

RESEARCH ARTICLE

How do reproductive events other than live births shape the timing of a second child?

Jitka Slabá¹ , Anna Šťastná¹  and Jiřina Kocourková¹ 

ABSTRACT Fertility research often overlooks reproductive events other than live births, e.g. miscarriages, induced abortions, stillbirths or infertility treatments. This study examines the extent to which the type and timing of such events influence the timing of a second live birth in Czechia. Using register data for women born between 1976 and 1991, Cox proportional hazards models were employed to assess the roles of age, cohort and reproductive experience. Events following a first live birth are generally linked to the postponement of a second live birth. In contrast, events that occur before a first live birth may act to accelerate the transition to a second live birth, especially within a short time of the first birth, thus suggesting the catch-up effect. The impact of induced abortion differs according to the reason, with the effect of an abortion for medical reasons on the birth interval resembling the effect of a miscarriage. These findings highlight the importance of including non-live birth reproductive events in fertility research to improve the understanding of how women navigate their reproductive trajectories.

KEYWORDS Second live births • Miscarriage • Induced abortion • Infertility treatment

Introduction

In recent years, fertility has been declining across Europe (including in Czechia), with total fertility rates in 2023 ranging from 1.06 in Malta to 1.81 in Bulgaria (Eurostat, 2025). The drivers of a potential recovery in fertility comprise both first-order fertility and, in particular, the extent of the realisation of second-order fertility. This pattern is evident in Czechia, where the increase in total fertility between 2013 and 2021 was primarily attributable to increases in both first-order and, in particular, second- and third-order births (Koukalová, 2023). Moreover, cohort evidence from Central and Eastern Europe indicates that the decline in completed fertility was fuelled largely by a reduction in the progression to a second birth rather than to a first birth (Zeman et al., 2018). Higher-order fertility thus emerges as a key factor in both overall fertility growth and the maintenance of stable fertility levels over time. Given the prevailing preference for a two-child family across Europe (Testa, 2012; Sobotka and Beaujouan, 2014), the focus of our analysis is directed towards the transition to a second live birth.

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The study of the fulfilment of first and second child reproductive intentions (e.g. Kapitány and Spéder, 2012; Kocourková and Šťastná, 2021) has revealed, *inter alia*, that success rates in achieving birth intentions decline with advancing maternal age (Beaujouan et al., 2019; Schmidt et al., 2012). However, evaluations of fertility intentions and the timing and occurrence of subsequent live births frequently overlook the occurrence of other reproductive events, such as miscarriages, induced abortions, stillbirths and infertility treatments, in the reproductive trajectories of women. The lack of attention devoted to other reproductive events was recently underscored by a study that focused on first reproductive experiences (Beaujouan et al., 2025).

The widespread postponement of childbearing in modern societies in recent decades has significantly shifted the timing of the first birth to later ages (Sobotka, 2017; Beaujouan, 2020), a factor that is associated with a higher risk of remaining childless or having fewer children than originally intended (te Velde et al., 2012). As the maternal age increases, the incidence of pregnancy-related complications, including infertility and pregnancy loss, also rises, which may, in addition to social and economic factors, help to explain the non-realisation of fertility intentions (Goisis et al., 2018; Magnus et al., 2019; Nguyen et al., 2019).

However, capturing complete reproductive experiences within the life course perspective in demographic studies remains challenging due to significant data limitations. Nevertheless, there is partial evidence indicating that fertility postponement has a significant impact on selected reproductive risks, including the elevated risk of a foetal loss for women in their late thirties and older, irrespective of the woman's reproductive history (Andersen et al., 2000), the age-related increase in the risk of miscarriage (Andersen et al., 2000; de La Rochebrochard and Thonneau, 2002; Magnus et al., 2019) and the rapidly increasing use of assisted reproductive technologies (ART) that support childbearing at advanced maternal ages or help women overcome fertility difficulties (Sobotka et al., 2008; Kocourková et al., 2023a).

This study focuses on the period between the first and the second live birth for selected cohorts of women in Czechia. The cohorts selected (1976, 1979, 1982, 1985, 1988 and 1991) represent different fertility timing models that reflect the significant transformation of fertility patterns in Czechia since the early 1990s, which have mainly been characterised by a shift towards the delayed childbearing fertility model (Kocourková et al., 2022). The 1976 cohort experienced the most intensive postponement of childbearing even though their first children were primarily born at younger maternal ages, i.e. between 20–24 years. Starting with the 1979 cohort, a more stable fertility pattern emerged in which childbearing became increasingly concentrated in older age groups, resulting in the formation of the late-fertility model (Kocourková et al., 2022). Moreover, Czech society has traditionally been characterised by a strong two-child norm (Sobotka and Beaujouan, 2014). Taking into account these cohort changes in fertility timing, as well as evidence suggesting that the interbirth interval typically shortens as the age at first birth increases (Berg and Rotkirch, 2014; Šťastná et al., 2019), this study investigates the extent to which reproductive events other than live births, including miscarriages, induced abortions, stillbirths and infertility treatments (that occurred before and/or after a first live birth), affect the timing of a second live birth. While we focus strictly on the observed behaviour of the studied cohorts, we are

aware that certain types of events are driven by different underlying impetuses, which reflect either positive or negative reproductive intentions.

The role of reproductive events other than live births in a woman's reproductive trajectory

In the medical literature, the “time to pregnancy” (TTP) indicator refers to the time between commencing attempts to conceive and the achievement of conception. The TTP increases with the age of the woman (Baird et al., 2005; Axmon et al., 2006; Schmidt et al., 2012), and is influenced by several factors, e.g. the length of the menstrual cycle, lifestyle (e.g. obesity, smoking) and the use of contraception prior to attempting to conceive (Mutsaerts et al., 2012). During this period, reproductive events other than a live birth, e.g. infertility treatments, may occur. In addition, not all successful conceptions result in live births. The age-related decline in fertility leads not only to the increasing need for infertility treatments and, in particular, the increased use of ART, but also to elevated genetic risks during pregnancy (Balasch, 2010; Schmidt et al., 2012). Moreover, the risk of a miscarriage increases significantly with maternal age (Balasch, 2010; Schmidt et al., 2012; Chester et al., 2022). An attempt to conceive again following a miscarriage clearly extends the interval between a first and a second live birth. This article focuses on both types of events: (1) those that occur during the TTP period, namely infertility treatments; and (2) those that are related to pregnancy, namely miscarriages, induced abortions and stillbirths.

