

Multiple births in an era of assisted reproduction and delayed motherhood: Evidence from Czechia and an international comparison

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ABSTRACT

This article examines recent international trends regarding multiple births, with a specific focus on Czechia. It stresses the role of assisted reproductive technology (ART) along with the fertility postponement process. Employing internationally harmonised datasets and detailed Czech data on deliveries and live births, we firstly provide a comparative overview of long-term trends concerning twinning/multiple birth rates prior to and following the widespread use of ART. Based on anonymised individual-level data for Czechia, we explore the role of ART and the maternal age in determining the proportion of multiple births and the structure of newborns. Particular attention is devoted to differences according to the maternal age and the mode of conception (with and without the use of ART). The results revealed the substantial international heterogeneity of twinning rates as driven primarily by differences in national ART practices rather than the overall volume of ART treatment. Czechia represents the most common pattern, i.e. a rapid increase in the twinning rate from less than 10 twin deliveries per 1,000 deliveries in the early 1990s to more than 21 twin deliveries per 1,000 in 2010, followed by a rapid decline. Regulatory changes in Czechia that have promoted single embryo transfers since 2012 have led to a marked decline in the incidence of multiple births. However, women aged 35 and older accounted for a significant share of multiple live births conceived through ART; 18% of all multiples born to women aged 35–39, and 36% of those born to women aged 40 and over, were conceived via ART in 2020.

KEYWORDS

fertility; multiple births; twinning rate; ART; Czechia

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1. Introduction

The twinning rate, defined as the number of twin deliveries per 1,000 total deliveries (Human Multiple Births Database 2025), has almost doubled in many developed countries over the past forty years due primarily to the increasing age of mothers at birth and the increased use of medically assisted reproduction (MAR), i.e. hormonal treatment and assisted reproductive technology (Pison et al. 2015). According to Pison et al. (2015), the role of MAR is significant; in many developed countries, MAR explained a large proportion of the total change in the twinning rate that occurred between 1970 and 2005. The authors estimate that the contribution of MAR to the increase in twinning rates ranged widely – from 22% in Poland to 87% in Japan – with an estimated share of 56% in Czechia (Pison et al. 2015, pp. 640–641).

The increasing twinning and multiple birth rate represents an important public health concern in terms of the association of multiple pregnancies with maternal and neonatal risks, e.g. the higher risk of a preterm birth and a lower birth weight, the elevated risk of a Caesarean section delivery, more complications at birth than for single births, and the more frequent occurrence of prematurity and the associated occurrence of many long-term health problems, higher stillbirth and infant mortality rates, etc. (Fait et al. 2022; Marleen et al. 2024; Whittaker et al. 2023; Santana et al. 2016; Pison et al. 2015; Blondel et al. 2006). Therefore, concerns surrounding the impacts of MAR on multiple pregnancies has prompted regulatory changes and modifications to clinical practice, including reductions in the number of embryos transferred and the promotion of an elective single-embryo transfer strategy (ESHRE Guideline Group on the Number of Embryos to Transfer et al. 2024). These measures led to the stabilisation or decline of twinning rates in many developed countries in the 2000s, while in others, twinning rates have continued to rise over the past decade; considerable differences persist in terms of elective single-embryo transfer practice and adherence to expert recommendations varies from country to country (Pison et al. 2015; ESHRE Guideline Group on the Number of Embryos to Transfer et al. 2024). This divergence may have been influenced by the increased reliance on MAR in relation to fertility postponement, non-ART ovarian stimulation (concerning which the trends remain unclear, Pison et al. 2015), and the expansion of cross-border reproductive care (McKelvey et al. 2009).

This article examines multiple birth trends both internationally and focusing specifically on Czechia. We explore the role of assisted reproductive technology (ART), defined as all interventions that include the *in vitro* (outside the body) handling of human oocytes, sperm or embryos for the purpose of reproduction (Zegers-Hochschild et al. 2017), in shaping these trends, and highlight the combined impact of

reproductive ageing and the expansion in the use of ART since the 1990s. The central research question examines patterns in multiple births in connection with ART and policy measures – especially the promotion of single embryo transfer (SET).

