Medically Assisted Reproduction and Partnership Stability

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*Despite the increasing use of medically assisted reproduction (MAR) in modern societies, there is limited evidence on whether conceiving with MAR or remaining involuntarily childless after MAR is associated with partnership stability. While older age, the more advantaged socioeconomic position of women undergoing MAR and their strong fertility intentions could lead to higher partnership stability, the experience of infertility and undergoing MAR may have an opposite effect, especially if couples remain involuntarily childless. Using data on Finnish nulliparous couples from 1995–2017 (*N = *149,884) and event-history models, we compare the risk of separation of couples who remained childless after MAR (*N = *3871), who conceived through MAR (*N = *14,474), who conceived naturally without MAR (*N = *167,962) or with a prior history of MAR (*N = *2273). Couples who remained childless after MAR had a higher risk of separation than couples who conceived with MAR or naturally. The higher risk of separation decreased over time since the discontinuation of treatments but persisted over the longer term. There were no differences in the risk of separation between couples who conceived with MAR or naturally. The results suggest that involuntary childlessness after MAR is associated with an increased risk of separation while undergoing MAR/experiencing infertility does not seem to play a role.*

Introduction

Infertility is a significant global issue, with one in six couples worldwide experiencing some form of infertility problem during their reproductive

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years (ESHRE 2022). Many of the couples affected by infertility seek medically assisted reproduction (MAR) treatments (such as ovulation induction drugs, artificial insemination, and assisted reproduction technology [ART; including in vitro fertilization (IVF) and intracytoplasmic sperm injection (ICSI)] to conceive (Boivin et al. 2007). The use of MAR is growing rapidly worldwide (Wyns et al. 2021) with about 2.6 million ART cycles and 500,000 children born after infertility treatments per year (ESHRE 2022). In countries with wider access to and provision of infertility treatments, like Denmark and Spain, the proportion of newborns conceived through MAR has reached nearly 9 percent of all births (Martins et al. 2018; ESHRE et al. 2023). As childbearing is increasingly postponed to later ages, the demand for and utilization of MAR treatments is expected to grow (Faddy, Gosden, and Gosden 2018; Raymer et al. 2020). Moreover, as many countries attempt to address low fertility rates, the expansion and wider subsidization of MAR treatments are likely to become more prominent on policy agendas (Rusanova 2020; Szekulesz 2022). But while MAR is playing an increasingly important role in helping individuals realize their fertility intentions in advanced societies, it does not always result in a live birth. A recent study showed that in Finland, 30 percent of women who underwent MAR to conceive their first child remained childless (Pelikh et al. 2024). Seeking pregnancy at older ages substantially lowers MAR treatment success rates and thus couples' chances of having biological children (Modest et al. 2018). The trend towards delayed childbearing could therefore result in an increasing proportion of couples who remain involuntarily childless after MAR.

Despite the growing numbers of couples who undergo MAR and its prominent role in family formation, existing research on partnership stability has given limited attention to this pathway into parenthood (Guzzo and Hayford 2020; Kuhnt and Passet-Wittig 2022; Barbuscia and Sironi 2023). This is a gap in knowledge given that undergoing MAR and partnership stability might be linked through multiple and potentially offsetting mechanisms. Existing studies show that couples who conceive through MAR treatments tend, on average, to be older, married, and in an advantaged socioeconomic position (Goisis et al. 2019, 2020; Barbuscia et al. 2020; Pelikh et al. 2022) which together with strong fertility intentions could be associated with higher partnership stability compared to couples who conceived naturally. However, the experience of infertility itself as well as of undergoing MAR treatments can be demanding and stressful which can negatively affect couple's well-being and partnership stability (Olivius et al. 2004; Verhaak et al. 2005, 2007; Kjaer et al. 2014; Ferreira et al. 2016; Martins et al. 2018), especially if couples remain involuntarily childless. Based on these mechanisms, it is difficult to establish a priori whether and, if so, how partnership stability is linked to undergoing MAR treatments and whether the association differs depending on whether they result in a live birth or involuntary childlessness.

To date, population-level studies of partnership stability in couples who underwent MAR have been rare due to a lack of high-quality data linking the use of MAR with information on the longitudinal partnership trajectories of couples before and after they started the treatments. Only two previous studies have compared partnership stability in couples who underwent MAR to that in couples who conceived naturally (Martins et al. 2018; Barbuscia and Sironi 2023). Their results are mixed, and the current evidence on the direction of the association is therefore inconclusive, calling for a better understanding of whether and how the experiences of MAR are associated with partnership stability in the short and long term.

Studying partnership stability in couples who undergo MAR is relevant and timely for two reasons. First, it advances our understanding of the life course and partnership trajectories in the fast-growing subpopulation group of couples who undergo MAR. Second, it provides evidence on the association between involuntary childlessness after MAR and partnership stability in the short and long term in comparison to groups that conceived and had a child. Using unique register data covering the whole population of Finland, we address the following research questions: Does the partnership stability of couples who undergo MAR differ depending on whether they remained involuntarily childless after discontinuing MAR treatments, conceived through MAR, or conceived naturally with or without a history of MAR? Do these associations change over the short and the longer term? Is the risk of separation moderated by the length of treatments in couples who undergo MAR to conceive?

Background

Medically assisted reproduction and partnership stability

The increasing use of MAR, alongside the reality that around 30 percent of women who undergo MAR remain childless (Modest et al. 2018; Pelikh et al. 2024), provides us with the opportunity to examine the consequences that undergoing MAR treatments and subsequent involuntary childlessness might have on partnership stability. It is difficult to predict a priori whether undergoing MAR is associated with partnership stability and, if so, in which direction since there are underlying multiple mechanisms that could have opposite and potentially offsetting effects.

On the one side, there is extensive evidence that the experiences of infertility and MAR can be stressful for both women and men and can negatively affect mental health and well-being at both the individual and the couple level (Klemetti et al. 2010; King 2003; Luk and Loke 2015; McQuillan et al. 2003, 2022; Milazzo et al. 2016; Tosi and Goisis 2021). Infertility and the medical procedures associated with MAR can also negatively affect a couple's sexual relationship (Luk and Loke 2015; Wischmann

2010). Over the longer term, infertility and repeated MAR treatments could lead to fatigue, a decrease in partnership satisfaction, and an increase in the risk of separation (Berg and Wilson 1991; Guerra et al. 1998; Repokari et al. 2007), although, in some cases, infertility can bring the partners closer and strengthen their relationship (Leiblum, Aviv, and Hamer 1998; Peterson et al. 2011; Schmidt et al. 2005; Sydsjö et al. 2002, 2005). MAR treatments could also have an indirect effect on partnership stability by impacting other areas of the partners' lives in ways that are known to increase the risk of separation. In particular, the treatments can be costly (Bitler and Schmidt 2012; Chambers et al. 2009; Passet-Wittig and Greil 2021), which may increase the financial strain on the couple. Couples (and especially women) could experience high levels of work-related stress due to their increased need to reconcile work and medical appointments and their decreased occupational engagement (Bell 2009, 2010; Collins 2019). Moreover, undergoing MAR treatments may lead the partners to make lifestyle changes, such as spending less time on leisure activities or socializing with friends, which can, in turn, lead to feelings of social isolation that increase the emotional load on the couple (Collins 2019; Parry and Shinew 2004).

