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Educational gradients in the prevalence of Medically Assisted Reproduction (MAR) births in a comparative perspective

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Alice Goisis, Peter Fallesen,
Marta Seiz, Leire Salazar, Tatiana Eremenko, Marco Cozzani

Joint Research Centre

Contact information
Name: Leire Salazar
Address: Joint Research Centre, European Commission (Seville, Spain)
Email: Leyre.SALAZAR-VELEZ@ec.europa.eu

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Educational gradients in the prevalence of Medically Assisted Reproduction (MAR) births in a comparative perspective

Goisis Alice (Centre for Longitudinal Studies, Social Research Institute, University College London), Peter Fallesen (ROCKWOOL Foundation, Copenhagen; Swedish Institute for Social Research, Stockholm University), Marta Seiz (Department of Sociology II (Social Structure), UNED), Leire Salazar (Joint Research Centre, European Commission, Seville), Tatiana Eremenko (Department of Sociology and Communication, University of Salamanca), Marco Cozzani (Department of Statistical Sciences, University of Bologna); Author order was randomized using the AEA Author Randomization Tool - Date entered: 2022-11-11 05:25:40, Confirmation code: 6iL1mnORUq9E.

Abstract

A handful of studies from individual countries have shown that parents of Medically Assisted Reproduction (MAR)-conceived children are more likely to have, relative to parents of naturally conceived (NC) children, higher socioeconomic status. Yet, a comparative perspective is lacking. In this paper we assess the extent to which children conceived after MAR are more likely to be born to socioeconomically advantaged mothers, measured through their level of education, and whether the gradient varies across countries with different institutional contexts, specifically Denmark, France, Spain, United Kingdom, and the United States, using national representative data and applying Linear Probability Models. Children of socioeconomically advantaged mothers are more likely to have been conceived after MAR across all contexts prior to adjustment for covariates. After adjustment, however, educational differences fully attenuate in France and the United Kingdom.

Keywords: Medically Assisted Reproduction, population-based studies, social inequality, comparative perspective

Authors: Goisis Alice (Centre for Longitudinal Studies, Social Research Institute, University College London), Peter Fallesen (ROCKWOOL Foundation, Copenhagen; Swedish Institute for Social Research, Stockholm University), Marta Seiz (Department of Sociology II (Social Structure), UNED), Leire Salazar (Joint Research Centre, European Commission, Seville), Tatiana Eremenko (Department of Sociology and Communication, University of Salamanca), Marco Cozzani (Department of Statistical Sciences, University of Bologna)

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Executive summary

STUDY QUESTION: To what extent are children conceived after Medically Assisted Reproduction (MAR) more likely to be born to socioeconomically advantaged mothers, and does the gradient vary across countries with different institutional contexts (Denmark, France, Spain, United Kingdom, United States)?

SUMMARY ANSWER: Live births resulting from MAR are more common among socioeconomically advantaged women and this gradient varies between countries. Differences are the largest in the United States, with the rest of the countries showing a similar gradient.

WHAT IS KNOWN ALREADY: A handful of studies from individual countries have shown that parents of MAR-conceived children are more likely to have, relative to parents of naturally conceived children, higher socioeconomic status. Yet, a comparative perspective is lacking.

STUDY DESIGN, SIZE, DURATION: Population-level data for the United States (2019) and Denmark (2018) comprising all live births. National perinatal survey including singletons born in a given week in 2003, 2010, and 2016 for France. Millennium Cohort Study for the United Kingdom including children born between 2000-2001. Spanish Fertility Survey from Spain (2018) with retrospective fertility histories starting in 1988.

PARTICIPANTS/MATERIALS, SETTING, METHODS: This study includes an overall sample of about 3.9 million live births. This is divided as N=61,983 for Denmark, N= 38,655 for France, N=12,889 for Spain, N= 17,097 for the United Kingdom, and N=3,754,132 for the United States. We used Linear Probability Models to estimate the association between maternal education, our indicator of socioeconomic status, and the probability that a live birth is the result of a MAR conception, before and after adjustment for age at delivery and marital/partnership status.

MAIN RESULTS AND THE ROLE OF CHANCE: Children of socioeconomically advantaged parents are more likely to have been conceived after MAR across all contexts prior to adjustment for covariates. After adjustment, educational differences fully attenuate in France and the United Kingdom.

LIMITATIONS, REASONS FOR CAUTION: The different data sources do not ensure full comparability across countries as they refer to different time points.

WIDER IMPLICATIONS OF THE FINDINGS: This study highlights how different policy settings are associated to different degrees with socioeconomic inequalities in access to MAR. In a global context of increased fertility postponement, large disparities in access to MAR may result in poorer fertility outcomes for mothers with low levels of socioeconomic resources.

1 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 (Zegers-Hochschild et al., 2017) – to realize their fertility intentions. As fertility rates decline, due to a preference for a small(er) offspring, childbearing postponement or other reasons, the recourse to MAR has increased very markedly and it has intensified most notably in Europe, Asia (particularly Japan) and North America (Adamson et al., 2022).

The economic costs of MAR – which depend on public coverage and vary substantially across societies (McCarthy-Keith et al., 2010) – as well as other barriers to access such as normative and cultural factors (Präg & Mills, 2017), suggest the existence of a socioeconomic gradients in use. A handful of studies from single countries have consistently shown that parents of children conceived through MAR are more likely to have higher socioeconomic positions – measured in various ways, depending on available information in the national data sources – relative to parents of naturally conceived (NC) children. Evidence thus far has been mostly focused on Finland (Klemetti, Gissler, Sevón, & Hemminki, 2007; Räisänen et al., 2013), the United States (Stephen & Chandra, 2000; Wilcox & Mosher, 1993) and Norway (Goisis, Håberg, Hanevik, Magnus, & Kravdal, 2020).

Cross-country research drawing on comparable measurements to investigate whether socioeconomic gradients are moderated by different contexts is important, as it allows to better understand contextual barriers to the realization of desired fertility. Yet, heterogeneity among studies regarding the methodologies, socioeconomic indicators – whether income, educational levels or other measures – and outcome variables used make it difficult to quantify whether socioeconomic differences[1] in MAR births are more pronounced in some contexts rather than others.