Employing both internationally harmonised datasets and Czech data on multiple births and ART, we firstly present a comparative overview of long-term developments concerning twinning birth rates prior to and following the widespread use of ART. Secondly, we focus on Czechia as an example of a country that has seen a dynamic increase in ART-related fertility (Kocourková et al. 2023). We investigate the timing and impacts of specific policy intervention measures aimed at promoting single embryo transfer. We analyse, at the anonymised individual data level, the extent to which the observed trends – namely the increasing use of ART accompanied by a reduction in the share of multiple embryo transfers and the continued postponement of childbearing to older maternal ages – are reflected in the proportion of multiple births and the structure of newborns from multiple deliveries according to the maternal age and mode of conception (with and without the use of ART).

2. Theoretical background

Numerous studies have identified two key factors that influence the intensity of multiple pregnancies: the age of childbearing and the development of medically-assisted reproduction (MAR). Twinning rates related to spontaneous conception without the use of MAR are associated with the maternal age (Bønnelykke 1990) and certain other factors, e.g. Bulmer (1970) highlighted the birth order and region/country of birth, which partly reflects genetic differences (Hoekstra et al. 2008). Regarding the 1960s, i.e. prior to the widespread use of MAR, Pison et al. (2015) identified a pattern of steadily increasing twinning rates up to the maternal age at birth of 35–39 years, followed by a rapid decline at age 45 and over. Even though the pattern was similar in all the developed countries studied, higher rates were identified for England and Wales than in France, with significantly lower rates in Japan, due possibly to genetic differences; Japan exhibits differing monozygotic twin and dizygotic twin patterns depending on the age of the mother. Prior to 1970, the monozygotic twin birth rate was consistent across maternal ages, birth orders and geographic origin, historically ranging from 3.5 to 4.5 per 1,000 deliveries (Bortolus et al. 1999; Bulmer 1970). In contrast, dizygotic twinning rates vary significantly based on maternal (age, parity) and region factors; the lowest rates have been determined for East Asia and Latin America (2–4 per 1,000) and the highest rates in sub-Saharan Africa (15 per 1,000), with intermediate rates in Europe and the US (7 per 1,000) (Hoekstra et al. 2008; Smits and Monden 2011).

Given the significant increase in the maternal age in developed countries since the 1970s (Frejka and Sobotka 2008), the question of the impact of ART, which acts to increase dizygotic twinning rates due to the transfer of two or more embryos, on the increase in twinning rates in developed countries is of significant importance. The proportion of single embryo transfer cycles at the end of the 1990s for those European countries that reported to ESHRE (The European IVF-Monitoring Consortium (EIM) for the European Society of Human Reproduction and Embryology [ESHRE] et al. 2023) comprised a mere 10% of all fresh in vitro fertilisation (IVF)/intracytoplasmic sperm injection (ICSI) cycles, while two and three embryo transfer cycles each accounted for approximately 40% of treatment cycles. Subsequently, the proportion of transfers involving three or more embryos declined steadily. In contrast, the proportion of two-embryo transfers increased and remained stable over the medium term at around 55% of all IVF/ICSI cycles; however, from 2014 onwards the proportion declined continuously to reach around 40% in 2019 (EIM for ESHRE et al. 2023). At the same time, the share of single embryo transfers increased – from slightly above 10% in the late 1990s to more than 55% in 2019 (EIM for ESHRE et al. 2023). As the number of embryos transferred per cycle progressively declined, the global proportion of twin and triplet births decreased accordingly. In 2019, the twin and triplet delivery rates following fresh IVF and ICSI cycles stood at 12.0% and 0.3%, respectively, compared to 26% and 3.5%, respectively in 1997. A similar downward trend was also observed for frozen embryo transfers (FET) (EIM for ESHRE et al. 2023).