The postponement of a first birth is linked to two scenarios for the transition to a second child: (1) the transition to a second child occurs within a shorter reproductive window (the “catch-up” or “time squeeze” effect), and (2) the transition to a second child is prolonged due to age-related constraints (the “postponement” effect) (Kreyenfeld, 2002; Bratti and Tatsiramos, 2012; Bartus et al., 2013; Compans et al., 2023). The catch-up effect refers to the tendency of women who delay having their first child – often for reasons related to their career or education – to accelerate subsequent childbearing in order to achieve their intended family size within a shrinking reproductive window. This effect is closely linked to the biological clock and the related perceived urgency as women approach their final reproductive years. One of the key consequences of a late first birth is an increased risk of not achieving a second birth, which has been called the postponement effect. This factor may also reflect the reassessment of reproductive intentions, which often evolve with age (Hayford, 2009; Iacovou and Tavares, 2011; Gemmill, 2019).

Without taking into account women's reproductive intentions throughout their life and reproductive trajectories, it is reasonable to assume that certain reproductive events are likely to lead to specific reproductive scenarios that affect the transition to a second child: some events have the potential to weaken the catch-up effect, e.g. the occurrence of a miscarriage or a stillbirth following a first live birth, whereas other events, such as an induced abortion, often act to reinforce the postponement effect. The role of infertility treatments is ambiguous, as the prolongation of treatments may act to delay the transition to a second or

subsequent child, while ultimately enabling parenthood for those who would otherwise be unable to conceive.

Induced abortion is shaped by both the social context and biological conditions. Factors such as the partner's negative attitude towards contraception or the failure of contraception increase the likelihood of abortion (Rasch et al., 2007). In addition, induced abortions are more common for single and unmarried women and for those living in unfavourable socioeconomic situations, including among women who have low status, are unemployed or are continuing their education (Rasch et al., 2008; Väisänen, 2010). Moreover, the probability of abortion increases with the number of previous births and abortions (Hansen et al., 2009).

Induced abortions have been available in Czechia for non-medical reasons since 1958. Since 1987, induced abortion upon request has been permitted in Czechia within the first 12 weeks of pregnancy. Abortion beyond 12 weeks is permitted only for medical reasons, such as to protect the life or health of the pregnant woman, or in cases of severe foetal abnormalities. Historically, induced abortions in Czechia have largely been the result of conscious decisions by women aimed at limiting their fertility, particularly in their early reproductive years (especially among very young women), but also in their later reproductive years after they have attained their desired family size (Kocourková and Fait, 2009). The incidence of induced abortion has declined in recent years due to improved access to modern contraceptives, which effectively prevent unwanted pregnancies (Frejka, 2008; Kocourková and Fait, 2011), and which have resulted in a notable drop in their incidence across Central Europe since the early 1990s (Fiala et al., 2022). In Czechia, around 20% of induced abortions in the past decade were conducted for medical reasons, thus indicating that not all terminated pregnancies were unwanted (CZSO, 2020). The literature suggests that women who have an induced abortion tend to be younger, of a lower social status and at higher risk of unintended pregnancy (Väisänen, 2010), which may be resolved via recurrent abortions (Hansen et al., 2009). Women who undergo an induced abortion at a younger age are at higher risk of experiencing a repeat abortion later in life (Heikinheimo et al. 2008; Bazarán Paredes et al. 2026), potentially extending the timing between successive births.

Hypothesis 1. Extended spacing between a first and a second live birth is expected following an induced abortion after the first live birth since it predominantly reflects a woman's decision not to have a second child at that time.

Hypothesis 2. Similarly, if a woman undergoes an induced abortion before her first live birth, the interval between the first and the second live birth is likely to be extended.

Women who actively manage their fertility differ from those who face difficulties conceiving. Of the various types of infertility treatments, ART have received considerable attention in recent years, particularly with respect to their contribution to overall fertility levels, especially among older age groups (Hoorens et al., 2007; Frejka, 2008; Kocourková et al., 2023a; Lazzari et al., 2023). While the emphasis is often placed on successful conception, it is equally important to assess the success rates for live births. A German study (Gnoth et al., 2011) reported success rates for a first birth following the use of ART ranging from 52% to 85%, depending on the number of treatment cycles, while an Australian study (Paul et al., 2020) found that the success rates for a second birth via the use of ART

(after a first ART-conceived birth) varied from 51% to 88%, according to the number of cycles and type of ART.

In vitro fertilisation was first introduced in Czechia in 1982. Since 1997, when public health insurance coverage of a limited number of treatment cycles was introduced, the number of cycles has increased steadily (Kocourková et al., 2023a). Access to ART has gradually been extended due to the liberalisation of legislation; since 2006, unmarried heterosexual couples have been eligible for treatment, and in 2012, the number of reimbursed cycles was increased from three to four provided that only one embryo is transferred during each of the first two cycles. Moreover, the whole range of ART methods is permitted in Czechia. However, centralised ART statistics have been recorded only since 2007, when approximately 18,000 cycles were documented. The number of cycles increased gradually up to 2011, when it reached around 25,000 cycles, and it increased even more rapidly in subsequent years, reaching around 47,000 cycles in 2019 (IHIS CR, 2020). Czechia has consistently ranked among the countries with the highest proportion of births conceived through ART. Of all children born following ART, approximately two-thirds are first-order births and around one-quarter are second-order births (Kocourková et al., 2023a). This indicates that ART contributes not only to the transition to parenthood, but also to the transition to a second child, thus confirming the particular relevance for the analysis of examining treatment events before and after a first live birth.

Hypothesis 3. If fertility treatment occurs after a first live birth, a significant extension of the birth interval is expected since it is assumed that couples attempt natural conception before seeking treatment.

Hypothesis 4. Conversely, if couples have already undergone treatment to conceive their first child, they are less likely to delay attempts to have a second child since they anticipate similar challenges in conceiving.

Experiencing a miscarriage is traumatic and negatively affects a woman's well-being (Engelhard, 2004; Nelson et al., 2017). The risk of a miscarriage increases not only with advanced maternal age (Balasch, 2010; Schmidt et al., 2012), but also with experience of previous miscarriages, obesity, past pregnancy complications and prolonged conception attempts (Lo et al., 2012; Magnus et al., 2019; Arge et al., 2022). Moreover, evidence exists that susceptibility to a miscarriage may be hereditary (Woolner et al., 2020). In addition, miscarriages often serve to prolong the time to a subsequent conception (Sapra et al., 2014). The proportion of pregnancies that ended in miscarriage in Czechia increased gradually from 6% in 1993 to 9% in 2022. This trend reflects the shifting age profile of women who experience a miscarriage, which corresponds to the increasing maternal age at childbirth (Kocourková et al., 2023b) and is consistent with findings on the higher incidence of miscarriage with increasing maternal age.

Hypothesis 5. It is expected that a miscarriage following a first live birth extends the interval to a second live birth due to the time required to conceive again.

Hypothesis 6. Conversely, if a miscarriage occurs before a first live birth, a shorter interval to a second live birth can be expected since couples may accelerate their efforts to conceive again due to concerns about the recurrence of a miscarriage.