On the other side, couples who undergo MAR represent a selective group whose socioeconomic characteristics and strong fertility intentions are likely to decrease their separation risk. Previous studies have universally shown that couples who undergo MAR have an advantaged sociodemographic profile: they are more likely to be older, to be highly educated, to be employed in professional occupations, to have a higher income, and to be in a stable, long-term relationship (Alon and Pinilla 2021; Goisis et al. 2019, 2020; Köppen, Trappe, and Schmitt 2021; Pelikh et al. 2022, 2024). Collectively, these characteristics have been shown to have a significant positive effect on partnership stability in studies of the general population (Härkönen and Dronkers 2006; Hogendoorn, Kalmijn, and Leopold 2022; Jalovaara and Kulu 2018). However, the extent to which these protective factors could offset the potentially increased risk of separation due to the stress surrounding the MAR experience discussed above is unknown, including whether these compensatory effects might vary depending on whether MAR treatments result in a live birth or involuntary childlessness.

Despite the rapid increase in the number of couples who conceive after MAR, the previous literature has paid very limited attention to this pathway into parenthood and its potential associations with partnership stability. The existing evidence suggests that the risk of separation is higher for couples whose treatments were unsuccessful and who remained childless than for couples who conceived after MAR (Ferreira et al., 2016; Kjaer et al. 2014; Martins et al. 2018; Barbuscia and Sironi 2023). However, only two studies have compared couples who underwent MAR to couples who conceived naturally, and their findings are mixed. A study based on US survey data found that, compared to married couples with children

who conceived naturally, married couples who underwent MAR reported lower separation rates regardless of whether the treatments were successful (Barbuscia and Sironi 2023). In contrast, a Danish register study found no difference in the risk of separation between couples who conceived naturally and those who conceived through MAR but also showed that the risk of separation was higher among couples who underwent MAR and did not conceive (Martins et al. 2018). These conflicting findings could be related to compositional differences between couples who underwent MAR in the United States and Denmark, as the US couples tended to be highly selected and advantaged due to a lack of subsidies for MAR treatments (e.g., Bitler and Schmidt 2012; Passet-Wittig and Greil 2021). In addition, both studies suffered from two main limitations. First, as both studies considered childless couples together with couples who already had children, either in common or with a different partner, they did not focus on the involuntarily childless after MAR. Partnership trajectories of couples with children might have differed from those of couples who were seeking to enter parenthood together, especially if they underwent MAR and remained childless after undergoing treatments. Second, these studies lacked precise data on treatment discontinuation timing, preventing analysis of couple dynamics in the immediate posttreatment period when separation risk may peak. The studies also did not assess how the couples adjusted to not being able to conceive after MAR over the longer term, and whether the associations were moderated by the length of treatments. Thus, more research on this topic is needed to understand whether and how undergoing MAR treatments is linked to partnership stability.

Present study

To advance our understanding of whether and how undergoing MAR is associated with partnership stability, we compare the risk of separation in four groups of nulliparous couples who either: remained involuntarily childless after undergoing MAR, conceived through MAR, conceived naturally without a history of MAR, and couples who discontinued the MAR treatments but later conceived naturally. On the one hand, comparing partnership stability between couples who remained childless after MAR, couples who conceived after MAR, and couples who discontinued the treatments but later conceived naturally enables us to isolate the effects of the stress of infertility and of undergoing MAR from the effects of involuntary childlessness after MAR on partnership stability. Couples who conceived after MAR or discontinued the treatments but later conceived naturally share many of the characteristics of couples who remained involuntarily childless after MAR: they tend to be socioeconomically advantaged but experience infertility and undergo emotionally and physically stressful treatment procedures that may have negatively affected many

aspects of their lives. Couples who discontinued the treatments but later conceived naturally could be different from those who conceived directly through MAR, for example, their fertility intentions might have been less strong or they might have experienced more treatment-related stress which led to the decision to discontinue the treatments before conception. Nevertheless, both groups clearly differ from the involuntary childless couples after MAR in that they were able to realize their desire to have a child.

On the other hand, couples who conceived after MAR or who discontinued the treatments but later conceived naturally share some important similarities with couples who conceive naturally as they experienced the transition to parenthood, but they also differ in important ways related to modes of conception and experience of infertility and MAR treatments. Therefore, comparing couples who conceived naturally to couples who conceived via MAR or who discontinued the treatments but later conceived naturally enables us to investigate whether experiencing infertility and undergoing MAR is associated with partnership stability among couples who became parents. It is important to highlight that couples who conceive naturally are a large and heterogeneous group in terms of socioeconomic status, fertility intentions, and pregnancy planning (Guzzo and Hayford 2012, 2014, 2020). While this prevents us from arguing that all natural conceptions were desired (like in the MAR groups) and urges us to be cautious when comparing these groups, we can still gain important insights into the role of infertility and undergoing MAR when doing so.

We use Finnish register data which covers the whole population enabling us to control for a wide range of sociodemographic and partnership characteristics associated with partnership stability. In addition to the unique dataset it provides, Finland is an attractive context to look at given that it offers a high rate of publicly subsidized infertility treatments. it offers a high rate of publicly subsidized infertility treatments. While three IVF/ICSI treatments are provided almost for free in the public sector for women aged up to 40, potentially preceded by a larger number of less invasive treatments, a proportion of cost in the private sector is also covered by the national insurance (Klemetti et al. 2007). As a result, we focus on a context where the socioeconomic selection into MAR is less pronounced than in other contexts (Goisis et al. 2020), which contributes to reduced selection bias and differences across the groups we are analyzing.

The strengths of our study include the ability to identify the exact point in time when a couple started seeking MAR treatments and to follow up on their full history of treatments in the same partnership up to and after the point in time when they conceived or the MAR treatments were discontinued. Moreover, the data enable us to investigate how experiences of infertility and MAR treatments were linked to long-term partnership stability and whether these associations were moderated by the length of the

treatments depending on the outcome of the MAR treatments (live birth vs. childlessness).

Method

Data and sample

We included in the sample nulliparous women born between 1971 and 1981 in Finland who underwent MAR treatments between 1995 and 2015 and/or had a live birth between 1996 and 2016 at ages 20–45 (n = 240,504). Cohorts and observation window selection are driven by data availability on both full MAR treatments and cohabitation histories. We excluded women who were not living with a partner at the beginning of MAR treatments or conception (n = 35,562; 14.8 percent). We additionally excluded women who were not counted in the Finnish population during all years between their 16th birthday and their first MAR treatment and/or conception (n = 16,044; 6.7 percent), as we did not have information on their full partnership and MAR histories.

We used data on cohabitation compiled by Statistics Finland since 1987 to create longitudinal partnership histories for the women in the sample. Statistics Finland provides data for opposite-sex couples whose partnership was intact at the end of a year, who had lived together for at least 90 days, and whose age difference was no more than 15 years (unless they were married or had common children), and who were not siblings. This dataset contains individual-level data on the dates of moving in together, marriage, separation, divorce, and the death of a partner. We defined the start of a partnership as the date the couple moved in together, or the date of marriage, if earlier. As data on cohabitation are based on migration statistics, it is possible that the cohabitation register includes some individuals who share an address but are not in a romantic relationship. However, since the individuals in the sample have lived together at the start of MAR treatments or conception (for natural conceptions), we believe the chance of misidentifying couples not involved in romantic relationships to be very low.