In this paper, we investigate whether children born after MAR treatments are more likely to have socioeconomically advantaged parents when compared to NC children, and if these differences vary across countries with diverse institutional settings. We go beyond existing contributions, focused on single countries, and consider five high-income nations – Denmark, France, Spain, the UK, and the US – with high-quality data, different proportions and growth trajectories of MAR-conceived births in the last years, and diverse legal frameworks facilitating or hindering access to MAR. We expect to observe smaller socioeconomic gaps, in particular narrower educational gradients in the prevalence of MAR vis-à-vis NC births, as we move to national contexts with broader public coverage of MAR and fewer access restrictions.

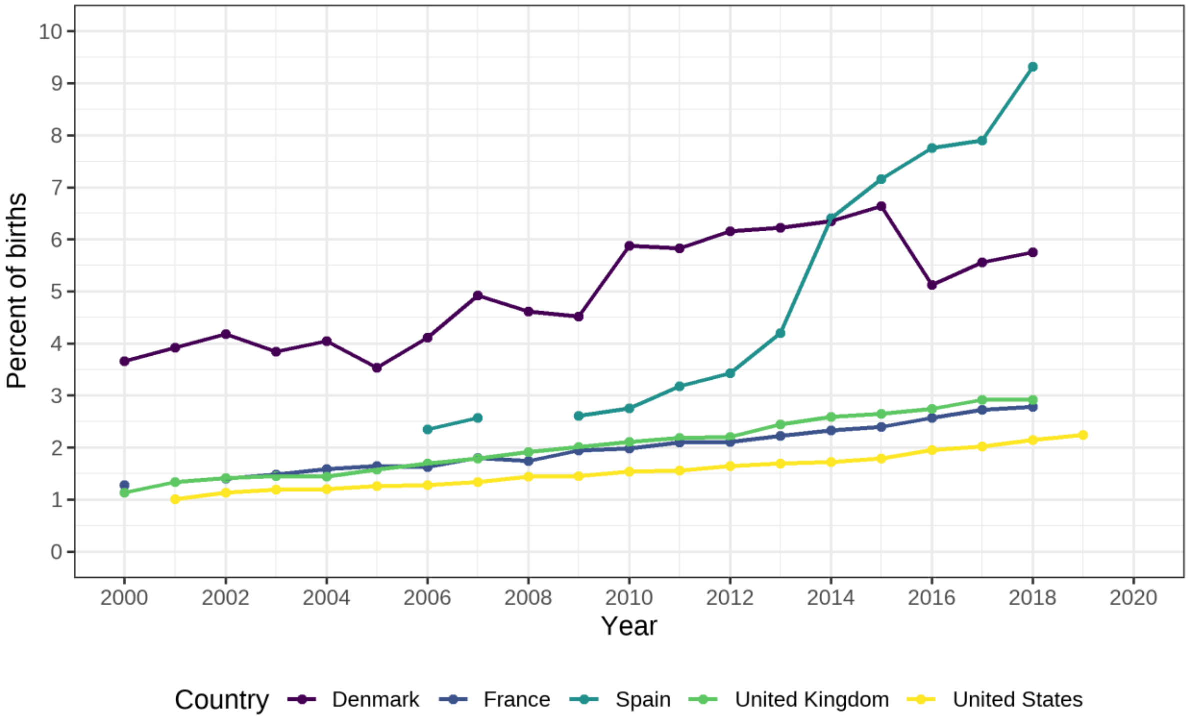
2 Use of MAR in selected high-income countries

The term MAR is defined as: "Reproduction brought about through various interventions, procedures, surgeries and technologies to treat different forms of fertility impairment and infertility. These include ovulation induction, ovarian stimulation, ovulation triggering, all ART procedures, uterine transplantation and intra-uterine, intracervical and intravaginal insemination with semen of

1 Throughout the paper, we use the terms socioeconomic/social differences, gradients and gaps indistinctly because the literature has relied on different indicators of parental socioeconomic position depending on available information in each data source. For instance, in the Finnish case that counts on administrative/register data, maternal occupation has been extensively used (Klemetti, Gissler, Sevón, & Hemminki, 2007; Räisänen et al., 2013). In the US, with survey data, maternal education and income have been often chosen (Stephen & Chandra, 2000; Wilcox & Mosher, 1993). The Norwegian case has relied on parental income and maternal level of education as the main indicators (Goisis, Håberg, Hanevik, Magnus, & Kravdal, 2020). The gradients might differ in size with the use of alternative indicators – education, occupation, earnings, income, social status, social class – and when considering just the mothers or also partners, when there is one. However, in this paper and because of the need to harmonize very different national data sources, we need to disregard these issues and resort to a lowest common denominator approach in measurement matters, as will be explained below.

husband/partner or donor." (Zegers-Hochschild et al., 2017). The number of infants specifically born after the use of Assisted Reproduction Technologies (ART) – MAR treatments entailing in vitro handling of gametes or embryos – has increased in all five countries since 2000 (Figure 1). 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). Further details on access to and use of various MAR treatments over time across countries and its main drivers can be found elsewhere (Seiz, Eremenko & Salazar, 2023).

Figure 1: Births due to ART (%) in Denmark, France, Spain, the UK and the US since 2000.



<u>Source</u>: European IVF-Monitoring Consortium (EIM) (ART births in Europe). Eurostat (live births in Europe). Centres for Disease Control and Prevention (ART births and live births in United States). Note: Reporting for Spain is not complete (some clinics do not provide statistics on their activity), meaning the actual number of ART births may be even higher. These estimates do not include births after artificial insemination (AI), as information on these treatments is inexistent or incomplete in many contexts. In Denmark and Spain, which receive an important number of cross-border reproductive care patients, this indicator may over-estimate the proportion of ART births as some take place in the mothers' country of residence. This mismatch happens because clinics report births due to treatments held in their sites leading to successful pregnancies, regardless of the place of origin of the mother and the place of birth of the baby.

3 A varied legislative and policy framework

The five countries covered in the study show a notable degree of variation in terms of: (a) the legal status of existing treatments, (b) access requirements for mothers/couples, and (c) the generosity of public provisions. Table A1 in Appendix A summarises the current fundamental features of each country and the main regulatory changes that have taken place in the period broadly covered in our analyses.