The risk of a stillbirth is higher among women of advanced maternal ages (Astolfi et al., 2004; Schmidt et al., 2012). Research conducted in Finland, Norway and Western Australia

determined that women who conceived within a year of a stillbirth did not face an increased risk of another stillbirth, a preterm birth or the birth of a small-for-gestational-age child (Regan et al., 2019). In contrast, a meta-analysis revealed that very short inter-pregnancy intervals (six months or less) significantly increased the risk of a stillbirth (Wang et al., 2022).

Since 1990, the stillbirth rate in Czechia has consistently remained below 4‰, with the lowest value observed in 2008 (2.3‰). The subsequent slight increase in stillbirths (between 3 and 4‰) can be attributed to a change in the definition of a stillborn child that came into effect in 2012 (CZSO, 2024). Given the very low prevalence of stillbirths in Czechia, it can be assumed that, since our analysis focuses only on selected cohorts, the absolute numbers observed are very low. Therefore, stillbirth events were included in the model for the sake of completeness; no detailed analysis was devoted to such events.

Data and methods

Data

This study employed national health register data obtained from the Czech National Health Information System (NHIS) to link and analyse the reproductive events of selected cohorts of women with the aim of providing a comprehensive overview of their reproductive trajectories. The data provided in the register cover the period from 1994 to 2022. Therefore, from the cohort perspective, women born in 1976, 1979, 1982, 1985, 1988 and 1991 were selected for the analysis, thus capturing the period characterised by the postponement of fertility in Czechia. The 1976 cohort experienced the most pronounced postponement, while the 1991 cohort reflected the stabilisation of the late fertility model (Kocourková et al., 2022).

The records include data on live births, miscarriages, induced abortions, other abortion events (mostly the termination of ectopic pregnancies), stillbirths and infertility treatments. Based on these records, the order of reproductive events was established by reconstructing complete individual reproductive trajectories (Slabá et al., 2026). The parity of live births was subsequently inferred from the chronological position of live births within these trajectories. With respect to infertility treatment, the data provide information only on assisted reproduction treatments, defined as all interventions involving the *in vitro* handling of oocytes, sperm or embryos for the purpose of reproduction. Other medical interventions, such as intrauterine insemination or fertility-enhancing treatments, are excluded from the records (IHIS CR, 2020). For the purpose of the analysis, we focused exclusively on treatment cycles aimed at achieving pregnancy (i.e. *in vitro* fertilisation, frozen embryo transfer and oocyte and embryo receipt), while procedures such as egg donation, preimplantation diagnostics and cryopreservation were excluded.

Reliable data on legal abortions of all types (miscarriages, induced abortions and other abortions) were available for the whole period under study since the reporting of abortions has been mandatory for hospitals and physicians since 1958. The reason for an induced abortion has been recorded since 2016 under the following classifications: (1) on request

and (2) for medical or other non-medical reasons. To assess the impact of induced abortions on request versus for medical or other reasons on the spacing of the first and the second live birth, a separate analysis was conducted on reproductive trajectories beginning with the first reproductive event (live birth or other) after 2016.

Sample

Due to the limited availability of the data and the cohorts studied, only those women who experienced a first live birth between the ages of 18 and 40 were included in the analysis. Since the reproductive trajectories of most of the studied cohorts had not been completed at the time that the register data were obtained, those women who did not experience a second live birth within the observation period (up to 12/2022) were treated as censored, and the number of months since the first live birth was set at the time that had elapsed up to December 2022. In addition, the period analysed from the first live birth was limited to 72 months, mainly in order to optimise the degree of comparability between the full sample (1994–2022) and the subsample of reproductive trajectories that commenced after 2016. The maximum observable length for these later trajectories was 83 months, but this value applied only when the first event was a first live birth that occurred in January 2016. If the first live birth occurred in December 2016, the maximum observable interval was 72 months. By setting this cut-off point, the analysis included all those women whose first reproductive event was a first live birth in 2016, thereby ensuring that the reproductive trajectories initiated in that year were fully represented in the observed spacing interval. Accordingly, those women who had a second child more than 72 months after a first birth were considered censored, and the maximum interval for a censored observation was set at 72 months. The second live births that occurred within this time frame accounted for 82% of all the recorded second live births.

Since the study focused on the specific impact of reproductive events other than live births, the analytical part included only those women with a maximum of one such event before their first live birth (referred to as BEFORE in the analytical section) and after a first live birth up to a second live birth (referred to as AFTER). The proportion of women in the studied populations with one other reproductive event ranged between 11 and 14% (Table 1). The overlap of women who experienced one event before and one event after was less than 2% (see the notes to Table 1). The type of these events may or may not have differed. This selection procedure acted to reduce the initial number of reproductive trajectories to around 96% (Table 1); thus, the results were valid for a substantial proportion of the women in the studied cohorts.

Two populations were studied: (1) women who had had at least one live birth, and who thus had a chance of having a second live birth; and (2) women who had had at least two live births, and who thus had already successfully transitioned to a second child. The population of women with at least two live births was therefore a subset of the population of women with at least one live birth. In addition to providing information on the behaviour of these two distinct groups, their comparison allowed for the determination of the overall success rate of the transition to a second child. As shown in Table 1, the entry data comprised

Table 1 Distribution of the women according to the number of other reproductive events they experienced other than live births

Women according to the number of live births		At least one live birth		At least two live births	
Timing of the event		BEFORE	AFTER	BEFORE	AFTER
Number of reproductive events experienced other than live births	0	83.00%	85.32%	84.97%	85.51%
	1	13.20%	11.20%	12.38%	11.48%
	2	2.50%	2.30%	1.93%	2.08%
	3	0.69%	0.70%	0.42%	0.56%
	4	0.28%	0.25%	0.14%	0.20%
	5	0.14%	0.12%	0.07%	0.09%
	6	0.08%	0.06%	0.04%	0.04%
	7	0.04%	0.03%	0.01%	0.02%
	8+	0.06%	0.04%	0.03%	0.03%
Total number of women		341,845	341,845	222,668	222,668

Note: BEFORE = before a first live birth; AFTER = after a first live birth and before a second live birth or before censoring (whichever occurred first in the at least one live birth model). The overlap between women with at least one live birth who experienced one event before (13.20%) and after (11.20%) was 1.76 percentage points, whereby the individuals in all cases experienced one event, with 0.54 percentage points of 11.20% experiencing multiple events after and 0.66 percentage points of 13.20% experiencing multiple events before. For those women with at least two live births, the overlap was 1.67 percentage points, with 0.14 percentage points of 11.48% experiencing multiple events after and 0.55 percentage points of 12.38% experiencing multiple events before.