To identify women who underwent MAR, we used a combination of data from three population registers: reimbursement records from the National Prescription Register of the Social Insurance Institution and data from the Healthcare Register and the Medical Birth Register of the Finnish Institute for Health and Welfare. The National Prescription Register provides data on all individual reimbursement records, including purchases of infertility drugs used during MAR since 1995. Through the Healthcare Register, we had access to data on the dates and types of MAR procedures performed by public hospitals. We defined the start of MAR treatments as the date of the first purchase of drugs specifically used for infertility treatments or the date of the first MAR procedure, whichever occurred

first. Similarly, we defined the last unsuccessful cycle as the date of the last drugs purchase or the date of the last MAR procedure, whichever occurred later. We also had access to data on children conceived through MAR from 2004 onwards from the Birth Register. To identify MAR treatments based on Finnish register data, we followed the algorithm introduced by Goisis et al. (2023). We excluded a small group of women who separated from their partner within three months after discontinuing unsuccessful MAR treatments to be able to assess how the couples adjusted to childlessness and to exclude cases in which the treatments may have been discontinued due to partnership breakdown ($n = 318$; <2 percent of all women who started MAR treatments). The final sample included 188,580 women, of whom 89.1 percent ($N = 167,962$) conceived naturally without prior MAR experience ("NC"), 7.7 percent conceived through MAR ($N = 14,474$; "MAR+"), 1.2 percent conceived naturally at some point after discontinuing MAR treatments ($N = 2273$; "MAR− then NC"), and 2.1 percent remained childless after they discontinued MAR treatments (i.e., treatments which did not resulted in a live birth, $N = 3871$; "MAR−").

Analytical strategy

We apply event-history analysis to investigate the risk of separation in couples who conceived naturally ("NC") or after MAR ("MAR+" and "MAR− then NC"), or who did not conceive by the end of the observation period ("MAR−"). We do not include couples who did not have children and did not have a history of MAR treatments as we would not know whether those couples were involuntary childless (and did not undergo MAR), voluntary childless, or postponing realization of their fertility intentions. We start following the couples at risk of separation from the time of conception,[1] which was calculated using the birth date and the gestational age from the birth register. For couples who did not conceive, the clock starts at the date of the last unsuccessful MAR treatment. The MAR groups were predefined according to the treatment success to be able to compare them to couples who conceived naturally with the clock setup at conception or the last unsuccessful treatment (for "MAR−"). In an ideal scenario, for all groups, the clock should have started when the couples started trying to conceive, in which case conception could have been treated as a time-varying variable increasing the time under observation for "MAR−" group. This information is, however, unavailable in the register data. We define separation (event of interest) as the date when one of the partners moved out of the joint household or the couple obtained a formal divorce (if married), whichever occurred first. All observations are censored on December 31, 2017, or after a 12-year follow-up period; at the time of either partner's death; or at the woman's emigration, if earlier. The couples were observed for a minimum of four months since the beginning

of the observation period. On average, couples with children were followed for nine years since conception. "MAR−" couples were observed for an average of five years since treatment discontinuation.

First, we report Kaplan–Meier nonparametric survival estimates of separation to give an overview of changes in partnership stability over time for each group of couples. Second, to take into account the differences in the sociodemographic and partnership characteristics of the groups, we present multivariate results from the piecewise constant event-history analysis. We specify the piecewise constant exponential model as follows:

$$\ln \mu_i (t) = \ln y (t) + \sum\nolimits_k \alpha_k x_{ik}, \quad (1)$$

where ε_i (t) denotes the hazard of separation for individual i, t refers to the time since conception/end of treatment, $y(t)$ denotes the baseline hazard, and x_k represents time-constant variables. Four baseline periods (under two years, two to three years, four to five years, and over six years) were defined based on the baseline hazard estimates produced for the annual periods.

We adjusted the models for covariates that could confound the association between undergoing MAR, conceiving naturally, and partnership stability. First, we controlled for the couple's sociodemographic characteristics: woman's age (19–25, 26–30, 31–35, 36–40, 41–45) and birth cohort (1971–1976 and 1977–1981). To measure the couple's education, we used data on the highest qualification levels both partners had obtained by the start of the observation point and distinguished between low (compulsory school education), medium (upper secondary and postsecondary nontertiary education), and high (tertiary) levels. As the shares of men and women with low education were small (3.6 percent and 3.7 percent, respectively), we combined the low-educated and the medium-educated classifications. The final variable has four categories: "both partners have tertiary education," "only the woman has tertiary education," "only the man has tertiary education," and "both partners have less than tertiary education."

Second, we adjusted for partnership characteristics that previous studies have found to be associated with partnerships stability (Guzzo 2014; Kulu 2014; Wu and Musick 2008): the age gap in a couple ("equal age or the man is up to three years older," "the man is three or more years older," "the woman is up to three years older," "the woman three or more years older"), the duration of the partnership (under two years, two to four years, four to six years, over six years), the type of partnership (marriage or cohabitation), and the partnership order in which the MAR treatments and/or childbearing occurred (first, second, third or higher order partnership). All variables in the study are time constant and measured at t_0 (time of conception/end of treatment).

Finally, we controlled for mental health, as previous studies have found that underlying mental health difficulties in a couple are negatively associated with partnership stability (e.g., Metsä-Simola, Martikainen, and Monden 2018). From previous research, we also know that compared to women who conceived naturally, the use of psychotropic medication is higher among women who underwent MAR up to 10 years before conception or the last treatment (Goisis et al. 2023). To account for selection into MAR by mental health characteristics that could confound the association with partnership stability, we included measures of a couple's mental health up to 10 years prior to conception or the start of MAR treatments.[2] We used data from the National Prescription Register of the Social Insurance Institution on purchases of the following psychotropic medications: anxiolytics (ATC codes N05B), hypnotics and sedatives (N05C), and antidepressants (N06A). These drugs are commonly used to treat anxiety, depression, insomnia, and related mental health conditions.[3] We distinguished between four groups: "couples in which neither of the partners had purchased psychotropics up to 10 years before t_0," "couples in which only the woman had purchased psychotropics up to 10 years before t_0," "couples in which only the man had purchased psychotropics up to 10 years before t_0," and "couples in which both partners had purchased psychotropics up to 10 years before t_0." We acknowledge that psychotropic medication purchases are a crude measure of mental health. Although the use of this measure allowed us to account for more severe cases of poor mental health, it did not comprehensively capture all individuals with poor mental health.

In Model 1, we report the differences in the separation risks of the groups, controlling only for the baseline period (time since t_0; four intervals). Model 2 reports the results adjusted for sociodemographic and partnership characteristics, and Model 3 additionally controls for prior mental health. To investigate whether the risks of separation differed between the groups over the short and the longer term, we estimated a model with period-specific effects (Model 4), which allowed the effects of the covariates to vary over time. These models included an interaction term with the baseline period for all covariates (Blossfeld, Golsch, and Rohwer 2007).