During the 1980s and 1990s, most countries developed detailed regulations for artificial insemination (AI), in vitro fertilization/intracytoplasmic sperm injection (IVF/ICSI) and treatments with donor gametes. These normative frameworks were subsequently amended throughout the early 2000s, with

France and Spain also introducing some modifications in 2021 (see specific legislation in Table A1 in Appendix A). The US is an exception characterized by a lack of comprehensive regulation, with treatments being offered based on professional guidelines, and state-level norms regulating general aspects of medical practice. This entails wide cross-state variations in terms of the techniques provided (Frith & Blyth, 2014).

There is also variability in access requirements. France stands out as the latecomer in providing access to MAR for single women or couples consisting of two women, having granted it only in 2021. Whereas in Denmark, Spain and the UK, equal treatment regardless of marital/partner status and sexual orientation was established substantially earlier (2006, 2006 and 2008, respectively; see Mohr & Koch, 2016 and the national legislations cited in Table A1 in Appendix A). The US is, again, an exceptional case given existing disparities in practice across states. Still, the American Society for Reproductive Medicine advocates equal treatment regardless of partnership status, and some states enforce it as a legal right (ESHRE, 2003; Frith & Blyth, 2014).

Regarding the generosity of the public health system in terms of funding access to treatments, differences appear in three dimensions: a) the number of cycles that are allowed; b) the degree to which different treatments are offered; and c) age limitations. For example, regarding IVF, Denmark and France provide the least restrictive schemes. In Denmark, three fresh IVF-transfers (or 5 started cycles) and an unlimited amount of frozen embryo replacement transfers (FER) are offered to childless women residing in Denmark until age 40 (ESHRE, 2017). In France, up to four in vitro fertilisation-embryo transfer (IVF-ET) cycles are publicly funded for women until age 43, with the possibility of four further cycles for a second child after the first pregnancy. Spain and the UK perform three IVF cycles on women under 40, although there are regional variations in the case of the UK, while Spain establishes limitations for women with poor ovarian reserve or who already have children (see legislation and references in Table A1). In the US there is, again, marked variability in public coverage across states (Frith & Blyth, 2014).

We overall expect to identify the greatest social gradients in the prevalence of MAR vis-à-vis NC births in contexts with more restrictive access requirements and public provision. Among the five countries that we analyse, we therefore anticipate that the US should stand out as displaying lower MAR births amongst women with a low socioeconomic position, and the widest social gap.

4 Materials and methods

4.1 Data sources and samples

We draw on high-quality representative national datasets, coming from both administrative registers, cohort studies, and 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 years analysed being slightly different across contexts. Table A2 in Appendix A synthetises the main features of all datasets.

For Denmark, we use data from the Danish Population Register together with data on all births from the Danish Fertility Database (Knudsen, 1998) and information on MAR treatments from the Danish National Register of Assisted Reproduction Techniques (Jølving, Erb, Nørgård, Fedder, & Larsen, 2021), 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 data 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 (Blondel & Kermarrec, 2011; Coulm, Bonnet, & Blondel, 2017). 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 use information on women sampled in the Spanish Fertility Survey (Encuesta de Fecundidad) for 2018 (see Esteve et al., 2021), which is 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.

For the UK, we use data from the Millennium Cohort Study (Connelly & Platt, 2014; Plewis, Calderwood, Hawkes, Hughes, & Joshi, 2007), 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). 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-NCHS covering all US birth certificates for children born in 2019 (Martin, Hamilton, Osterman, & Driscoll, 2019). 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.

Ethical approval is granted by national data producers.

4.2 Variables and definitions

The dependent variable is a binary indicator of whether the birth resulted from a MAR or natural conception. We do not distinguish between specific MAR techniques, nor the number of cycles undergone in order to make results as comparable as possible across countries.

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, which is operationalized differently across datasets, by distinguishing mothers having a university degree – ISCED level 5 or higher – from the rest (for the US, we also include a category for unknown level of education). 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 also because of the more stable occupational situation and higher socioeconomic status of older individuals accessing fertility in these settings. 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.

4.3 Statistical analyses

Separately for each country, we estimate Linear Probability Models (LPMs) predicting the 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. We use LPM to ensure comparability of estimates across regressions for each country (Mood, 2010). This result constitutes the baseline quantification of the extent to which a socioeconomic 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 (Goisis, Remes, Martikainen, Klemetti, & Myrskylä, 2019; Lazzari, Gray, & Chambers, 2021) the models were conducted on all births and then separately for first and second or higher order births.

5 Results

5.1 Descriptive statistics

Table 1 displays the descriptive statistics of the analytical samples by country and mode of conception: NC vs. MAR; 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: *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		
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