While the overall number of embryos transferred per IVF/ICSI cycle has steadily decreased across Europe, significant differences between countries persist. In the late 1990s, countries such as Czechia, Greece and Spain exhibited the highest triple and quadruple embryo transfer rates – up to 76% – compared to 5–10% in Sweden and Finland (Kocourková, Fait 2009). In 2019, most countries reported single embryo transfer rates in excess of 50%, with some (e.g. Iceland and Finland) exceeding 95%; nevertheless, a small number of countries continue to report two and more embryo transfer rates of over 60% of all fresh IVF/ICSI cycles (e.g. Germany, Greece) (EIM for ESHRE et al. 2023).

Compared to the relatively well-documented field of assisted reproductive technology (ART), which is often covered by both international and national registries, significantly less information is available on fertility and children born following other forms of hormonal treatment, even though their contributions to the total number of births is significant. For instance, a study by Blondel et al. (2012) revealed that in France in 2010, 2.3 percent of children were conceived via ovulation induction (i.e. non-ART

methods), identical to the percentage of children conceived through in-vitro fertilisation.

In recent decades, trends concerning multiple births have reflected the complex interplay between increasing maternal ages, broader societal changes and medical intervention, particularly assisted reproductive technology (ART). Building upon this context, this paper examines trends in the development of twinning/multiple birth rates and focuses in detail on Czechia via the analysis of the roles of legislative changes/professional guidelines and the maternal age in terms of shaping these trends.

2.1 Availability and public coverage of ART in Czechia

An age limit of 50 years was introduced in Czechia for access to assisted reproductive technology (ART) in 2012. However, legislation introduced in 1997 already provided for at least the partial reimbursement of ART costs for women under the age of 39 for up to three treatment cycles. A significant shift occurred in April 2012, when legislation explicitly encouraged the single embryo transfers via the extension of reimbursement to a maximum of four treatment cycles on the condition that only a single embryo is transferred during the first two cycles. Since 2022, ART treatment costs have been covered by the public health insurance system up to a woman's 40th birthday. However, the reimbursement of ART treatment costs by the statutory health insurance system excludes certain modern laboratory techniques (Kocourková et al. 2023).

ART in Czechia is limited to women who are able to provide written consent from a male partner, thus excluding single women and same-sex couples. Nevertheless, the number of ART cycles per woman of reproductive age in Czechia is one of the highest in Europe (EIM for ESHRE et al. 2023), largely due to cross-border reproductive care for foreign women who travel to Czechia to undergo ART treatment (Volejníková et al. 2025).

3. Data and methods

3.1 Data sources

We employed data obtained from various sources. For international comparison purposes, we relied on data on multiple deliveries obtained from the Human Multiple Births Database (HMBD) and on data on ART obtained from the European Society of Human Reproduction and Embryology (ESHRE), which is freely available. The HMBD (<https://www.twinbirths.org/>) provides demographic data on twin and higher-order multiple births. It contains annual statistics on deliveries by multiplicity – it distinguishes between singleton and multiple deliveries – and, where available,

provides details of the number of children born in multiple deliveries (twin deliveries, triplet deliveries, etc.). The database further includes indicators of the twinning and multiple birth rates, defined as the number of twin or multiple deliveries per 1,000 total deliveries each year (Torres et al. 2023). Twin deliveries account for the vast majority of multiple deliveries – e.g. 97.9% in France in 2010–2015 (Torres et al. 2023), 99% in Czechia (Němečková 2016). Therefore, this article considers both indicators – multiple deliveries in general and, in certain sections, twin deliveries specifically for international comparison purposes.

We employed data from May 2025, at which time the Human Multiple Births Database included information on 25 national populations across Europe, the Americas, Oceania and Asia. We focused exclusively on data from European countries for the period 1950–2022 for the purposes of this analysis. Most countries report data on total births, including both live births and stillbirths. For more information on the data collection approach and the database methodology, see Torres et al. (2023). While the inclusion of stillbirths in reported deliveries varies, most countries report deliveries including stillbirths; whenever both classifications were available, we employed data that included stillbirths in the analysis.