341,845 women with at least one live birth and 222,668 women who had already experienced a second live birth. Following the reduction of the sample for the age at first live birth (between 18 and 40) and for those women with a maximum of one other reproductive event before and/or after the first live birth, the analysed sample for the 1994–2022 period consisted of 278,825 women with at least one live birth and 172,131 women with at least two live births. The subsample for the analysis of the 2016–2022 period consisted of 70,187 women with at least one live birth and 28,187 women with at least two live births.

Methods

The study analysed the time that elapsed from a first live birth to a second live birth by applying the Cox proportional hazards model, which allowed for the assessment of those reproductive events other than live births that influenced the occurrence and the timing of a second live birth. Only those women with a singleton first live birth were included, and the dependent variable was the time in months that had elapsed since the first live birth. The model included the woman’s age at first birth (age 25 was set as the reference category), the birth cohort (the 1976 cohort was the reference) and the type of reproductive event other

than a live birth, i.e. a miscarriage, induced abortion, stillbirth or infertility treatment (no other reproductive event was the reference).

The Cox proportional hazards model was implemented in R (Zhang et al., 2018; Therneau et al., 2024). Our model did not consider time-varying covariates to be a concern for events that occurred before the first live birth since they occurred prior to the observation period, which commenced upon a first birth. However, events that occurred following a first live birth were treated as time-varying since they occurred during the observation period and may have dynamically influenced the timing of a second birth.

We considered both types of models, i.e. without and with the consideration of the time-varying covariates, as analytically appropriate. The model without time-varying covariates captured the overall relationship between reproductive events and the spacing of the first and the second live birth. In contrast, models incorporating time-varying covariates allowed us to trace the specific effects of individual events as they occurred, particularly during the transition between the last reproductive event and a second live birth.

To account for the time-varying covariates, we restructured the data into the counting process format (Zhang et al., 2018), in which each of the women contributed multiple records that represented distinct time intervals between the first and the second live birth. Each row indicated the presence or absence of a specific reproductive event (e.g. a miscarriage, abortion) during that interval.

The proportional hazards assumption was tested by applying the Schoenfeld residuals test, which revealed violations for several covariates, thus indicating that their impacts varied over time. To address this issue, we explored two modelling strategies: first, we divided the follow-up period into discrete intervals and estimated the separate impacts within each interval; second, we applied time interaction models that allowed for the impacts of specific covariates to vary smoothly over time. However, neither approach produced interpretable or stable estimates.

The average hazard ratio (HR) therefore did not represent a time-constant effect, but rather a weighted summary of the time-varying effects within the 72-month period following the first birth (or the last reproductive event), since the estimated hazard ratios (HRs) were influenced by the temporal variation and were not stable throughout the studied period (Grambsch and Therneau, 1994). Figure S.1 in the Supplementary material (available online at <https://doi.org/10.1553/p-f6d9-zjjz>) illustrates these average HRs, thus providing an overall view of the combined effects of factors such as age, cohort and type of reproductive event. However, a more reliable interpretation requires the examination of Figures 1–5 in the Results section, which depict the evolution of the HRs over the time from the first birth (or last reproductive event). Importantly, the Schoenfeld test results did not undermine the validity of the time-specific HR estimates, which remain the appropriate measure when effects vary over time (Hess, 1995).

We initially applied a spline with 10 degrees of freedom in order to explore the detailed patterns of the time-varying effects and to ensure that no relevant temporal structure was overlooked (Lehr and Schemper, 2007). To improve the degree of interpretability, we subsequently smoothed the resulting curves. The smoothed profiles were consistent with the results obtained when applying fewer degrees of freedom. This served to demonstrate the robustness of our substantive conclusions regarding the choice of the spline flexibility.

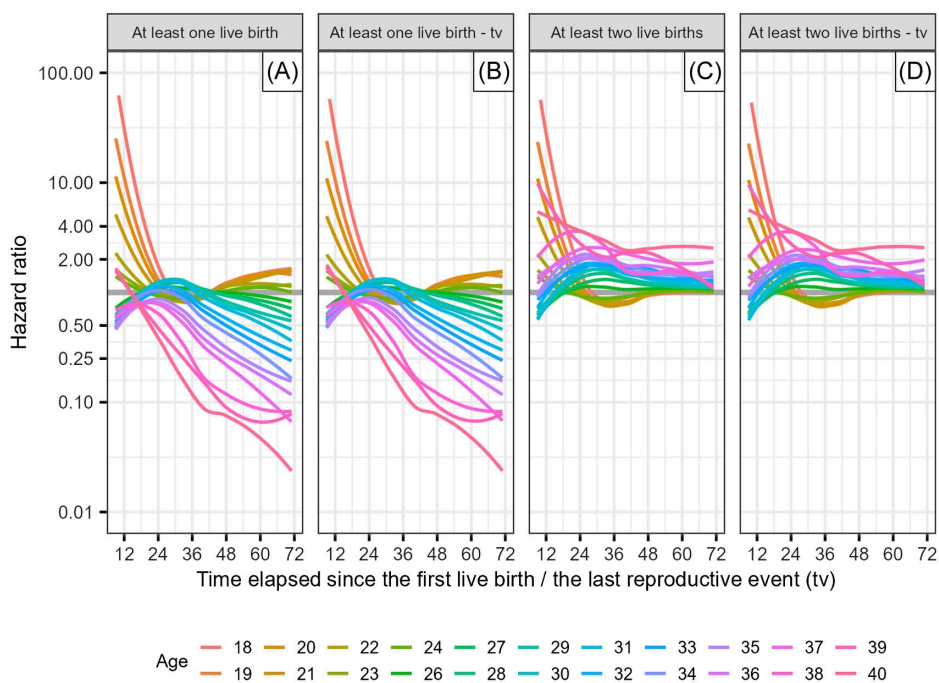
We therefore presented the smoothed spline curves as a tool for visualising the temporal variability.

Results

Figures 1 to 4 show the development of the time-varying patterns in the HRs for second live births for the variables included in the Cox proportional hazard models (see the Supplementary material, Table S.1). These figures are interrelated since their panels (A, B, C and D) correspond to the same models (Supplementary material, Table S.1: M1, M2, M4 and M5, respectively, which present the average HR). In addition, the average HRs are visualised in the Supplementary material (Figure S.1).