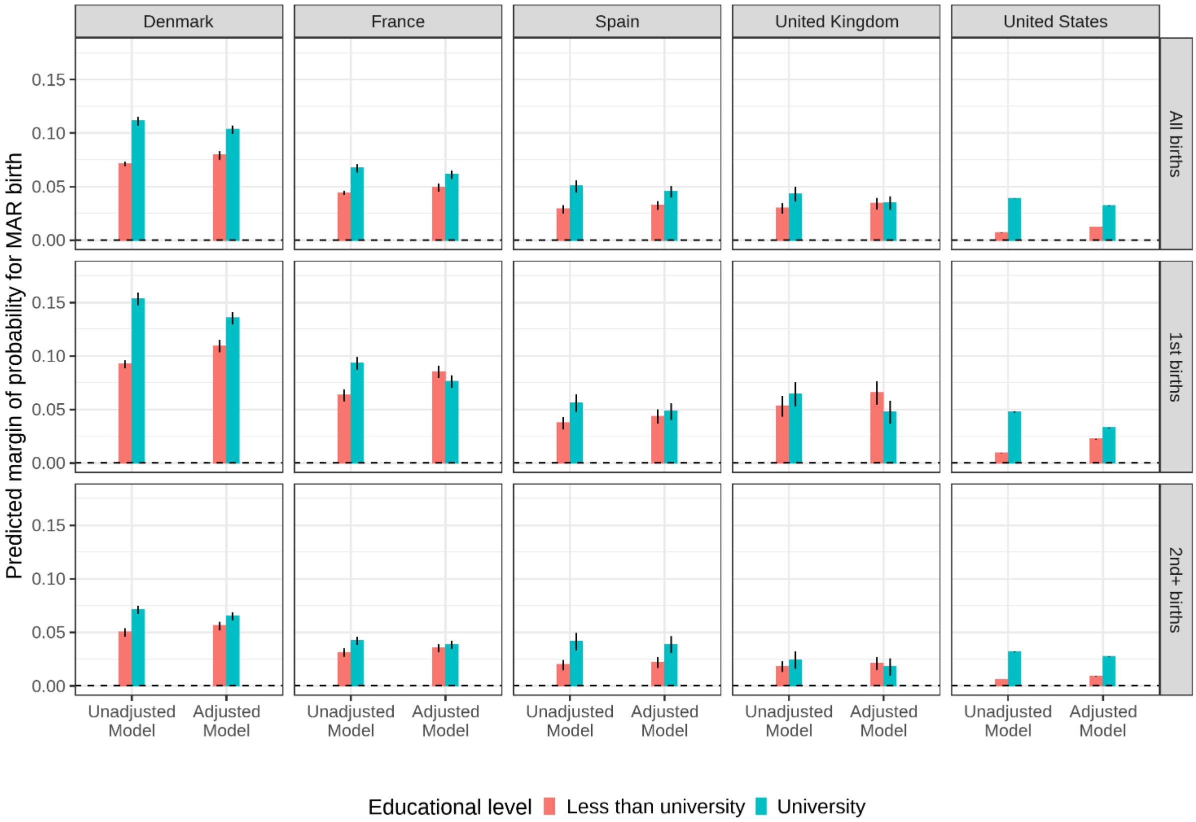
Note: #This refers to unmarried, as the US registers do not report cohabitation, the figure also does not include those with missing information on marital status, which are included in the regression analyses in a specific "unknown" category. Abbreviations: NC = naturally conceived; MAR = Medical assisted reproduction. Column percentages. The data cover births in 2018 in Denmark, pooled births in 2003, 2010 and 2016 in France, pooled births between 1998 and 2018 in Spain, births in 2000-2002 in the UK, and births in 2019 in the US. Further details on the data sources in Table A2 in Appendix A.
Source: Authors' calculations from the national datasets.

5.2 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 Appendix A: Tables A3-A7. 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, MAR-conceived children have a higher probability of being born to a mother having a university degree, and this result holds in both unadjusted and adjusted models. The exception is the UK, where after adjusting for covariates, we do not find differences in MAR-conceived children's likelihood of being born to a mother with a university degree versus one without it. Among firstborns (middle panel, adjusted models), MAR-conceived children are generally more likely to be born to university educated mothers. Yet, this pattern loses statistical significance when we adjust for the basic covariates in France (Less than university β = 0.085, 95% CI 0.091, 0.079; University β = 0.076, 95% CI 0.082, 0.070), Spain (Less than university β = 0.043, 95% CI 0.05, 0.037; University β = 0.048, 95% CI 0.056, 0.040), and the UK (Less than university β = 0.065, 95% CI 0.076, 0.055; University β = 0.047, 95% CI 0.058, 0.037). Among second or higher-order births (lower panel), the pattern is similar. MAR-conceived children are more likely to be born to university educated mothers in all five countries except for France and the UK, where we observe no meaningful statistical differences.

Figure 2: Predicted probabilities of having a MAR-conceived child across educational levels, by country and parity (95% confidence intervals).



Note: Predicted probabilities obtained by Linear Probability Models. Adjusted models include maternal age, maternal marital/relationship status, parity (only for all births models) and year (in countries with more than one data draw). University indicates ISCED level ≥ 5. 95% confidence intervals for US are very small due to large sample size. The data cover births in 2018 in Denmark, pooled births in 2003, 2010 and 2016 in France, pooled births between 1998 and 2018 in Spain, births in 2000-2002 in the UK, and births in 2019 in the US. Further details on the data sources in Table A2 in Appendix A.
Source: Authors' calculations from the national datasets.

To provide an alternative scale of the disparities in births due to MAR, Figure 3 displays bars reporting the relative overrepresentation of MAR children born to university educated mothers relative to those born to 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 an educational gradient in MAR births, with MAR children more likely to be born to highly educated mothers (all births: Denmark 53%; France 52%; Spain 74%; 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 MAR children among highly educated mothers (180% 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, 11% for first births, 113% for second or higher-order births), MAR children are significantly (only all birth and second or higher-order parity) and substantially more likely to be born to university educated mothers.

Figure 3: Relative differences: Overrepresentation of children born after MAR among university educated women (ISCED level ≥ 5) by country.

Note: Relative overrepresentations obtained by dividing the predicted probability of having a MAR child for women with a university education by the probability of having a MAR child for those with less education. Adjusted models include maternal age, maternal marital status, parity (only for all births models) and year (in countries with more than one data draw). Over-bar horizontal line reports whether estimates between adjusted and baseline models are statistically different. The data cover births in 2018 in Denmark, pooled births in 2003, 2010 and 2016 in France, pooled births between 1998 and 2018 in Spain, births in 2000-2002 in the UK, and births in 2019 in the US. Further details on the data sources in Table A2 in Appendix A.
** $p < .05$; ** $p < .01$; *** $p < .001$*
Source: Authors' calculations from the national datasets.

Full models on which Figure 2 and Figure 3 draw are shown in Appendix A, Tables A3-A7. Taken together, these results are consistent with previous evidence for single-country analyses documenting socioeconomic gradients in MAR births, but in addition they suggest the existence of substantial variation across institutional settings. In particular, our expectation that the US, as the most extreme case of restrictive access requirements and stringent public funding in our sample, should display the most notable social gradient receives empirical support. We come back to this point in the Discussion section.

5.3 Supplementary analyses

We test whether our main results are robust to the use of alternative indicators of socioeconomic position such as those based on financial resources. In addition, education may be highly correlated with marital status and maternal age – especially for MAR births – leading to the null educational gradient after adjustment in some countries, hence the appropriateness of performing the analyses using other variables such as income. With this double aim in mind, we replicate our analyses in all the countries except the US, where the information on income is not available. For the UK, Spain, and Denmark, we use income quintiles, and for France we use pre-determined income bands available in the survey. For Spain and France, we perform the analyses for a subset of observations for which income data are available. We find that MAR children are more likely to be born to families with a higher income, 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. Results are reported in Tables A8-A11 in Appendix A.