Among the couples who underwent MAR treatments, we were able to account for the length of treatments, defined as the time between the start of MAR treatments and the time of conception or the end of MAR treatments (t_0). We distinguished between two categories: under two years and over two years since the start of MAR treatments. To investigate whether the association between the treatment outcome and the subsequent partnership stability was moderated by the length of the treatment period and how it might have changed over time, we show the results of the analysis including a three-way interaction term between the length of the treatment period, the MAR group, and the baseline period (Model 5).

Results

To document the selection of couples into MAR groups and whether they differ from couples who conceived naturally, we described the sociodemographic, partnership, and mental health characteristics of couples who remained involuntarily childless after MAR ("MAR−"), conceived through MAR ("MAR+"), conceived naturally with history of MAR ("MAR− then NC"), or conceived naturally without history of MAR (NC) (Table 1). Compared to couples who conceived naturally, couples who underwent MAR to conceive ("MAR+," "MAR−," "MAR− then NC") were, on average, older, better educated, and more likely to be married. Moreover, these couples had, on average, lived together for a longer period of time prior to conception or the discontinuation of treatments. Among most of the couples with children, the partners were the same age or the man was less than three years older than his partner (ranging from 40.9 percent to 43.1 percent). However, among the couples who remained childless, the share of cases in which the man was more than three years older than his partner (46.5 percent) or the woman was more than three years older than her partner (5.7 percent) was higher. Among the couples who conceived naturally, the share of cases in which neither of the partners had a history of psychotropic medicine purchases preconception was 82.2 percent. This figure was lower among all other groups, with the proportion of couples in which only the woman had a history of drugs purchases being the highest among the "MAR−" group (15.7 percent). Table A1 in the Supporting Information shows the number of separations and person-months by categories of the main covariates.

Figure 1 describes differences in separation risk between the four study groups when differences in their sociodemographic, partnership, and mental health characteristics are not yet accounted for. The absolute risk of separation among couples who remained childless after MAR ("MAR−") was around four times higher than that among couples who conceived naturally and was about 5.5 times higher than that among couples who conceived through or after MAR (Table A1 in the Supporting Information). Among the "MAR−" couples, the risk of separation gradually declined after reaching a peak of nearly 25 percent within the first two years after the discontinuation of treatments. Overall, half of the couples who remained childless after MAR separated within 8.2 years of the discontinuation of treatments. In contrast, differences between couples who conceived either through MAR or naturally with or without a history of MAR were small, with around 75 percent of these couples remaining together 12 years after the conception. The risk of separation was very low during pregnancy and the child's first year of life, but gradually increased over time.

Table 2 shows the hazard ratios of separation for the couples who underwent MAR to conceive in comparison to the couples who conceived

TABLE 1 Sociodemographic, partnership, and mental health characteristics, by experience of medically assisted reproduction (MAR) and childbearing status in Finland (1995–2017)

Covariates	MAR−	MAR+	MAR− →NC	NC	All
Woman's age at t_0 (%):					
19–25	7.8	8.1	11.4	28.1	25.9
26–30	24.1	33.0	40.7	43.8	42.5
31–35	31.5	41.9	33.5	23.4	25.1
36–40	27.9	15.5	12.9	4.5	6.0
41–45	8.7	1.5	1.6	0.2	0.5
Cohort (%)					
1971–1976	66.5	56.9	65.3	51.2	52.1
1977–1981	33.5	43.1	34.7	48.8	47.9
Age gap in couple (%)					
Equal age or man is older by <3 years	31.4	40.9	43.1	41.1	40.9
Man is older by 3+ years	46.5	35.6	35.7	34.6	35.0
Woman is older by <3 years	16.4	18.8	17.4	19.1	19.0
Woman is older by 3+ years	5.7	4.7	3.8	5.2	5.1
Partnership duration at t_0 (%)					
<2 years	9.5	10.6	9.2	41.8	38.2
2–3 years	16.8	23.5	21.7	25.6	25.3
4–5 years	20.0	24.4	23.2	16.4	17.1
6+ years	53.7	41.5	45.9	16.3	19.4
Partnership order (for women, %)					
First	64.1	69.1	74.9	71.3	71.0
Second	26.4	23.7	20.1	22.4	22.6
Third or higher order	9.5	7.2	5.0	6.3	6.4
Type of partnership at t_0 (% in column)					
Cohabiting	35.1	31.5	31.3	59.2	56.2
Married	64.9	68.9	68.7	40.8	43.8
Education at t_0 (%)					
Both tertiary	30.0	40.3	32.9	26.2	27.5
Only woman tertiary	27.1	27.3	25.9	25.7	25.9
Only man tertiary	8.8	8.5	9.1	9.2	9.2
Both below tertiary	34.1	23.9	32.1	38.9	37.5
Psychotropic medicine purchases within 10 years pre-MAR*					
None of the partners	74.2	76.3	80.9	82.2	81.6
Only woman	15.7	13.7	11.5	10.3	10.7
Only man	6.8	6.9	5.8	5.6	5.8
Both	3.2	3.1	1.9	1.9	2.0
Length of treatments (%)					
<6 months	32.1	37.0	20.1	N/A	N/A
6–11 months	9.6	13.7	16.5	N/A	N/A
12–23 months	19.1	27.8	28.2	N/A	N/A
2+ years	39.2	21.5	35.3	N/A	N/A
Total *N*	3871	14,474	2273	167,962	188,580

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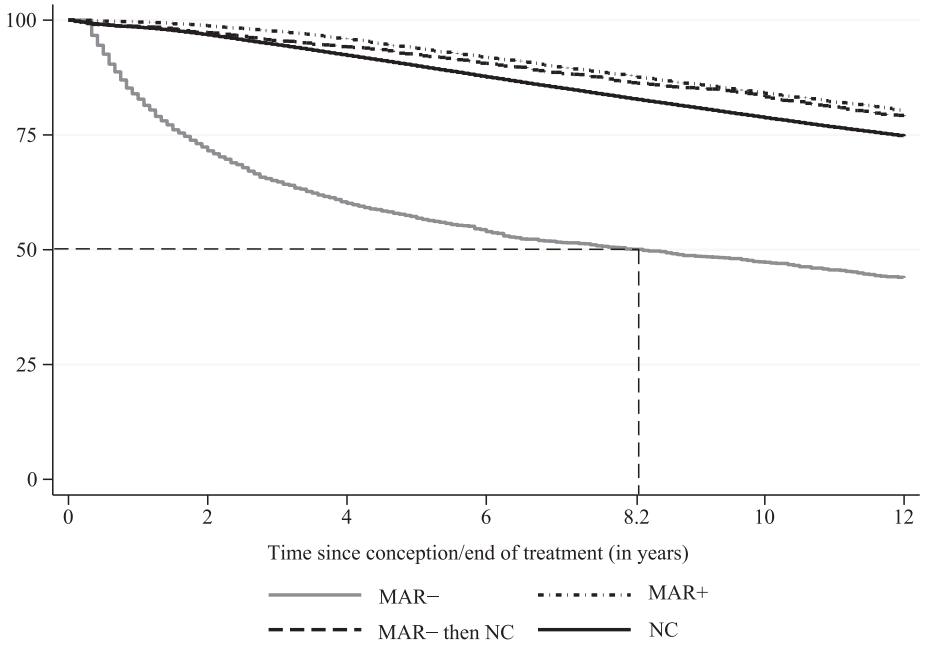
TABLE 1 (Continued)

NOTE: "MAR−" refers to couples who discontinued unsuccessful MAR treatments and remained childless; "MAR+" refers to couples who conceived after undergoing MAR treatments; "MAR− → NC" refers to those who conceived naturally at some point after discontinuing MAR treatments. "NC" refers to couples who conceived naturally. For women with children, t_0 refers to the time of conception. For women who remained childless after MAR ("MAR−"), t_0 is the date of the last MAR treatment. "N/A" stands for "not applicable" to the mean duration of treatments among women who conceived naturally. Psychotropic medicine purchases within 10 years pre-MAR refer to 11 years of prepregnancy for naturally conceived ("NC") couples.
SOURCE: Authors' calculations from Finnish population register data.