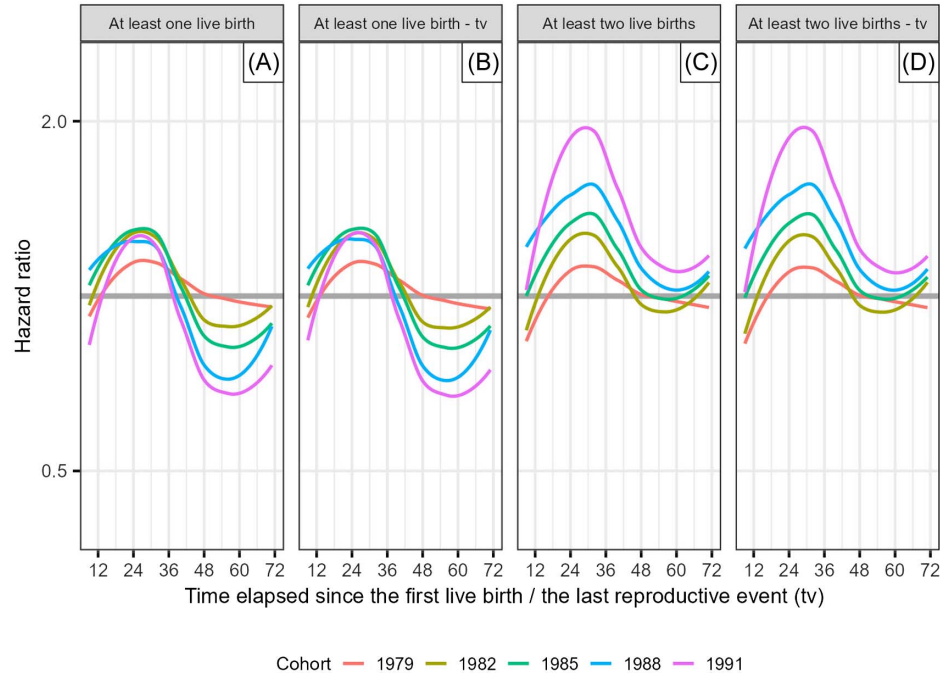
Panels A and C in all cases show the models without time-varying covariates, i.e. the HRs depending on the time elapsed since the first live birth, while panels B and D show

Figure 1 Hazard ratios for a second live birth over the time elapsed since the first live birth or the last reproductive event by the age at the first live birth – smoothed splines



Note: “tv” refers to the model with time-varying covariates for events that occurred after the first live birth (panels B and D), for which the x axis shows the time elapsed since the last reproductive event, while in panels A and C, the x axis shows the time elapsed since the first live birth. The average hazard ratios are shown in the Supplementary material, Table S.1 (M1, M2, M4 and M5). The smoothed splines comprise the results obtained from the complex model as presented in Figure S.1 (reference categories: age 25, 1976 cohort and no other reproductive events before and after).

Figure 2 Hazard ratios for a second live birth over the time elapsed since the first live birth or the last reproductive event by the birth cohort of the women – smoothed splines



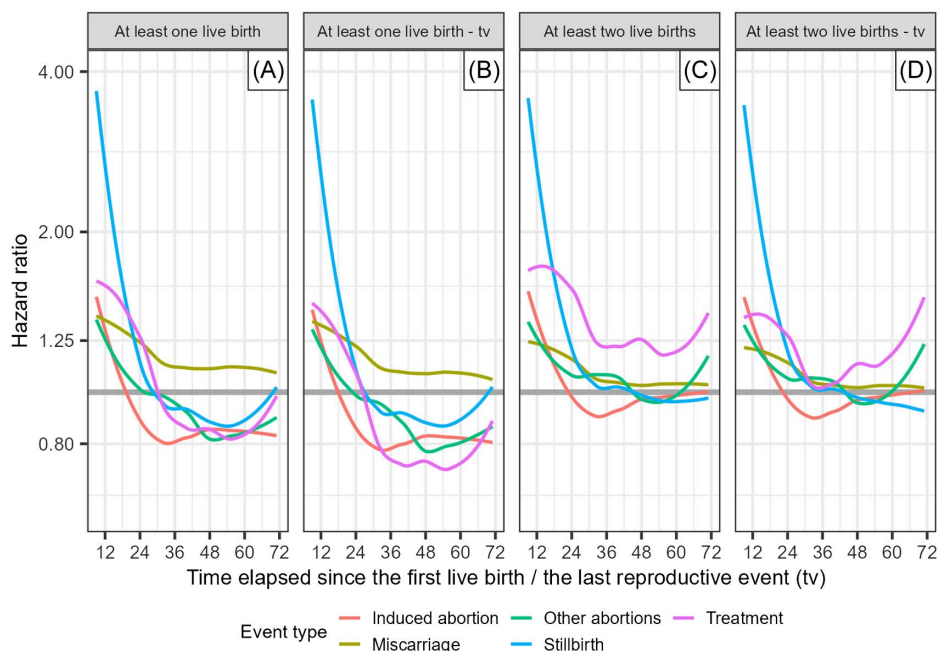
Note: “tv” refers to the model with time-varying covariates for events that occurred after the first live birth (panels B and D), for which the x axis shows the time elapsed from the last reproductive event, while in panels A and C, the x axis shows the time elapsed since the first live birth. The average hazard ratios are shown in the Supplementary material, [Table S.1](#) (M1, M2, M4 and M5). The smoothed splines comprise the results obtained from the complex model as presented in [Figure S.1](#) (reference categories: age 25, 1976 cohort and no other reproductive events before and after).

the models incorporating time-varying covariates, in which the time variation is taken into account for events that occurred after the first live birth, thus reflecting the HRs depending on the time since the last observed reproductive event (first live birth or other reproductive events). The two populations studied were distinguished as women with at least one live birth (panels A and B) and women with at least two live births (panels C and D).

Effects of age, cohort and other reproductive events on a second live birth, 1994–2022 reproductive trajectories

[Figure 1](#) presents the development of the HR for a second live birth by the time elapsed since either the first live birth or the last reproductive event, according to the mother’s age at the

Figure 3 Hazard ratios for a second live birth over the time elapsed since the first live birth or the last reproductive event by the type of event that occurred before the first live birth – smoothed splines