6 Discussion

In this study, we have used high-quality data to investigate the social gradient in MAR births in five high-income countries with various institutional arrangements. Unadjusted results show a marked and consistent educational gap across all the countries considered. Children born after MAR are disproportionally more likely to have mothers with a high level of education. When models include adjustments for maternal age and partnership status, the magnitude of the coefficients systematically reduces in size, but it retains statistical and substantive significance in all countries except for France and the UK, where the initial small gap becomes negligible.

The results of this study point towards two findings. First, institutional barriers matter considerably in shaping women's chances to have a child after MAR, as revealed by the disproportionate difference between the US and 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 it translates in the largest educational differences in the probability of having a MAR conceived child and in the lowest probabilities of having a MAR-conceived child among women with lower levels of education (i.e. those with fewer socioeconomic resources). State-based funding schemes that facilitate access to MAR seem therefore to 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 educational gradient in MAR births is not solely explained by the subsidization of MAR treatments. The mechanisms are likely to be multifactorial and unfortunately an explicit empirical test cannot be undertaken with the data at hand. On one side, the fact that the educational gradients fully (France, UK) or partially (rest of the countries) attenuate when adjusting for partnership status at birth and maternal age could suggest that the educational gradient is partially explained by differences in needs – i.e. highly educated women postpone childbearing to ages characterized by higher levels of subfertility (Mills, Rindfuss, McDonald, & Te Velde, 2011) – and/or by differences in access requirements, since in many contexts being in a stable relationship is a prerequisite for access (Table A1 in Appendix A). On the other side, this interpretation requires caution, since partnership and age at birth are strongly socially patterned and could reflect other processes.

Additionally, we believe there may be many other explanations underlying educational differences in MAR births, which relate to the actual need and preferences in seeking MAR, as well as obstacles in access and treatment success. Mothers from different socio-economic backgrounds may have different preferences regarding fertility, and the number of children they want to have (Jalovaara et al., 2019; Mynarska, Matysiak, Rybińska, Tocchioni, & Vignoli, 2015). Differences in preferences may translate in differences in seeking treatment and ultimately in chances of having MAR births stratified by SES group. The resources 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 socioeconomic 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 (Lazzari, Baffour, & Chambers, 2022). Finally, 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 (Mackenbach, 2006) and are more likely to avoid unhealthy behaviours and to comply with medical advice (Pampel, Krueger, & Denney, 2010); thus increasing their chances of a successful MAR treatment. With respect to access to resources, we provide some related evidence pointing to their relevance for explaining MAR births, 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.

6.1 Limitations

One limitation of the paper is the lack of full comparability of available data across countries. The five selected contexts differ as regards the nature of the data, the period covered – and thus the specific cohorts of women and births included –, 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. None of the datasets used have been devised *ex profeso* to address MAR-related research enquiries, but nonetheless they still offer valuable information on all the phenomena that we intended to study.

In the paper, and 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 only look at social gradients in 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 and data sources. We cannot distinguish either which MAR-conceived births take place in the public vs. private healthcare sector. All these challenges to complete comparability urge data production agencies to intensify their efforts for including more detailed information on MAR and harmonising cross-country data collection, including for countries outside Europe and the US, where access to and use of MAR, together with legislative and policy framework are expected to differ. A final drawback is that we cannot provide an explicit empirical test of the precise mechanisms generating the socioeconomic gap that we observe.

7 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 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 (Magnus, Havdahl, Wilcox, & Goisis, 2022). Addressing waiting times until (successful) treatment is granted in the public system is a key issue for these varied reasons.

Nonetheless, the existence of socioeconomic 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 collection 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 (Pelikh, Smith, Myrskylä & Goisis, 2022) – f.e. 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 (Cozzani, Aradhya, & Goisis, 2021). If access to and successful use of MAR becomes more homogeneously distributed across social backgrounds, then special efforts (antenatal and perinatal care), would need to be made to avoid children from families with fewer resources being disproportionally affected by the possible negative health outcomes and their related consequences due to these treatments. 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 (Goisis, Özcan, & Myrskylä, 2017). This overall improvement is however compatible with adverse consequences being unequal across the various social backgrounds.

8 Data availability

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 are 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).

9 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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12 Appendix A

Table A1: Main characteristics of the legal framework in Denmark, France, Spain, the UK and the US.

	Denmark	France	Spain	United Kingdom	United States
Treatments available					
AI w/donor sperm	No legal regulation until 1997. First sperm bank founded in 1967.	Use of AI with donor sperm spreads since the 1950s. 1973: creation of first sperm banks (*Centres d'etude et de conservation du sperme humain, CECOS*).	No legal regulation until 1988. First sperm bank founded in 1978.	Some use of AI with donor sperm since the 1930s, when the clinical practice of AI was initiated. Legal regulation through the Human Fertilization and Embryology Act (1990).	Minimally regulated; varies across states. In 1973 the Uniform Parentage Act (UPA) acknowledged as fathers men who consented to their wives' AI with donor sperm. Adopted on a state-by-state basis and with varying requirements. In 2000, UPA was extended to non-married couples (not adopted by all states).
IVF/ICSI	First IVF baby in 1983. First ICSI baby in 1994.	First IVF baby in 1982. First ICSI baby in 1992	First IVF baby in 1984. First ICSI baby in 1992.	First IVF baby in 1978. First ICSI baby in 1991.	Large differences among states regarding coverage, implementation of the regulations, and access, but healthcare costs are high. 19 states have some insurance coverage for infertility treatment; only 8 specify that IVF must be covered by insurance to some degree. Generally, coverage is not comprehensive.
Donor oocytes	Yes, since 1994.	Yes, since 1994. Still, limited number of available oocytes due to strict conditions on who can donate and lack of remuneration. This results on many women going abroad for egg donation treatments.	Yes, since 1988.	Yes, since the 1980s. Legal regulation through the Human Fertilization and Embryology Act (1990) and the resulting creation of the Human Fertilization and Embryology Authority, which prohibited gamete commodification. In 2004, it was established that children born through gamete donation would have the right to find out about the identity of their genetic parents at age 18. This	The American Society for Reproductive Medicine's (ASRM) guidelines recommend limiting reimbursement for egg donation (10,000 $ in 2016). Otherwise, widespread lack of general regulation and large cross-state variation in terms, conditions, access and price. Most egg donation treatments take place within a private, commercial context.