Concerning the use of ART, we employed data that is collected and published annually by the European Society of Human Reproduction and Embryology (ESHRE, <https://www.eshre.eu/>) in “ART in Europe: results generated from European registries by ESHRE” journal articles, accompanied by a series of detailed tables. Data was provided by 40 European countries in 2019 covering ART treatment that commenced between 1 January and 31 December 2019. The data on deliveries cover the outcomes of treatment performed in 2019 (EIM for ESHRE et al. 2023). This approach differs from the publication of data by the HMBD and the Czech Statistical Office (CZSO) for Czechia (see below), which considers births that occur within a given calendar year. The number of countries displayed in each graph varied since their inclusion depended on the completeness of the data obtained from the two sources, i.e. the HMBD and ESHRE. Neither source covers all European countries, and in the case of ESHRE, not all countries report data from all the clinics in the respective country. Some countries do not report certain data at all, or they report data only from a subset of clinics. More detailed information on the scope of the data presented is provided in the notes below each graph.

Data obtained from the Czech Statistical Office (CZSO) were employed for the detailed analysis of the situation in Czechia. The analysis focused on births according to multiplicity, regardless of whether the children were born alive or stillborn; births according to multiplicity and the maternal age were also considered. The main source comprised the CZSO

Demographic Yearbook for the period 1955–2023, specifically the “Births and Children Born from Twins and Triplets by Sex and Mother’s Age” table (https://csu.gov.cz/casova_rada_demografie).

Moreover, we employed data on fertility obtained from the Czech Statistical Office and data on ART from the National Register of Assisted Reproduction for the detailed study of children born in twin deliveries according to the maternal age and the role of ART treatment. We considered individual level data stored in the National Register of Reproduction Health, managed by the Institute of Health Information and Statistics of the Czech Republic (IHIS CZ). The reporting of data on ART cycles is compulsory for all reproductive centres/clinics according to legislation introduced in 2006 (IHIS CZ 2022). We employed individual-level data for the period 2013–2020 obtained from the National Register of Assisted Reproduction that was subsequently linked via the women’s birth identification numbers aimed at identifying those mothers who gave birth following an embryo transfer in Czechia. We excluded all the ART cycles of foreign women who received cross-border reproductive care in Czechia that were included in the National Register of Assisted Reproduction, since such live births do not form a part of the vital statistics data on live births in Czechia. ART live births were considered to be live births following an embryo transfer that occurred within a maximum of 40 weeks prior to the date of birth.

3.2 Methods

This article combines a variety of data sources aimed at illustrating both the overall situation and trends in multiple births, both internationally and in detail for Czechia; thus, it employs a range of indicators. The individual indicators and the formulas are presented below. The two main analytical approaches applied in the article comprise: a) the analysis of deliveries, and b) the analysis of live births. We therefore distinguished whether the input data refers to deliveries or to live-born children in the formulas. Since demography conventionally works with live births, in accordance with established international practice, we denoted them as N^v . In the case of deliveries, we provide the term in full in the formulas so as to avoid confusion.

Two indicators were used for the analysis of multiple-birth patterns – the twinning rate and the multiple birth rate. We followed the HMBD definition and defined the twinning rate as:

$$\text{Twining rate} = \frac{\text{Deliveries}^{\text{Twins}}}{\text{Deliveries}} \times 1000$$

And, with respect to the twining rate, more specifically by the age group of women at delivery defined as:

$$\text{Twining rate}_x = \frac{\text{Deliveries}_x^{\text{Twins}}}{\text{Deliveries}_x} \times 1000$$

where x comprises the –24 years, 25–29 years, 30–34 years, 35–39 years and 40+ years age groups. Three-year moving averages were used to smooth any significant year-to-year fluctuations – particularly for those age groups with relatively low numbers of births.