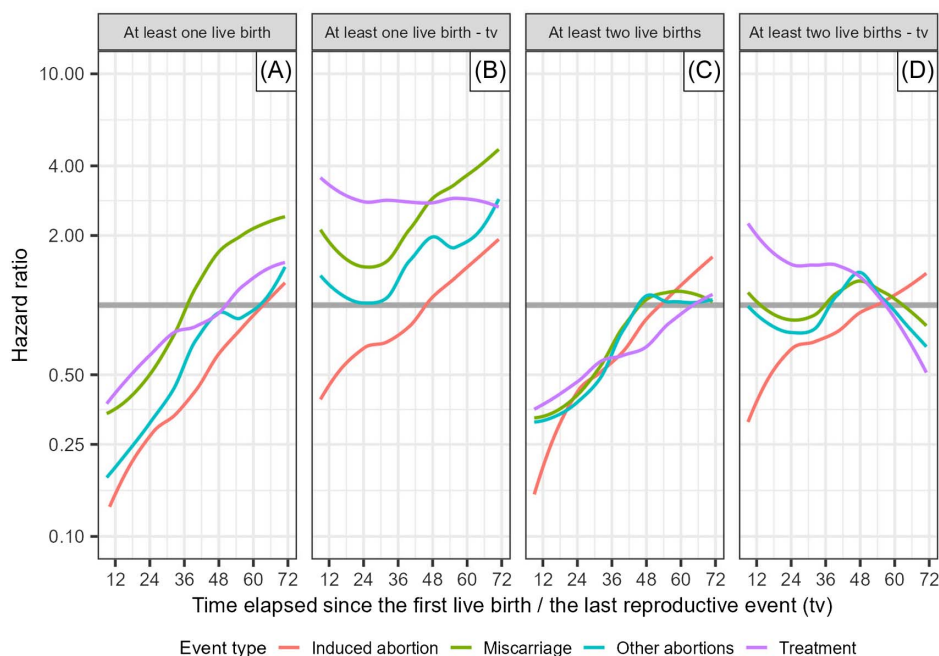


Note: “tv” refers to the model with time-varying covariates for events that occurred after the first live birth (panels B and D), for which the x axis shows the time elapsed from the last reproductive event, while in panels A and C, the x axis shows the time elapsed since the first live birth. The average hazard ratios are shown in the Supplementary material, Table S.1 (M1, M2, M4 and M5). The smoothed splines comprise the results obtained from the complex model as presented in Figure S.1 (reference categories: age 25, 1976 cohort and no other reproductive events before and after).

first live birth. The horizontal line of HR 1 represents the reference age of 25. For those women with at least one live birth (panels A and B), the HR of a second live birth peaked at between 24 and 36 months from the first live birth. The highest HR in this period was faced by women who had a first live birth at around the age of 28 (see also the Supplementary material, Table S.1). Women who had their first child at age 35 experienced the maximum HR for a second live birth slightly earlier (between 18 and 30 months). This shift in the maximum HRs – depending on whether the time was measured since the first live birth (panel C) or since the last reproductive event (panel D) – was even more evident for those women with at least two live births. The shift in the maximum indicates the shortening of the birth interval with increasing age at a first live birth, while the overall more intensive decline in the HR with time elapsed since a first live birth indicates the postponement effect.

These patterns held for both of the models, i.e. with and without the time-varying covariates for events following the first live birth.

Figure 4 Hazard ratios for a second live birth over the time elapsed since the first live birth or the last reproductive event by the type of event that occurred after the first live birth – smoothed splines

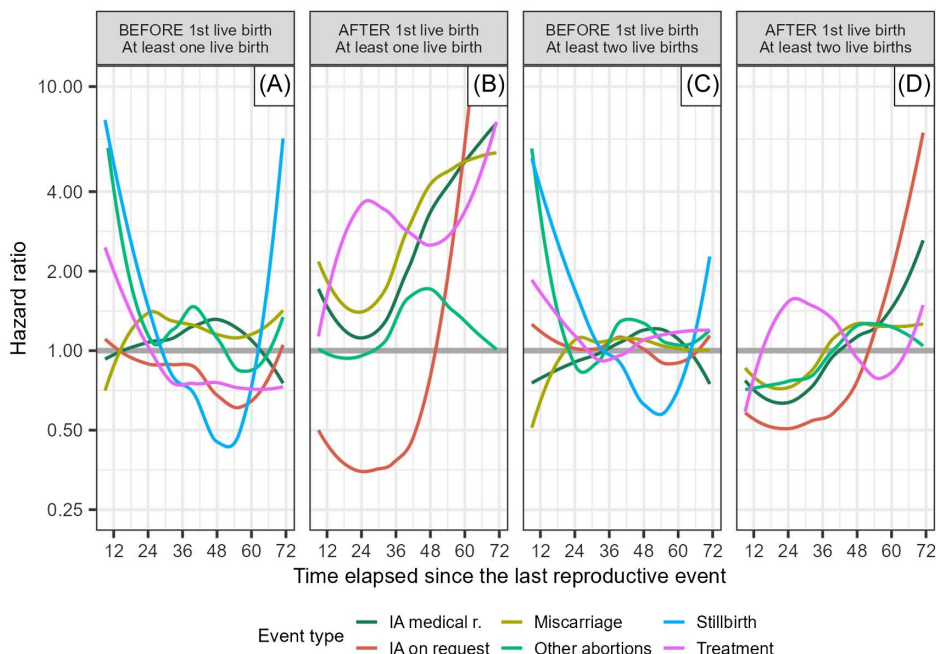


Note: “tv” refers to the model with time-varying covariates for events that occurred after the first live birth (panels B and D), for which the x axis shows the time elapsed from the last reproductive event, while in panels A and C, the x axis shows the time elapsed since the first live birth. The average hazard ratios are shown in the Supplementary material, [Table S.1](#) (M1, M2, M4 and M5). The smoothed splines comprise the results obtained from the complex model as presented in [Figure S.1](#) (reference categories: age 25, 1976 cohort and no other reproductive events before and after).

The average HRs of a second live birth further differed by cohort (see the Supplementary material, [Figure S.1](#)). The younger cohorts with at least two live births exhibited higher second live birth HRs, and thus the highest HR was achieved by the youngest (1992) cohort, whereas for women with at least one live birth, the highest HR for a second live birth was achieved by the 1982 cohort. This may have been due to the fact that many of the women in the younger cohorts had not yet had a second child, thereby lowering the overall HR for this broader group. Since the women in the 1991 cohort were just 31 years old in 2022, it is likely that many of them were still in the family formation process; thus, the full extent to which these women would transition to a second live birth was not yet reflected in the data.

[Figure 2](#) compares the HRs across the studied cohorts with respect to the time that elapsed from the first live birth/the last reproductive event. For those women with at least one live birth (panels A and B), the highest HRs for a second live birth were between 18 and 30 months for all the cohorts, with the exception of the 1979 cohort,

Figure 5 Hazard ratios for a second live birth over the time elapsed since the last reproductive event by the type of event that occurred BEFORE or AFTER the first live birth with respect to the type of induced abortion for the reproductive trajectories observed in 2016–2022 – smoothed splines



Note: All the models are with time-varying covariates for the event following the first live birth. The average hazard ratios are shown in the Supplementary material, Table S.1 (M3 and M6). The reference categories: age 25, 1976 cohort and no other reproductive events before and after.

among whom the HRs for a second live birth peaked slightly later and at lower levels. The 1979 cohort was also exceptional in terms of the overall pattern, i.e. the respective HR did not decline as sharply after 30 months for this cohort as it did for the younger cohorts. In contrast, among those women who had already had a second live birth (panels C and D), the HR was highest for the youngest cohort (1991) throughout the 12–72 months following the first birth/the last reproductive event. The results of the models with and without the time-varying covariates did not differ to such an extent that it affected the interpretation.