	Denmark	France	Spain	United Kingdom	United States
				resulted in relatively low rates of egg donation and long waiting periods.	
PGD	Yes, since 1997 for scientific purposes, and more broadly available in 1999, although it was only allowed in cases of serious hereditary conditions/chromosome abnormalities. Since 2004, also allowed when a donor is needed for a sibling with a serious condition.	Yes, since 1994 for serious and incurable genetic disorders.	Yes. Allowed since 1988 for the embryo's benefit. Permitted more extensively since 2006.	Yes. First used in 1990.	Yes. In most states it is not covered by insurance policies.
Surrogacy	Currently legal only if done altruistically, no AR techniques are used, and the oocytes of the surrogate mothers are used. No targeted legislation regulates the process.	No	No	Only altruistic surrogacy is legal.	No federal law that regulates it. Different state-level regulations.
Access to fertility treatments to single women / female couples (if yes, since when)	Yes, since 2006.	Yes, since 2021 (Law 2 August 2021).	Yes, since 2006.	Yes, since 2008.	The American Society for Reproductive Medicine (ASRM) advocates equal treatment regardless of marital/partner status or sexual orientation. In practice, there are variations across programmes and states. In some states, there is a legal obligation to offer all individuals equal treatment.
Funding scheme (current)	Public funding: 3 fresh IVF-transfers or 5 started cycles. FER transfers are not limited (source: ESHRE 2020). IVF treatments are publicly covered for all involuntarily childless	Public funding: Up to 4 IVF-ET with embryo transfer cycles. And if clinical pregnancy, up to 4 for 2nd child. Women are eligible for publicly funded treatment until age 43.	Artificial Insemination - with partner's sperm: 4 publicly funded cycles; with female age limit; with donor sperm: 6 publicly funded cycles; with female age limit; IVF - 3 publicly funded cycles (with age limit).	3 cycles funded by the National Health Insurance, but considerable geographical variation. Women must be under 40 years old at the time of treatment.	Varies by state (only 17 states have insurance mandates to either cover or offer coverage for those treatments). Who is eligible for treatment also varies across states.

	Denmark	France	Spain	United Kingdom	United States
	women residing in Denmark until age 40.		Long waiting lists and limited resources. IVF not performed if poor ovarian reserve. Number of attempts offered reduced if results are poor. IVF with donor oocytes only accessible to women under certain conditions. A maximum of 3 cycles is offered.		
Main MAR regulations	1997: Law on artificial fertilization in connection with medical treatment, diagnosis, and research (with some amendments through other legal norms in 2004 and 2006).	1994: 1st Law on Bioethics. Revised every ≈ 10 years. Latest change in 2021.	Law 35/1988; Law 45/2003; Law 14/2006; Royal Decree 1030/2006; Order SND/1215/2021.	Surrogacy Arrangements Act 1985; Human Fertilization and Embryology Act 1990; Human Fertilization and Embryology Act 2008.	Lack of comprehensive regulation. ARTs are offered within the framework of professional guidelines and some state-level regulations linked to the regulation of general medical practice. The Fertility Clinic Success Rate and Certification Act from 1992, the CDC, the FDA and the Centers for Medicare and Medicaid Services offer some general oversight at the federal level. Still, wide cross-state variations regarding ART practices.
References	(Busardò, Gulino, Napoletano, Zaami, & Frati, 2014; Casella et al., 2020; Mohr & Koch, 2016; Nordic Council of Ministers, 2006; Piersanti, Consalvo, Signore, Del Rio, & Zaami, 2021)	(Cahen, 2013; de La Rochebrochard, 2003; European Society of Human Reproduction Embryology, 2017)	(Alon & Pinilla, 2021; Busardò et al., 2014; Moya-González & Ramón-Fernández, 2018; Orozco et al., 2013)	(Brinsden & Brinsden, 2009; European Society of Human Reproduction Embryology, 2017; Mohr & Koch, 2016; Nordic Council of Ministers, 2006; Piersanti et al., 2021; Richards, 2016)	(Bayefsky, DeCherney, & Berkman, 2016; Ho et al., 2022; Johnson, 2017; Kawwass, Penzias, & Adashi, 2021; Piersanti et al., 2021; Roche, Racowsky, & Harper, 2021); https://www.ncsl.org/research/health/insurance-coverage-for-infertility-laws.aspx

Note: AI: Artificial Insemination, IVF: In Vitro Fertilization, ICSI: Intracytoplasmic Sperm Injection, PGD: Preimplantation Genetic Diagnosis.
Source: Authors' systematisation from the national sources.

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Table A2: Characteristics of the national datasets used.

	Denmark	**France**	**Spain**	**United Kingdom**	**United States**
Source	Statistics Denmark and the Danish Health Data Agency	National Perinatal Survey	Spanish Fertility Survey	Millennium Cohort Study	CDC-NCHS
Type of data	Administrative population data	Medical records and survey	Survey	Survey	Administrative population data
Universe	All live births to residents in 2018	All singletons born or transferred to maternity wards 13-19 October 2003, 15-21 March 2010[a], and 14-20 of March 2016	Sample of retrospective fertility history as of 2018 (first births dating back to 1988; latest births occurring in 2018)	Sample of live children born in UK 2000-2002	All official live births in 2019
MAR techniques recorded	IVF, ICSI, FER/WBR, IUI, OD	IVF, IUI, OI, Other category[b]	PI, IUI, IVF, ICSI, GS, Other treatment	OI, GIFT, IUI, ICSI, IVF, FER/WBR, LS	OI, ICSI, IUI, IVF, GIFT, FER/WBR, ZIFT
Definition of MAR birth	Mother receiving any type of treatment within 10 months of giving birth	Pregnancy resulted from treatment	Ever received fertility treatment prior to childbirth	Self-reported conception following MAR	Pregnancy resulted from treatment
Number of births	61,983	38,655	12,889	17,097	3,754,132

<u>Note</u>: FER: Frozen embryo replacement. GIFT: Gamete Intrafallopian Transfer. GS: Gestational Surrogacy. ICSI: Intracytoplasmic Sperm Injection. IUI: Intrauterine insemination. IVF: In Vitro Fertilization. LS: Laparoscopic surgery; OD: Oocyte donation; OI: Ovulation-inducing drugs. PI: Programmed intercourse. WBR: Vitrified-warmed blastocyst replacement. ZIFT: zygote intrafallopian transfer.