FIGURE 1 Kaplan–Meier survival estimates of partnership stability, by experience of medically assisted reproduction (MAR) and childbearing status



NOTE: "MAR−" refers to couples who discontinued unsuccessful MAR treatments and remained childless; "MAR+" refers to couples who conceived after undergoing MAR treatments; "MAR− → NC" refers to those who conceived naturally at some point after discontinuing MAR treatments. "NC" refers to couples who conceived naturally. For women with children, t_0 refers to the time of conception. For women who remained childless after MAR ("MAR−"), t_0 is the date of the last MAR treatment.
SOURCE: Authors' calculations from Finnish population register data.

naturally before (Model 1) and after controlling for sociodemographic, partnership, and mental health characteristics (Models 2 and 3). Figure 2 visually shows the main results for Models 1 and 3. In the unadjusted models (Model 1 in Table 2), the risks of separation among couples who conceived after MAR ("MAR+") or who underwent MAR and then conceived naturally ("MAR− then NC") were slightly lower than those among couples who conceived naturally. Once the couples' sociodemographic and partnership characteristics were taken into account (Model 2 in Table 2), the separation risks were similar among couples who conceived naturally and couples who conceived after MAR ("MAR+" and "MAR− then NC"). By

TABLE 2 Hazard ratios of separation, by experience of MAR (MAR) and childbearing status

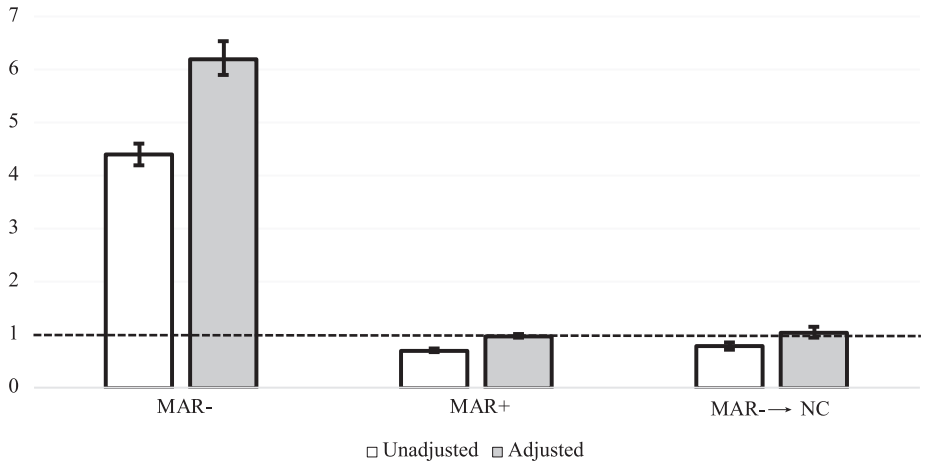
Covariates	Model 1: Unadjusted	Model 2: Adjusted for sociodemographic and partnership characteristics	Model 3: Adjusted for sociodemographic, partnership, and mental health characteristics
MAR treatment outcome (Ref: NC)			
MAR−	4.40***	6.16***	6.21***
MAR+	0.71***	0.99	0.99
MAR− then NC	0.79***	1.05	1.05
Time since t_0 (baseline hazard)			
<2 year	0.0016***	0.0008***	0.0008***
2–3 years	0.0019***	0.0011***	0.0010***
4–5 years	0.0021***	0.0012***	0.0011***
6–12 years	0.0022***	0.0012***	0.0011***
Woman's age at t_0 (Ref: 26–30)			
19–25		1.31***	1.36***
31–35		0.89***	0.85***
36–40		0.76***	0.69***
41–45		0.54***	0.49***
Cohort (Ref: 1971–1976)			
1977–1981		1.08***	1.05***
Age gap in couples (Ref: equal or man is older by <3 years)			
Man is older by 3+ years		1.19***	1.17***
Woman is older by <3 years		1.07***	1.07***
Woman is older by 3+ years		1.36***	1.36***
Partnership duration at t_0 (Ref: <2 years)			
2–3 years		0.90***	0.91***
4–5 years		0.87***	0.88***
6+ years		0.90***	0.92***
Partnership order (Ref: first)			
Second		1.37***	1.35***
Third or higher order		1.95***	1.89***
Type of partnership (Ref: cohabitation)			
Married		0.73***	0.73***
Education at t_0 (Ref: both tertiary)			
Only woman tertiary		1.41***	1.40***
Only man tertiary		1.33***	1.31***
Both below tertiary		2.05***	2.02***
Psychotropic medicine purchases within 10 years pre-MAR* (Ref: none)			
Only woman			1.38***
Only man			1.48***
Both			2.33***

/...

TABLE 2 (Continued)

NOTE: "MAR−" refers to couples who discontinued unsuccessful MAR treatments and remained childless; "MAR+" refers to couples who conceived after undergoing MAR treatments; "MAR− → NC" refers to those who conceived naturally at some point after discontinuing MAR treatments. "NC" refers to couples who conceived naturally. Psychotropic medicine purchases within 10 years pre-MAR* refer to 11 years of prepregnancy for naturally conceived (NC) couples.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
SOURCE: Authors' calculations from Finnish population register data.

FIGURE 2 Hazard ratios of separation, by experience of medically assisted reproduction (MAR) and childbearing status



NOTE: Models are controlled for sociodemographic, partnership, and mental health characteristics; see Table 2. The dashed line represents couples who conceived naturally, the reference category in the models. "MAR−" refers to couples who discontinued unsuccessful MAR treatments and remained childless; "MAR+" refers to couples who conceived after undergoing MAR treatments; "MAR− → NC" refers to those who conceived naturally at some point after discontinuing MAR treatments.
SOURCE: Authors' calculations from Finnish population register data.

contrast, the negative association between unsuccessful MAR treatments and involuntary childlessness ("MAR−") and partnership stability became more pronounced in the adjusted models (the coefficient increased from 4.4 to 6.2 (Model 2 in Table 2). Compared to couples who conceived naturally, all couples undergoing MAR were more likely to have characteristics known to have a protective effect on partnership stability, including an advanced woman's age, a longer partnership duration, and a higher likelihood of being married and being highly educated, and taking this selection into account increased the hazard ratios by around 30–40 percent.