Similarly, we defined the multiple birth rate as the number of multiple deliveries per 1,000 total deliveries:

$$\text{Multiple birth rate} = \frac{\text{Deliveries}^{\text{Multiple}}}{\text{Deliveries}} \times 1000$$

With regard to the analysis of live births, we used the multiple birth rate in relation to the use of ART methods indicator, defined as the number of ART multiple live births per 1,000 ART live births (4) and the number of non-ART multiple live births per 1,000 non-ART live births (5).

$$\text{Multiple birth rate}^{\text{ART}} = \frac{N^{\text{v, ART, multiple}}}{N^{\text{v, ART}}}$$

$$\text{Multiple birth rate}^{\text{nonART}} = \frac{N^{\text{v, nonART, multiple}}}{N^{\text{v, nonART}}}$$

Furthermore, we calculated the shares of live-born children from multiple pregnancies disaggregated by the use of ART for all children from multiple pregnancies:

$$\text{Share of multiple births}^{\text{ART}} = \frac{N^{\text{v, ART, multiple}}}{N^{\text{v, multiple}}}$$

$$\text{Share of multiple births}^{\text{nonART}} = \frac{N^{\text{v, nonART, multiple}}}{N^{\text{v, multiple}}}$$

We used the indicator published by the European Society of Human Reproduction and Embryology

(ESHRE) – the number of ART cycles per 1 million females of reproductive age in each country for the international comparison of the prevalence of ART across countries. This indicator is published and presented in our analysis only for those countries that report data to ESHRE from all clinics in the respective country since the accuracy of the analysis depended on the calculation of the indicator only for countries that fully register the provision of ART treatment.

4. Results

4.1 Twinning rates in European countries and links to the use of ART

A significant increase in the proportion of twin births has been observed in European countries (Fig. 1) since the early 1990s, prior to which the share of twin births was generally in decline. This trend was associated with decreasing higher-order fertility, which led to a gradual decline in the mean age of mothers at childbirth (Human Fertility Database 2025). Moreover, European populations exhibited a relatively homogeneous pattern in terms of the prevalence of twin births before the 1990s, especially when compared to the divergence that emerged after 1990 (Fig. 1).

From the 1990s onwards, significant advances were made in assisted reproductive technology (ART) with respect to the volume, techniques and quality of care. In addition, differences in national practices – in terms of both the use of ART and the number of embryos transferred per cycle comprised

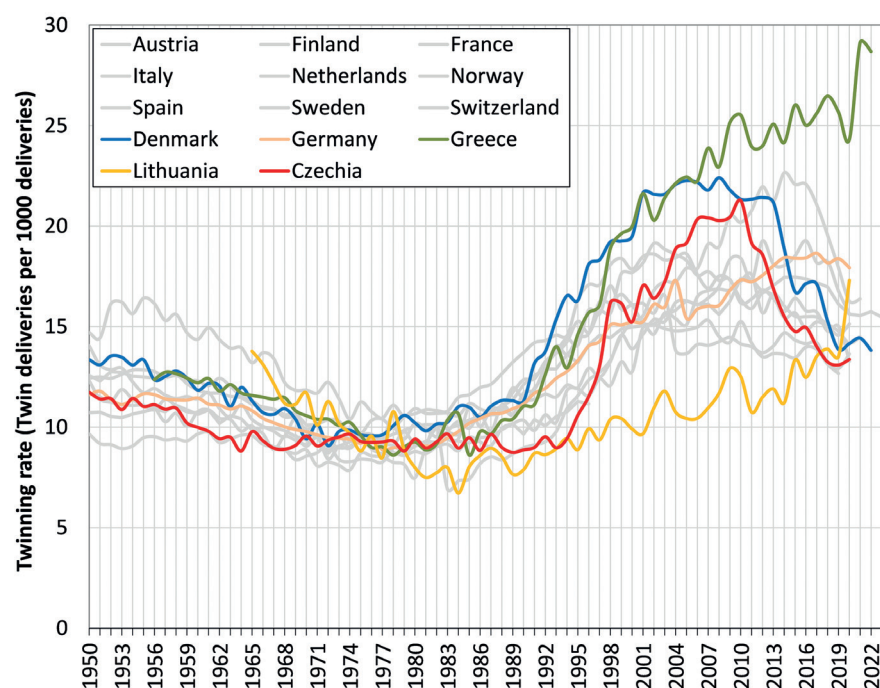


Fig. 1 Twinning rates in selected European countries 1950–2022.
Source: The Human Multiple Births Database (2025).