The average HRs (see the Supplementary material, Figure S.1) suggest that those reproductive events that occurred before a first live birth (referred to as BEFORE) had a lower impact on the HR for a second live birth than those that occurred after a first live birth (referred to as AFTER). In both models, regardless of whether the time variation of events that occurred after the first live birth was included, the results consistently showed that women with at least one live birth had a lower HR of having a second live birth within six years than those who already had two live births.

In the case of BEFORE events, this pattern may suggest that those women who had two live births interpreted any reproductive experience prior to their first live birth as a reason not to further postpone conception. However, concerning miscarriages, the opposite tendency was observed, which may indicate the presence of health-related barriers that lowered the HR for women with two live births compared to those with at least one live birth.

For women with at least two live births, experiences such as a miscarriage or stillbirth prior to the first live birth were associated with higher second live birth HRs than for women who reported no such experiences. In contrast, an induced abortion prior to a first live birth was associated with a lower HR, thus suggesting that this type of event was related to women with a higher likelihood of experiencing unplanned pregnancies and who probably had weaker fertility intentions.

Figure 3 compares the HRs according to another reproductive event before the first live birth with respect to the time elapsed since the first live birth/the last reproductive event (the reference line refers to no other reproductive event before the first live birth). The results show that experiencing a reproductive event before the first live birth accelerated the transition to a second child, especially within a short time of the first birth. The HR for a second live birth was higher than one for all the other types of reproductive events up to 18 months from the first live birth for women with at least one live birth. After 18 months, the women who had experienced an induced abortion had a lower HR for a second live birth than those who had no such experience. The only other event that exerted a positive impact on the HR for a second live birth over the observed period of 72 months from the first live birth/the last reproductive event was having experienced a miscarriage before the first live birth. The effect of a stillbirth, infertility treatment and other abortion differed between the women with at least one live birth (panels A and B) and the women who had already experienced a second live birth (panels C and D). For the women with at least one live birth, the HR for a second live birth equalled less than one after a period of 30 months, while for the women with two live births, the HR was observed to decline more gradually and remained at around one.

The nature of the relationship for the other reproductive events that occurred BEFORE a first live birth – both in comparison to the reference group and across the studied populations of women – remained consistent regardless of whether the time variation of events following the first live birth was included or not.

The average HRs for a second live birth associated with other reproductive events that occurred AFTER a first live birth (but before a second live birth) differed depending on whether the model accounted for the time variance (see the Supplementary material, Figure S.1). In the models that did not consider the time variance, all the HRs were below one (ranging from 0.4 to 0.8), thus indicating that experiencing a reproductive event following a first live birth was associated with a lower HR for a second live birth than not experiencing another reproductive event following a first live birth. This pattern was consistent both for the women with at least one live birth and for those who had already experienced a second live birth. However, the relationships between the HRs for these two populations varied depending on the type of event. Regarding induced and other abortions, the HR was lower for those women with only one live birth. In contrast,

concerning infertility treatment and miscarriage, the HR was lower for those women who already had two live births. This distinction highlights the division between those events that act as barriers to a planned second birth and those that may be the result of an unintended pregnancy.

The situation differed in the models that incorporated the time variance for an event that occurred following the first live birth, which allowed for the examination of the pace of the transition to a subsequent conception following another reproductive event. One of the key findings was that among the women with at least one live birth, the average HR for having another child was greater than one for all the events with the exception of an induced abortion. However, among the women who had already had two live births, only undergoing infertility treatment following the first birth was associated with an average HR of above one (Supplementary material, [Figure S.1](#)).

The time variance of an event following a first live birth further influenced the development of the HR with respect to the time that elapsed from the first live birth ([Figure 4](#)). In the models without time-varying covariates (panels A and C), the coefficients gradually increased from a very low HR (less than 0.5) over the elapsed time. Therefore, the HR for a second live birth increased with the time since the first live birth. However, the models incorporating time-varying covariates revealed a slightly different trend, especially with respect to infertility treatment, concerning which the HR for a second live birth remained stable over the time that elapsed since the last reproductive event (an average of 2.88) for those women with at least one live birth (panel B), and it decreased from a HR of around two (and declined to below one after 54 months) for those women with at least two live births (panel D). The experience of a miscarriage and other abortion was reflected in the finding that with the time that elapsed since such an event, the HR of a second live birth increased for those women with at least one live birth, and in cases in which a second live birth had already occurred, a decline was observed in the HR of between 12 and 36 months from an event that was subsequently compensated for by an increase of between 36 and 60 months.

Impacts of the reason for an induced abortion on a second live birth, 2016–2022 reproductive trajectories

Since the reason for having an induced abortion was recorded for those reproductive events that occurred after 2016, an additional analysis was conducted for those women whose first reproductive event of any type occurred after this year. The HRs by the maternal age at first birth and cohort were observed to be more extreme for this restricted sample than for the full sample that covered events that occurred from 1994 onwards, although the overall pattern remained consistent (Supplementary material, [Table S.1](#)). The main insight provided by this additional analysis was that elective induced abortions (performed at the woman's request) were primarily responsible for the trends observed in the full sample for all induced abortions ([Figure 5](#)). In contrast, induced abortions for medical or other non-elective reasons influenced the spacing of the first and the second live birth in a manner that more closely resembled that of miscarriages ([Figure 5](#)).

Discussion

The development of the HR for a second live birth based on the time elapsed since the first live birth/the last reproductive event revealed an interesting finding with respect to the phenomenon of fertility postponement and the two scenarios identified as responses to delayed reproduction: the postponement effect and the catch-up effect (Bratti and Tatsiramos, 2012). The HRs for the studied cohorts showed a shift in second live births closer to that for first live births from the 1976 cohort onwards, which is in line with current knowledge of reproductive behaviour across these cohorts in Czechia (Kocourková et al., 2022). This pattern can be interpreted as reflecting the catch-up scenario, according to which a portion of postponed births are realised within a shorter interval after the first birth, thereby accelerating the recuperation of fertility, a trend that has also been identified in other countries (Beaujouan et al., 2023). The patterns observed among the younger cohorts do not yet allow for a definitive assessment of cohort-specific differences in the transition to a second live birth. Although the HRs exhibit a broadly similar temporal pattern across cohorts, typically peaking between 18 and 36 months after the first live birth and declining thereafter, these similarities should be interpreted with caution. In particular, the more pronounced decline in HRs beyond 36 months observed among the younger cohorts may partly reflect the incomplete reproductive histories of these women, rather than a stable cohort effect.

Given that a substantial share of women in the younger cohorts had not yet reached the ages at which second births often occur, transitions taking place at longer durations since the first birth were likely underrepresented due to right-censoring.