The additional adjustment for the couples' underlying mental health (Model 3 in Table 2) resulted in negligible changes in coefficients, which suggests that the association was not driven by prior mental health problems. This is further supported by the findings that when only couples without a history of psychotropic medication purchases were considered, the separation risks among couples who underwent MAR but remained childless ("MAR−") were higher than those among couples with

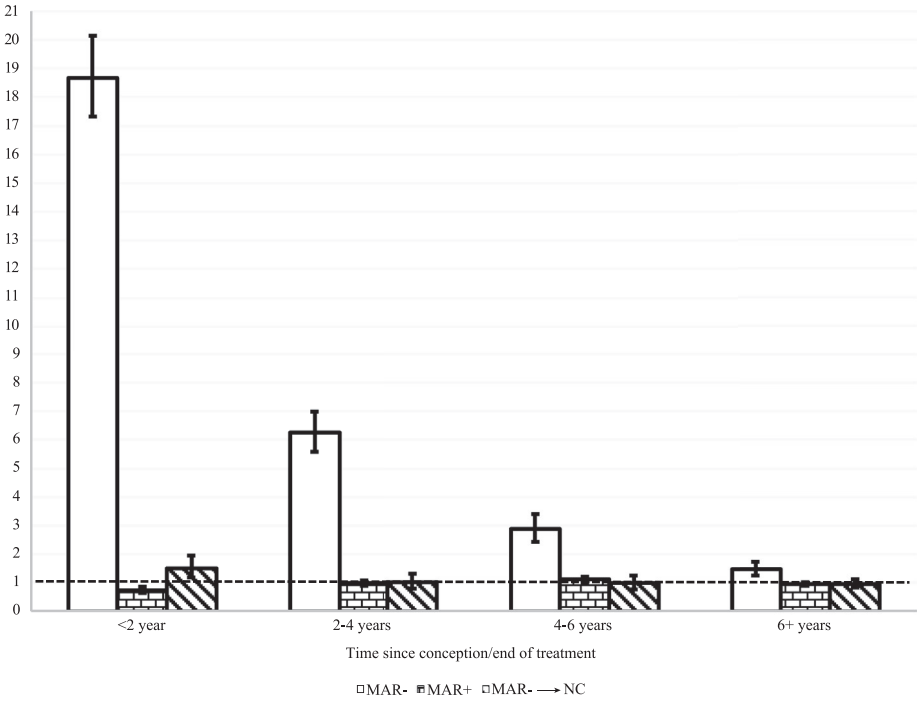
children regardless of the mode of conception (Table A2 in the Supporting Information).

Additionally, we examined whether the ages of both partners were associated with different separation risks across subgroups (Table A3 in the Supporting Information shows the results for the interaction effect between couple's age and MAR groups), as it could have different implications for couples depending on treatment outcomes. Our findings revealed that among the "MAR−" group, couples in which both partners were under 35 years old at the time of treatment discontinuation had nearly twice the hazard ratio of separation compared to couples where either one of both partners was over 35 years old. In contrast, higher age at treatment discontinuation, most prominently among couples where both partners were over 35 years old, had a protective effect on the separation risks for these couples. There were no substantial differences in separation risks in relation to the ages of the partners within couples among the other groups.

To test whether the differences in separation risks among the groups varied across time, we estimated models with period-specific effects (Figure 3). Among the "MAR−" group, the risk of separation decreased gradually over time since the moment when the couple discontinued the MAR treatments: compared to the risk of separation among "NC" couples, among these couples, the coefficient decreased from 18.7 over the short term (two years since the discontinuation of MAR) to 1.5 times the risk over the long term (over six years since the discontinuation of MAR); however, the difference remained significant. The magnitude of the coefficients in the first period was mainly driven by the fact that very few "NC" couples (reference group in the analysis) separated in the two years following the conception (<3 percent). By contrast, the risk of separation among couples who conceived through MAR was lower over the short term (under two years) but was very similar to that among couples who conceived naturally in all other periods. Compared to the risk of separation among the "NC" couples, the risk among couples who discontinued treatments but conceived naturally later ("MAR− then NC") was higher over the short term, but was similar in all the other periods.[4]

Finally, we investigated whether the changes in the separation risk over time among couples who underwent MAR were moderated by the length of MAR treatments (Figure 4). The risk of separation was higher among the "MAR−" couples than among the couples who conceived through MAR regardless of the length of treatments. However, the excess risk of separation was almost a third lower among the "MAR−" couples who had undergone treatments for more than two years. Among the "MAR−" couples who were undergoing treatments for less than two years, the risk of separation was nearly 40 times higher over the short term (<2 years) compared to that among couples who conceived within two years of starting MAR treatments. The magnitude of the coefficients was unusually large for

FIGURE 3 Hazard ratios of separation, by time since conception/last treatment, experience of medically assisted reproduction (MAR), and childbearing status



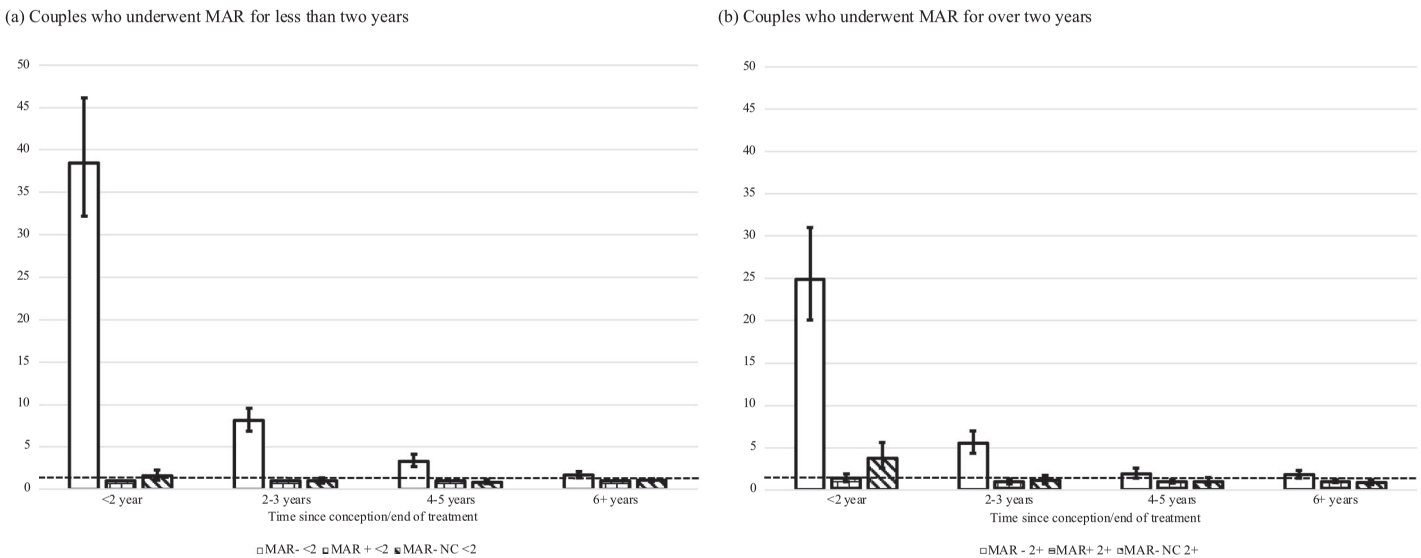
NOTE: Models are controlled for sociodemographic and partnership characteristics and mental health; see Table A4 in the Supporting Information. The dashed line represents couples who conceived naturally, the reference category for each period in the models. "MAR−" refers to couples who discontinued unsuccessful MAR treatments and remained childless; "MAR+" refers to couples who conceived after undergoing MAR treatments; "MAR− → NC" refers to those who conceived naturally at some point after discontinuing MAR treatments.
SOURCE: Authors' calculations from Finnish population register data.