the principal drivers of the growing heterogeneity of twinning rates across European countries (Fig. 1). Figure 1 shows that Lithuania exhibits a persistently low twinning rate, which exceeded 15 twin deliveries per

1,000 deliveries only as recently as in 2020. Conversely, Greece experienced a sharp and sustained increase in the twinning rate during the 1990s. Unlike several other countries that have adopted more restrictive

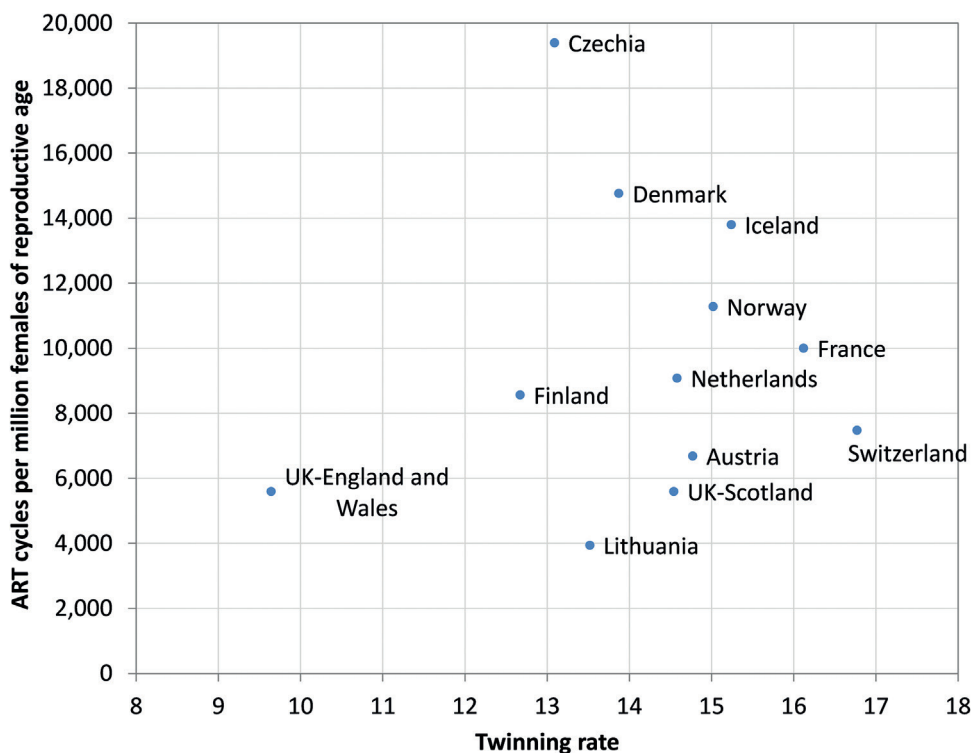


Fig. 2 Twinning rates and number of ART cycles per 1 million females of reproductive age, selected European countries, 2019.

Source: The Human Multiple Births Database (2025) and EIM for ESHRE et al. (2023).

Note: only those countries that reported events at all clinics to the national register of ART in 2019.