Nevertheless, even after explicitly controlling for the maternal age at first birth, the cohort and experience of other reproductive events, robust patterns emerge. Fertility postponement scenarios are linked to the postponement of childbearing to more advanced ages across the cohorts. Our findings revealed that the shift in the maximum HR of having a second live birth closer to a first live birth (the catch-up effect), followed by the more pronounced decline in the HR with increasing age (the postponement effect), applied not only to advanced fertility ages, but across the whole of the reproductive age spectrum.

The evaluation of the impact of at most one other reproductive event before and at most one other reproductive event after the first live birth on the timing of a second live birth was conducted according to a set of predefined hypotheses. Hypotheses 1 and 2 focused on the impact of an induced abortion on the spacing of first and second live births. Regardless of whether the abortion occurred before or after a first live birth, with respect to both of the studied groups – women with only one live birth and those with two or more live births – an induced abortion was associated with a lower HR for a second live birth. Moreover, the HR for having a second child was lower for women with at least one live birth, thus suggesting that women who experienced an induced abortion were less likely to pursue the aim of having two children, potentially reflecting the postponement effect, though not exclusively. Nevertheless, the development of the HR within the time elapsed since the last reproductive event revealed that the HR was low in the first four years, after which it appeared to increase to compensate for the previous low level. An abortion that occurred between a first and a second live birth often reflected the poor timing of the pregnancy (i.e. conception occurring too soon after the previous birth), and thus a mistimed pregnancy rather than an unwanted

pregnancy, as other studies have shown (Väisänen, 2017; Lichtenstein Liljeblad et al., 2020; Barbuscia et al., 2024). Therefore, while an induced abortion was a factor in delaying a second childbirth, it did not necessarily mean that the woman had abandoned the aim of having a second child. The effect of an induced abortion varied according to the reason. The findings above applied to elective abortions performed at the woman's request, whereas abortions for medical reasons exhibited patterns similar to those of a miscarriage, as discussed below.

Our findings confirmed hypotheses 3 and 4 regarding the impact of infertility treatment. When treatment was provided before a first live birth, a higher HR (especially shortly after the first live birth) was observed for those women who successfully transitioned to a second live birth, thus suggesting the catch-up effect. This may be related to the fact that this group of women used stored gametes or embryos, which would have facilitated more rapid conception. An Australian study revealed that women who had a first child through ART had a relatively high chance of having a second child through ART (Paul et al., 2020). Our finding in this respect is novel; no other relevant studies have, to date, demonstrated that the interval between a first and a second live birth is shorter for women whose first pregnancy was achieved via in vitro fertilisation than for those who conceived naturally.

Hypotheses 5 and 6 were also confirmed. Women who experienced a miscarriage before a first live birth tended to have a higher ratio for a second live birth, especially within 36 months of the first live birth, thus suggesting the catch-up effect. In contrast, women who experienced a miscarriage after a first live birth typically exhibited a lower average HR for a second live birth with an increasing trend as the time since the first live birth elapsed. This supports a finding by Sapra et al. (2014) regarding prolonged periods of time to a subsequent conception. The results for the shorter period studied (2016–2022) revealed the similarity of the impact of a miscarriage with that of an induced abortion for medical reasons.

With respect to stillbirths before a first live birth, the HR for a second live birth was observed to be significantly higher during the first 18 months than for any other events. The potential impact of experiencing a stillbirth after a first live birth can only be discussed based on insights from previous research, given that no cases of a stillbirth between the first and the second live birth within six years of the first birth were reported in the data. Since stillbirth occurs late during pregnancy, it can reasonably be expected to result in a longer birth interval after a first live birth than that resulting from an induced abortion or miscarriage. However, this effect may be offset if the stillbirth occurred after a short interval following the previous birth given the elevated risks associated with short inter-pregnancy periods.

The main limitation of this study concerns the lack of information on the socioeconomic and demographic characteristics of the women that could have influenced the transition to a second child (e.g. education, partnership status, socioeconomic position, religiosity and factors related to the family of origin and socialisation experiences), as well as data on their health and lifestyle habits, such as obesity, smoking and use of contraception. These characteristics are of crucial importance since they shape both (1) intentions to have a second child; and (2) attitudes towards the use of reproductive services, particularly in situations in which reproductive outcomes involve individual choices, such as the decision to undergo

assisted reproduction or to terminate a pregnancy. Both dimensions ultimately affect reproductive behaviour, i.e. whether a second child is born at all, and, if so, when.

The aim of this analysis, however, was not to model the overall transition to a second live birth, but rather to assess the extent to which other reproductive events affect the timing of this transition. The omission of fertility intentions and background characteristics therefore primarily influences the timing of a second live birth for the reference group in the models (women without other reproductive events), whereas the estimated impacts of reproductive events on second birth timing are only indirectly affected since they are expressed relative to this group. Even events that might seem to reflect choice (assisted reproduction treatment, induced abortion) usually represent responses to unplanned or adverse circumstances, such as an unintended pregnancy, infertility or medical complications. Finally, potential biases stemming from differences in the socio-demographic composition and from cohort-related shifts in fertility timing (i.e. differences within the reference group) are mitigated via the inclusion in all the models of the age and the cohort as control variables.

Conclusion

This study contributes to the understanding of live birth spacing and reproductive behaviour by showing that the coping strategies associated with fertility postponement, i.e. the catch-up and postponement effects ([Bratti and Tatsiramos, 2012](#)), are not strictly related to a delayed transition to parenthood but are instead observed across the entire age spectrum. This factor broadens the theoretical relevance of these concepts beyond advanced maternal age alone.

As expected, our findings indicate that reproductive events that occur after a first live birth (and before a second live birth) generally contribute to extended spacing via delays due to unsuccessful conception or TTP. Nevertheless, overall, these events do not negatively influence the HR of a second live birth, i.e. they reflect only a delayed transition to a second live birth, and not the abandonment of the desire to have a second child. Interestingly, reproductive events that occur prior to a first live birth appear to exert the protective effect of delayed childbearing, particularly in the form of behavioural or motivational catch-up mechanisms once parenthood is initiated. This is observed to be valid with respect to experiencing a miscarriage or undergoing infertility treatment before a first live birth.

The study highlights the importance of disaggregating induced abortion according to the reason, since the women who undergo an elective abortion clearly display different reproductive behaviour than those who terminate for medical reasons. This distinction reflects findings from the register data that show that one in five abortions in Czechia is performed for medical reasons. Moreover, this subgroup of women is found to be more similar in terms of their reproductive behaviour following an induced abortion to women who experienced a miscarriage.

Overall, the findings confirm the relevance of reproductive events other than live births in terms of shaping the timing and realisation of second live births and demonstrate the analytical value of linking health register data to demographic theory.

Supplementary materials

Available online at <https://doi.org/10.1553/p-f6d9-zjjz>

Supplementary file 1. Figure S.1, Table S.1



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