an event-history study and is partially driven by our definition of subgroups and data setup. Thus, the contrast differences in the risk of separation were mainly driven by the fact that very few "MAR+" couples (reference group in the analysis) separated during pregnancy and up to two years since conception (<2 percent). In contrast, around 25 percent of "MAR−" couples separated during the first two years after the discontinuation of treatments, and nearly 60 percent of those had a treatment period of less than one year (Table 1). There were no significant differences in separation risks among couples who conceived through MAR regardless of the length of treatments and the time since conception.[5]

Sensitivity analyses

We performed two sensitivity analyses on the subset of MAR couples. First, we excluded couples who separated within six months of discontinuing

FIGURE 4 Hazard ratios of separation, by length of treatments and time since conception/end of treatment, among couples who experienced MAR. (a) Couples who underwent MAR for less than two years. (b) Couples who underwent MAR for over two years



NOTE: Models are controlled for sociodemographic, partnership, and mental health characteristics; see full results in Table A5 in the Supporting Information. The dashed line represents couples who conceived directly through MAR ("MAR+") after less than two years since the start of treatments—the reference category in the models for each period. "MAR−" refers to couples who discontinued unsuccessful MAR treatments and remained childless; "MAR+" refers to couples who conceived after undergoing MAR treatments; "MAR− → NC" refers to those who conceived naturally at some point after discontinuing MAR treatments.
SOURCE: Authors' calculations from Finnish population register data.

MAR treatments (Table A7 in the Supporting Information). This enabled us to exclude from the analyses couples whose relationship problems may have resulted in the discontinuation of MAR treatments and childlessness and to explore to what extent our results might be driven by reverse causality. Although this exclusion reduced the short-term excess separation risk among the "MAR−" couples by around 20 percent, the risk for these couples remained considerably higher than that for the "MAR+" couples.

Second, for all groups that underwent MAR, we started the follow-up for separation at the start of treatments instead of the time of conception or treatment discontinuation, including conception as a time-varying covariate and controlling for other covariates fixed at the start of MAR. From an event-history analysis perspective, this approach provides a more formal categorization and distinction between couples who conceived and those who did not as all couples are considered childless for as long as they undergo MAR and do not conceive. Consequently, it extends the observation time for the "MAR−" group compared to our main analyses, which set the clock at the treatment discontinuation point. The advantage of doing this is that we can rule out that the analysis results are driven by the differences caused by the clock setup (i.e., treatment discontinuation being potentially the most vulnerable period for a couple, while time around conception is typically associated with the lowest risk of separation). The hazard ratio of separation among couples who remained involuntary childless after MAR reduced from 6.2 and 6.3 (main results from Table 2 estimated with "MAR+" as the reference category) in the unadjusted and fully adjusted models to 2.7 and 2.6, respectively (Table A8 in the Supporting Information). While this model specification lowered the overall separation risk for couples who remained involuntarily childless after MAR ("MAR−"), their risk of separation remained notably higher compared to couples who had children through MAR. There were no differences in separation risks between those who conceived directly through MAR or discontinued the treatments but conceived naturally later, echoing the results of the main analyses (Table 2). Overall, the sensitivity analyses corroborate our main findings, confirming that involuntary childlessness after MAR is consistently associated with decreased partnership stability across various model specifications, while couples who conceived through or after MAR faced similar separation risks.

Discussion

Given the increasing numbers of couples undergoing MAR—a trend associated with the continued postponement of childbearing towards older ages and increased availability of and access to MAR treatment—it is important and timely to study whether undergoing MAR treatments is associated with partnership stability. Using data from Finnish Population Registers,

we examined this link by comparing the partnership stability amongst four groups of couples: those who remained involuntarily childless after undergoing MAR treatments, those who conceived through MAR, conceived naturally without a history of MAR, and couples who discontinued the treatments but later conceived naturally. This study's results enhance our understanding of the partnership dynamics of the fast-growing population of couples who undergo MAR to conceive through three key results.

First, our findings provide evidence that couples who remained involuntarily childless after MAR had a higher risk of separation not only compared to couples who conceived after MAR but also compared to couples who conceived naturally both with and without a history of MAR. The results show that the association between MAR and subsequent partnership stability seems to be primarily driven by treatment outcomes (live birth vs. involuntary childlessness) rather than the experience of infertility and undergoing MAR treatments. This is supported by the fact that couples who remained involuntarily childless after MAR had sociodemographic advantages (i.e., high education, longer partnership duration) relative to couples who conceived naturally without a history of MAR that should have protected them against the risk of separation. Indeed, after accounting for the couples' advantaged characteristics, the results showed an even stronger association between involuntary childlessness after MAR and separation. This argument is further supported by the results showing that the separation rates of couples who were able to conceive and have a child were similar regardless of whether they had prior experience of infertility and underwent MAR treatments. It is noteworthy that we found a similar risk of separation among couples who discontinued MAR but later conceived naturally later: that is, among couples who experienced infertility, underwent stressful MAR treatments, and discontinued treatments, but who were able to fulfill their desire to have a child. This can suggest that although infertility- and MAR-related stress might be associated with a decrease in a couple's well-being and mental health (Klemetti et al., 2010; King 2003; Luk and Loke 2015; Milazzo et al. 2016; Verhaak et al. 2007), couples who were able to conceive and become parents were able to overcome these challenges contributing to their partnerships remaining intact (Goisis et al. 2023; Tosi and Goisis 2021; Verhaak et al. 2007).

Second, our results showed the risk of separation for couples who remained involuntarily childless after MAR was highest around the time of treatment discontinuation and then decreased over the longer term. In other words, couples who overcame the initial distress associated with unsuccessful treatments and involuntary childlessness were likely to stay together over the long term. These findings are in line with previous studies showing a decrease in separation rates over time among couples who were unable to conceive after infertility treatments (Kjaer et al. 2014), which suggests that couples might adjust to involuntary childlessness over the long

term (Daniluk 2001; Sydsjö et al. 2005; Verhaak et al. 2005). Notably, these couples were, on average, older (both partners over 35 years old) at the time of treatment discontinuation, which could have also helped in adapting to involuntary childlessness. Our finding that the relative differences in the separation rates compared to couples who conceived both naturally and after MAR became smaller over time could also be related to research showing that most couples, on average, report greater happiness and life satisfaction around the transition to parenthood (Aassve, Goisis, and Sironi 2012; Kohler and Mencarini 2016; Myrskylä and Margolis 2014; Tosi and Goisis 2021), and hence have very low separation risks during this period. However, as time passes and new parents face challenges associated with raising children, couples might experience a decline in partnership satisfaction and an increase in separation rates (Andersson 1997; Lillard and Waite 1993; Kalmijn and Leopold 2021) which could contribute to attenuate differences between the involuntarily childless group and the other groups.