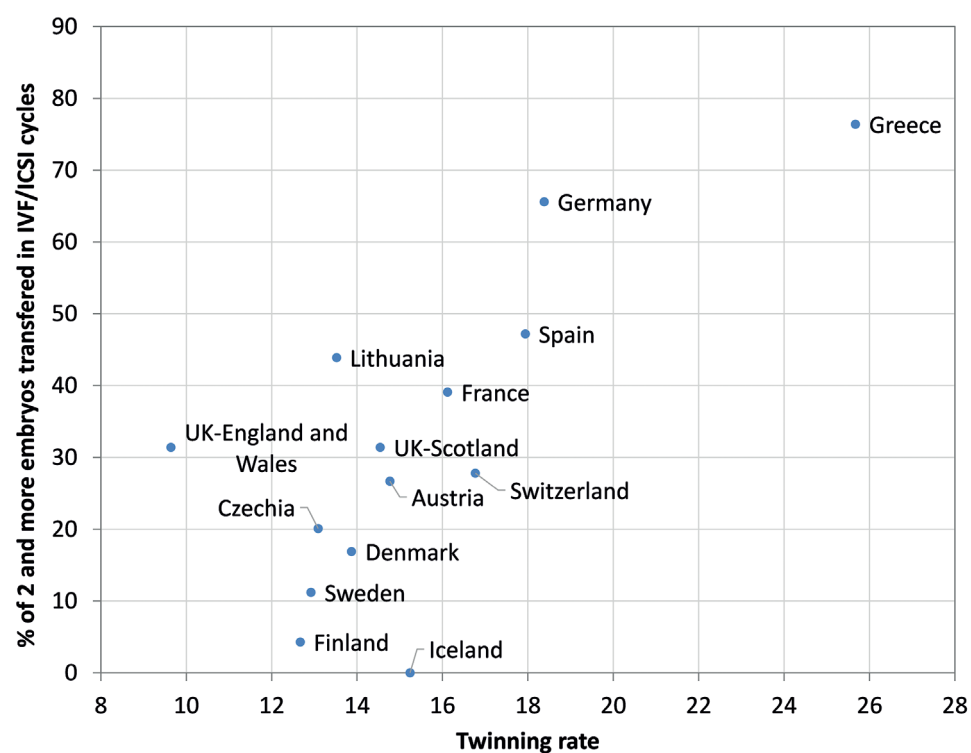


Fig. 3 Twinning rates and the proportion of 2+ embryos transferred in one IVF/ICSI cycle, selected European countries, 2019.

Source: The Human Multiple Births Database (2025) and EIM for ESHRE et al. (2023).

embryo transfer policies since the 1990s, the upward trend in Greece has not slowed significantly and the twinning rate is currently approaching 30 twin deliveries per 1,000 deliveries.

Czechia and Denmark (Fig. 1) shared a common pattern that was observed in many other countries, i.e. a rapid and pronounced initial increase in the twinning rate, which began to decelerate in the early 2000s. The slowdown coincided with the intensification of the professional discourse on, and the gradual implementation of, single embryo transfer policies specifically aimed at reducing the incidence of multiple births and the associated elevated health risks for both mothers and infants. In many countries, this shift – driven by both the medical community and, in part, by legislation – led to the stabilisation of, and in some cases, such as in Czechia and Denmark, to a relatively rapid decline in twinning rates.

The twinning rates currently observed in high-income countries are largely influenced by the expanding use of ART. However, as illustrated in Figures 2 and 3, the overall extent of ART use, as measured by the number of ART cycles per one million women of reproductive age (Fig. 2), is not the primary differentiating factor. Countries with vastly different levels of ART provision may exhibit very similar twinning rates. For example, Czechia, where the high volume of ART services provided is partly attributable to a significant share of foreign women seeking cross-border reproductive care (Volejníková et al. 2025), exhibits the highest level of ART provision relative to the population of women of reproductive age, but only

average twinning rates. Indeed, the variations in twinning rates between countries appear to depend to a significant extent on clinical practice, specifically the proportion of cycles involving the transfer of more than one embryo (Fig. 3). For example, more than half of IVF/ICSI cycles provided in Germany and Greece, which report some of the highest twinning rates of the countries analysed, involve the transfer of two or more embryos. Conversely, twinning rates are considerably lower, i.e. typically around 13 to 15 twin deliveries per 1,000 deliveries, in countries in which multiple embryo transfers account for fewer than one-third of IVF/ICSI cycles.