[a]In 2010, maternity units with over 2000 deliveries a year were allowed to spread data collection across two weeks, collecting data every second day.

[b]Only in 2016.

<u>Source</u>: Authors' systematisation from the national datasets.

Table A3: Linear probability models predicting the probability of having a MAR born child in Denmark.

	(1) Full sample	(2) Full Sample	(3) First birth	(4) First birth	(5) Second+ birth	(6) Second+ birth
Ref: < University						
University	0.040***	0.024***	0.060***	0.026***	0.021***	0.009**
	(0.002)	(0.002)	(0.004)	(0.004)	(0.003)	(0.003)
Ref: <25						
25-29		0.028***		0.037***		0.015***
		(0.003)		(0.004)		(0.003)
30-34		0.066***		0.120***		0.038***
		(0.003)		(0.005)		(0.003)
35-39		0.122***		0.229***		0.088***
		(0.004)		(0.008)		(0.005)
40+		0.239***		0.413***		0.172***
		(0.009)		(0.018)		(0.010)
Ref: Married						
Cohabiting		-0.003		-0.029***		-0.007*
		(0.002)		(0.004)		(0.003)
Single		0.045***		0.020**		0.019**
		(0.005)		(0.007)		(0.006)
Constant	0.071***	0.015***	0.092***	0.038***	0.050***	0.008*
	(0.001)	(0.003)	(0.002)	(0.004)	(0.002)	(0.003)
Observations	61,564	61,564	30,584	30,584	30,980	30,980

*Note: p < 0.05, ** p < 0.01, *** p < 0.001*
Source: Authors' calculations from the national datasets.

Table A4: Linear probability models predicting the probability of having a MAR born child in France.

	(1) Full sample	(2) Full Sample	(3) First birth	(4) First birth	(5) Second+ birth	(6) Second+ birth
Ref: 2003						
2010	0.0115***	0.0124***	0.0190***	0.0243***	0.0061**	0.0063**
	(0.0028)	(0.0028)	(0.0049)	(0.0049)	(0.0031)	(0.0031)
2016	0.0155***	0.0156***	0.0295***	0.0306***	0.0073**	0.0077**
	(0.0029)	(0.0029)	(0.0052)	(0.0051)	(0.0031)	(0.0031)
Ref: < University						
University	0.0232***	0.0115***	0.0302***	-0.0086*	0.0110***	0.0027
	(0.0024)	(0.0025)	(0.0042)	(0.0047)	(0.0026)	(0.0028)
Ref: <25						
25-29		0.0180***		0.0363***		0.0052
		(0.0027)		(0.0043)		(0.0032)
30- 34		0.0319***		0.0848***		0.0195***
		(0.0030)		(0.0060)		(0.0035)
35- 39		0.0565***		0.1585***		0.0397***
		(0.0041)		(0.0111)		(0.0044)
40+		0.0908***		0.2473***		0.0589***
		(0.0094)		(0.0271)		(0.0089)
Ref: Married						
Cohabiting		-0.0176***		-0.0564***		-0.0102***
		(0.0026)		(0.0050)		(0.0027)
Single		-0.0421***		-0.0846***		-0.0314***
		(0.0033)		(0.0063)		(0.0035)
Constant	0.0347***	0.0236***	0.0474***	0.0537***	0.0270***	0.0167***
	(0.0020)	(0.0029)	(0.0037)	(0.0051)	(0.0022)	(0.0034)
Observations	37,533	37,533	16,230	16,230	21,303	21,303

*Note: p < 0.05, ** p < 0.01, *** p < 0.001*
Source: Authors' calculations from the national datasets.

Table A5: Linear probability models predicting the probability of having a MAR born child in Spain.

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample	Full Sample	First birth	First birth	Second+ birth	Second+ birth
University	0.021***	0.013**	0.019***	0.0046	0.022***	0.0169***
	(0.0036)	(0.004)	-0.005	(0.0054)	(0.0049)	(0.005)
Ref :<25						
25-29		0.0029		0.00118		0.0033
		(0.002)		(0.0031)		(0.0031)
30-34		0.016***		0.0181***		0.0126**
		(0.003)		(0.0048)		(0.0044)
35-39		0.054***		0.1042***		0.0254***
		(0.006)		(0.011)		(0.007)
40+		0.149***		0.2767***		0.0583***
		(0.020)		(0.037)		(0.019)
Ref: Married						
Cohabiting		-0.014**		-0.033***		-0.0004
		(0.005)		(0.0065)		(0.007)
Single		-0.0021		-0.01175		-0.009
		(0.0054)		(0.0074)		(0.006)
Constant	-6.23***	-3.88***	-9.07***	-5.872***	-3,33***	-2.04***
	(0.444)	(0.473)	(0.7056)	(0.722)	(0.527)	(0.590)
Observations	12,889	12,889	7,083	7,083	5,806	5,806

*Note: p < 0.05, ** p < 0.01, *** p < 0.001*
Source: Authors' calculations from the national datasets.

Table A6: Linear probability models predicting the probability of having a MAR born child in the United Kingdom.

