemental Material A).

Discussion

In this study, we have used high-quality data to investigate the educational gradient in MAR births in five high-income countries with different institutional arrangements. Unadjusted results show a consistent educational gap across all the countries considered. University educated mothers are disproportionally more likely to have a MAR child. When models include adjustments for maternal age and partnership status, the magnitude of the coefficients systematically reduces in size. Nevertheless, they retain statistical and substantive significance in all countries except for the UK, to some extent Spain when we stratify for first order parity, and France where it disappears when we stratify the analyses by parity.

The results of this study seem to point towards two main findings. First, institutional barriers may matter in shaping women's chances to have a child after MAR, as suggested by the finding that educational differences are larger in the US when compared with the other countries. Among the countries included in this study, the US is the only one without a wide state-subsidized scheme regulating access to MAR treatments, and this may translate in larger educational differences in the probability of having a MAR conceived child. State-based funding schemes that facilitate access to MAR may therefore play an important role in reducing socio-economic disparities in MAR births.

Second, despite state-subsidized funding of MAR in the other countries, they still show educational disparities in MAR births, suggesting that the gradient is not solely explained by the subsidization of MAR treatments. The mechanisms are likely to be multifactorial. On the one hand, the fact that the educational gradients fully (UK, France if stratified by parity) or partially (rest of the countries) attenuate when adjusting for partnership status at birth and maternal age could suggest that the educational gradient is explained by differences in needs – i.e. highly educated women postpone childbearing to ages characterized by higher levels of subfertility (28) – and/or by differences in access requirements, since in many contexts being in a

stable relationship is a prerequisite for access (Supplemental Table 1 in Supplemental Material A). On the other hand, since partnership and age at birth are strongly socially patterned and could reflect other processes, this interpretation requires caution.

Additionally, we believe there may be many other factors underlying educational differences in MAR births, which relate to the probability of MAR treatment success, access to MAR, preferences, or resources. Regarding success of MAR treatment, highly educated mothers may be more likely to undergo treatments in private clinics, thus avoiding long waiting times for referrals to publicly funded MAR. Additionally, they have on average better health (29) and are more likely to avoid unhealthy behaviours and to comply with medical advice (30); thus increasing their chances of a successful MAR treatment. Mothers from different socio-economic backgrounds may also have different preferences regarding fertility, and the number of children they want to have (31, 32). Such differences in preferences may translate into differences in seeking treatment and ultimately into stratification by SES of the chances of having MAR births. Finally, resources derived from belonging to a certain socio-economic group may influence both access to and success of MAR. Higher income availability may enable women to seek MAR treatment after the state-subsidized age deadline has been reached, thus extending the time a woman has to conceive. Workplace flexibility associated with a higher SES position may allow women to attempt more treatments, which often require multiple visits at the fertility clinic and repeated time taken off from work. Living in a large urban centre may also facilitate access to MAR, as long commuting times may be necessary if living in rural areas (33). With respect to access to resources, we provide some related evidence, as our supplementary analyses show that MAR children are more likely to be born to higher income families before and after adjusting for covariates in all the contexts for which information was available.

Limitations

This work is not free of limitations. The first limitation of the paper is inherent to the fact we compare different data sources. The five selected contexts differ to some extent as regards the type of data, the period covered, the types of variables available, the amount of missing information, the types of MAR techniques that can be singled out, sample sizes, and the degree of disaggregation allowed by the data. However, we have undertaken extensive efforts in harmonizing the data and making them comparable.

Second, to maximise cross-country comparability, we have adopted a strategy in which we take the lowest common denominator in the conceptualization and operationalisation of variables. Also, we focus on educational gradients in MAR births – disregarding gaps in access to MAR and in pregnancy success after various numbers of attempts, since this information is not available for all countries – and we group together all available MAR techniques even though these are not the same across the five settings. We cannot distinguish either which MAR-conceived births take place in the public vs. private healthcare sector, nor can we identify cross-border treatments. All these challenges to complete comparability urge data collection agencies to intensify their efforts for including more detailed information on MAR in a way that facilitates cross-country comparisons.

Third, we acknowledge that the NVSS US birth register underreports MAR births, and that these results may be more representative of US states such as Utah, Wisconsin, and Oregon, which have a better reporting, and less of others such as Florida, Indiana, and Texas (including Tennessee and South Carolina, for which MAR data are missing) (20). Similarly, these results are more likely generalizable to population groups with better ART data quality, such as high-risk groups as we mentioned in the supplementary analyses section (20, 21). Reassuringly, multiple estimations on subsamples with better ART reporting are consistent: all these results display an overrepresentation of university educated in delivering MAR births, and these estimates are systematically higher than estimates from the other countries analysed. Moreover, since other data such as SART or NASS are not publicly available, there are not many other options for this kind of research. Despite these limitations, we believe that it is highly unlikely that the large differences that we observe between the US and the rest of the countries are largely explained by the underreporting issues that the US data are subject to.