Third, analyses showed that most couples who separated within a short period of time after discontinuing treatments had been undergoing treatments for less than one year. This result suggests that the initial stress associated with the beginning of MAR treatments and the lack of immediate success can take a toll on a couple's well-being and relationship quality, causing the partners to separate (Gameiro et al. 2012; Olivius et al. 2004; Walschaerts et al. 2013). However, this association could also be driven by the couple's level of commitment and fertility desires. Indeed, among couples who conceived via MAR, the length of MAR did not seem to play a role. It is possible that the less committed couples were more likely to discontinue treatments and to separate shortly thereafter, whereas the highly committed couples were more likely to continue treatments for a longer period of time and to stay together even if they remained childless. At the same time, whereas the couples with strong fertility intentions might have been more likely to continue treatments for a longer period of time, they may have found it harder to adjust to involuntary childlessness, which could have increased their risk of separation over the longer term. Indeed, previous studies have found that undergoing infertility treatments that were not successful can have long-lasting negative consequences for couples' mental health, sexual life, and relationship satisfaction (Bagade et al. 2022; Goisis et al. 2023; Lechner, Bolman, and van Dalen 2007; Verhaak et al. 2007; Wirtberg et al. 2007), which could increase their risk of separation over the longer term.

The strengths of our study include the use of large-scale, high-quality population register data to compare the partnership stability of all nulliparous couples who underwent MAR, including those who became parents and those who remained childless, with that of couples who conceived naturally. These data cover the whole population and are not affected by the nonresponse and recall bias issues associated with using survey

data. We employed all available data sources to comprehensively identify women in the Finnish population who underwent MAR treatments and their partners and linked this information to the women's longitudinal partnership and fertility histories, as well as to the couple-level sociodemographic and partnership characteristics and measures associated with poor mental health. We were also able to identify the exact points in time when the MAR treatments started and were discontinued. Our novel analytical approach highlighted the importance of looking at separation risks over the short and the longer term, which enabled us to gain a better understanding of how couples were adjusting to involuntary childlessness and how the length of treatment moderated these associations.

Our study has a few limitations. First, although using register data has many advantages, these data do not contain information on people's intentions or subjective well-being. Thus, among couples who conceived naturally, we could not distinguish between those who did and did not intend to get pregnant, which might be associated with different risks of separation. Previous research has shown that having an unintended pregnancy might lead to increased levels of distress in parents (Barber and Steinberg 2022; Beck 2001; Maximova and Quesnel-Vallée 2009) and to higher separation rates (Guzzo and Hayford 2012, 2014; Stykes and Guzzo 2020). Another element missing in the register data is partnership quality. As we could not observe this factor, we cannot exclude the possibility that poor partnership quality was driving the discontinuation of MAR treatments and subsequent childlessness. However, the results of our sensitivity analyses did not support this hypothesis. The separation rates of couples who remained involuntarily childless after MAR were attenuated, but remained substantially higher after excluding couples who separated within six months after the discontinuation of treatments, which suggests that poor partnership quality was unlikely to be the main explanatory factor in the elevated separation risks. Moreover, couples who conceive via MAR and couples who remain involuntarily childless after MAR could differ in other ways that are unobserved in the data and are associated with higher separation risk and treatment failure/discontinuation. Nonetheless, we think it is unlikely that the pronounced differences in separation risks we observe between these groups are entirely due to unobserved confounding as adjustment for couple's sociodemographic characteristics resulted in larger rather than smaller differences in separation risks between these groups. Second, distinguishing between the types of treatments couples undergo could also shed light on differences in separation rates, as undergoing more intensive treatments (ART) may be associated with different causes and longer periods of infertility before seeking MAR, and with greater psychological distress during the treatments, which could, in turn, affect partnership stability. Third, we did not look at adoption, and doing so in

future research could help shed light on the polarization in separation rates among couples who failed to conceive. Previous research has shown that, on average, couples who decide to adopt adjust better to involuntary childlessness and have high levels of life and relationship satisfaction over the longer term (Daniluk 2001; Leiblum, Aviv, and Hamer 1998; Sydsjö et al. 2005).

While our analysis focuses on a country with a high proportion of publicly subsidized treatments and a less selective profile of couples undergoing MAR compared to countries where most cycles are privately funded, we believe the observed associations between MAR and partnership stability may be generalizable to other contexts, albeit with some important considerations. In countries where MAR is predominantly privately funded, the financial burden of treatments might have more disruptive impacts on couples' relationships, potentially amplifying the stress associated with treatments and exacerbating risks to partnership stability. Conversely, in such contexts, couples receiving MAR may represent a more selective group, typically being more affluent and potentially in more stable relationships, which could act as protective factors against separation. Furthermore, cultural attitudes towards childbearing and childlessness, infertility and MAR, and the availability of adoption or surrogacy may vary across different contexts, influencing how couples might cope with the infertility- and treatments-related stress and potential involuntary childlessness after MAR. Despite these potential variations, we believe that the emotional challenges associated with infertility and involuntary childlessness after MAR—including disappointment and the need to adjust fertility desires—are likely to be universal. Therefore, while the magnitude of the effect may differ, the overall trend of increased risk to partnership stability among involuntarily childless couples after MAR is likely to be observed across various cultural and economic settings. Future research comparing these associations across different healthcare systems and cultural contexts is necessary for improving our understanding of the implications that infertility and MAR treatments may have on partnership stability.

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Data availability statement

The data that support the findings of this study are available from Statistic Finland. Restrictions apply to the availability of these data, which were used under license for this study. This study was approved by the Ethics Committee of Statistics Finland's permission TK-52-1121-18.

Notes

1 There are 2818 couples in the sample (predominantly those who conceived naturally) who separated between conception and birth.

2 Less than 2 percent of couples purchased psychotropic medication for the first time between the start of MAR (or 12 months prepregnancy for NC couples) and conception (or treatment discontinuation). Only purchases from age 18 onwards are considered.

3 In Finland, all psychotropic medications are prescribed by clinical doctors. The prescription register contains information on the purchase date and the medication type for medications prescribed in both the public and private sectors.

4 Nearly 74 percent of couples in this group have conceived within 12 months since the last treatment (53 percent within six months, 21 percent between 6 and 12 months). The higher risk of separation in the two years following the conception in this group contributes to the evidence that couples who discontinued MAR treatments face the highest risk of separation in the short term. This elevated risk could potentially be attributed to accumulated stress from MAR procedures and relationship fatigue. For some couples, even achieving conception may not have been sufficient to overcome these challenges. However, it is important to note that only 62 couples in this group separated within the first two years after conception. This relatively small number reduces the statistical precision, and these findings should be interpreted with caution.

5 Additional sensitivity analysis in which we disaggregated the treatment length by <1, 1–2, and 2+ years showed an elevated risk of separation among couples who underwent MAR for less than one year and remained childless (Table A6 in the Supporting Information).

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