	(1) Full sample	(2) Full sample	(3) First birth	(4) First birth	(5) Second + birth	(6) Second + birth
Ref: < University						
University	0.013***	0.000	0.011	-0.018**	0.006	-0.003
	(0.004)	(0.004)	(0.007)	(0.008)	(0.005)	(0.006)
Ref: Married						
Cohabiting		-0.023***		-0.049***		-0.010**
		(0.004)		(0.007)		(0.004)
Single		-0.028***		-0.046***		-0.018***
		(0.004)		(0.009)		(0.003)
Ref: <25						
25-29		0.013***		0.028***		0.006**
		(0.004)		(0.008)		(0.003)
30-34		0.022***		0.049***		0.014***
		(0.004)		(0.009)		(0.004)
35-39		0.043***		0.112***		0.028***
		(0.007)		(0.018)		(0.007)
40+		0.075***		0.207***		0.051***
		(0.019)		(0.059)		(0.018)
Constant	0.030***	0.023***	0.053***	0.046***	0.018***	0.011***
	(0.002)	(0.004)	(0.005)	(0.007)	(0.003)	(0.003)
Observations (unweighted)	17,097	17,097	6,399	6,399	10,698	10,698

*Note: $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$*
Source: Authors' calculations from the national datasets.

Table A7: Linear probability models predicting the probability of having a MAR born child in the United States.

	(1) Full sample	(2) Full Sample	(3) First birth	(4) First birth	(5) Second+ birth	(6) Second+ birth
Ref: < University						
University	0.0316***	0.0202***	0.0386***	0.0261***	0.0106***	0.0182***
	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0003)	(0.0002)
Ref: Unmarried						
Married		0.0130***			0.0215***	0.00975***
		(0.00013)			(0.0003)	(0.0001)
Unknown		0.00168***			0.00113**	0.00122***
		(0.00020)			(0.0004)	(0.0002)
Maternal Age						
Ref: <25						
25/29		-0.0019***			0.000208	-0.00113***
		(0.00011)			(0.0002)	(0.00012)
30/34		0.0068***			0.0234***	0.00267***
		(0.00015)			(0.0004)	(0.00016)
35/39		0.0258***			0.0710***	0.0160***
		(0.00026)			(0.0008)	(0.003)
40+		0.0816***			0.195***	0.0544***
		(0.00082)			(0.002)	(0.00078)
Constant	0.0068***	-0.0037***	0.0089***	0.0057***	-0.0043***	-0.0027***
	(0.00006)	(0.00005)	(0.0001)	(0.00006)	(0.00008)	(0.00008)
Observations	3,700,442	3,700,442	1,395,703	2,304,739	1,395,703	2,304,739

*<u>Note</u>: p < 0.05, ** p < 0.01, *** p < 0.001*

<u>Source</u>: Authors' calculations from the national datasets.

Table A8: Linear probability models predicting the probability of having a MAR born child by income levels in Denmark.

	(1) Full sample	(2) Full Sample
Ref: 1st Q		
2nd Q	0.032***	0.034***
	(0.003)	(0.003)
3rd Q	0.055***	0.057***
	(0.003)	(0.003)
4th Q	0.078***	0.075***
	(0.003)	(0.003)
5th Q	0.125***	0.111***
	(0.004)	(0.004)
Ref: <25		
25-29		0.016***
		(0.003)
30-34		0.043***
		(0.003)
35-39		0.097***
		(0.004)
40+		0.214***
		(0.009)
Ref: Married		
Cohabiting		-0.005*
		(0.002)
Single		0.079***
		(0.006)
Constant	0.034***	-0.012***
	(0.002)	(0.003)
Observations	60,449	60,449

*Note: p < 0.05, ** p < 0.01, *** p < 0.001*
Source: Authors' calculations from the national datasets.

Table A9: Linear probability models predicting the probability of having a MAR born child by income levels in France.

	(1) Full sample	(2) Full Sample
Ref: 2010		
2016	0.0035	0.0037
	(0.0031)	(0.0031)
Ref: <2000€		
2000-2999 €	0.0215***	0.0142***
	(0.0035)	(0.0037)
3000-3999 €	0.0412***	0.0289***
	(0.0042)	(0.0045)
4000+ €	0.0637***	0.0426***
	(0.0053)	(0.0056)
Ref: <25		
25-29		0.0169***
		(0.0035)
30-34		0.0243***
		(0.0039)
35-39		0.0498***
		(0.0053)
40+		0.0949***
		(0.0118)
Ref: Married		
Cohabiting		-0.0217***
		(0.0034)
Single		-0.0403***
		(0.0045)
Constant	0.0338***	0.0308***
	(0.0026)	(0.0040)
Observations	24,179	24,179

*<u>Note</u>: p < 0.05, ** p < 0.01, *** p < 0.001*
<u>Source</u>: Authors' calculations from the national datasets.

Table A10: Linear probability models predicting the probability of having a MAR born child by income levels in Spain.

	(1) Full sample	(2) Full Sample
Ref: 1st Q		
2nd Q	0.095	0.055
	(.066)	(0.065)
3rd Q	0.05	0.063
	(.0499)	(0.060)
4th Q	0.2*	0.197*
	(0.082)	(0 .08)
5th Q	0.263*	0.254*
	(0.103)	(0.106)
Ref: <25		
25-29		-0.010
		(0.084)
30-34		0.057
		(0.08)
35-39		-0.0718
		(.070)
40+		-0.078
		(.083)
Ref: Married		
Cohabiting		-0.103
		(0.048)
Single		-0.037
		(.072)
Constant	0.001	0.037
	(0.001)	0.075
Observations	107	107

*Note: p < 0.05, ** p < 0.01, *** p < 0.001*
Source: Authors' calculations from the national datasets.

Table A11: Linear probability models predicting the probability of having a MAR born child by income levels in the United Kingdom.

	(1) Full sample	(2) Full Sample
Ref: 1st Q		
2nd Q	0.137***	0.009*
	(0.0034)	(0.004)
3rd Q	0.028***	0.02***
	(0.005)	(0.0047)
4th Q	0.034***	0.0215***
	(0.005)	(0.006)
5th Q	0.054***	0.038***
	(0.005)	(0.006)
Ref: Married		
Cohabiting		-0.198***
		(0.004)
Single		-0.0139**
		(0.005)
Ref: <25		
25-29		0.009*
		(0.004)
30-34		0.0137**
		(0.004)
35-39		0.033***
		(0.007)
40+		0.068***
		(0.019)
Constant	0.0066***	0.0075***
	(0.001)	(0.019)
Observations	17,069	17,069

*Note: p < 0.05, ** p < 0.01, *** p < 0.001*
Source: Authors' calculations from the national datasets.

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