Conclusion

A policy implication of our findings has to do with how to tackle inequities in access to and/or successful use of publicly provided/funded assisted reproduction. Our results seem to suggest that the social gradient tends to be more marked in contexts where costs are high and/or public coverage is limited, such as the US. This suggests that prioritisation mechanisms in public provision should be thoroughly reconsidered, possibly explicitly favouring women/parents with fewer socioeconomic resources. Co-payment schemes in the public system could also be conceived for parents in more advantaged economic situations. Longer time to pregnancy, which might be an indicator of sub-fecundity and/or its underlying causes, has evident implications in terms of stress, which in turn correlate with chances of treatment success. Longer times to pregnancy have also been shown to correlate with children's neurodevelopmental delays and difficulties (34), so addressing waiting times until (successful) treatment is granted in the public system is a key issue.

Nonetheless, the existence of educational gradients even in contexts in which a solid public-funded provision of MAR is available, such as Denmark, reinforces the notion that financial constraints are just one piece of the puzzle and that more comprehensive accounts of different types of access barriers (e.g., geographical, cultural), including those regarding preferences, are called for. This necessarily requires more systematic and comprehensive data collections at the national level and more intense attempts to harmonise them across countries to promote comparative research.

Our results also have the potential to be relevant for the analysis of reproduction of intergenerational social inequalities. In the current context in which more resourceful families are overrepresented in MAR births, the potential adverse birth outcomes that MAR children more frequently face – low birth weight, prematurity – and the implications of these for later health and development are expected to be at least partially compensated by these families' greater parental resources (35). If access to and successful use of MAR becomes more homogeneously distributed across social backgrounds, then there is a risk that children from families with fewer resources might be disproportionally influenced by negative birth outcomes and their related consequences. Research available so far suggests that some of the potential disadvantages faced by MAR-conceived babies are diminishing over time thanks to advances in neonatal and obstetric practice (36). This overall improvement is however compatible with adverse consequences being unequal across the various social backgrounds.

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Authors' roles

LS conceived the study. All authors were involved in the design of the study, data interpretation, drafting of the manuscript and revisions of the manuscript. PF conducted the analyses for Denmark; MC conducted the analyses for the US; AG conducted the analyses for the UK; MS conducted the analyses for Spain; TE conducted the analyses for France. All authors have made a substantial contribution to the paper (author order has been randomized) and have approved the final manuscript.

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Figures Legends

Figure 1 Legend

Figure 2 Legend

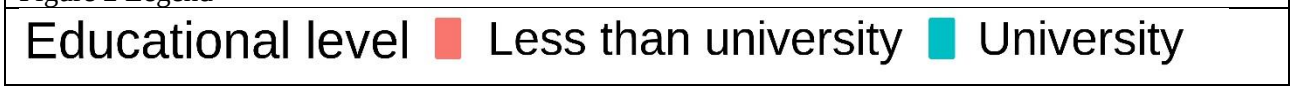

Table 1. Descriptive statistics in the five countries

	Denmark		France		Spain		United Kingdom		United States	
	NC	MAR	NC	MAR	NC	MAR	NC	MAR	NC	MAR
Maternal age at birth										
24 or less	10·7	2·3	17	5·1	9·9	0·2	18·5	3·3	23·9	2·1
25-29	35·6	20·4	33·2	27·4	26·2	6·4	30·2	24·1	29·1	13·5
30-34	35	37·1	32·2	36·8	37	28·8	33·3	37·7	28·9	34·6
35-39	15·4	27·9	14·6	23·8	22·8	45·2	15·8	28·5	14·9	33
40+	3·3	12·3	3	6·9	4·2	19·5	2·3	6·4	3·2	16·7
Mother's level of education										
University	48·7	60·7	49·5	61·3	41·8	65·3	34·8	43·8	41·1	81·3
< University	51·3	39·3	50·5	38·7	58·2	34·7	65·2	56·2	58·9	18·7
Mother's partnership status at birth										
Married	48·5	51·9	45·5	58·1	75·9	80·5	62·7	85	59·1	91·9
Cohabiting	44·3	37·2	47·8	40·2	16·2	14	24·5	11·6	NA	NA
Single	7·1	10·9	6·7	1·7	7·9	5·5	12·8	3·3	40·9[#]	8·1[#]
Parity										
First born	48·3	66·5	42·1	62·5	54·5	65·9	37·2	64·3	37·4	50·8
Second + born	51·7	33·5	57·9	37·5	45·5	34·1	62·8	35·7	62·6	49·2
%	90·9	**9·1**	94·5	**5·5**	96·2	**3·8**	96·6	**3·4**	98	**2**
N	55,950	5,614	35,460	2,073	12,402	487	16,581	518	3,626,293	74,149

Note: [#]This refers to unmarried, as the US registers do not report cohabitation, the figure also does not include those with missing information on marital status, which are included in the regression analyses in a specific “unknown” category.

Abbreviations: NC = naturally conceived; MAR = Medical assisted reproduction.

Column percentages.