4.2 Czechia – long term trends in the twinning rate focusing on the roles of age and ART

The most pronounced impact of the growing use of ART on the twinning rate was observed in Czechia in the 1990s and the first decade of the new millennium, at which time the twinning/multiple birth rate increased rapidly, with a notable rise in both the number and proportion of multiple births. At the beginning of the 1990s, the twinning rate stood at around 9 twin deliveries per 1,000 deliveries (Fig. 4). By the end of the 1990s, it had doubled, reaching its peak in 2010 at 21 twin deliveries per 1,000 deliveries. Although the sharp rise in the mean age of mothers at birth may also have contributed to the growing incidence of multiple births during the second half of the 1990s, the decisive factor at that time concerned the increasing use of ART and the high proportion of ART cycles

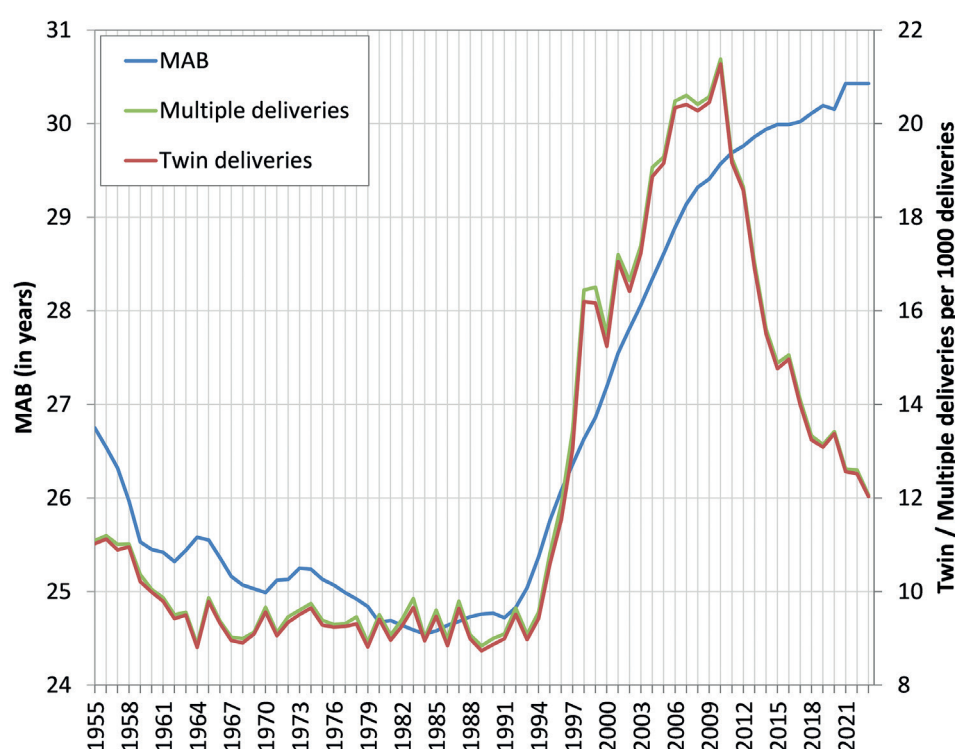


Fig. 4 Mean age at birth (MAB), twinning rate and multiple birth rate, Czechia, 1955–2023.

Source: CZSO (2025), authors' calculations.

involving the transfer of multiple embryos. According to long-term ESHRE statistics, only 10% of IVF/ICSI cycles involved the transfer of a single embryo in Czechia at the end of the 1990s, while the remaining 90% of cycles involved the transfer of multiple embryos – most commonly three or more embryos (76.2% in 1997 and 70.9% in 1999) (The European IVF-monitoring programme [EIM], for the European Society of Human Reproduction and Embryology [ESHRE] 2000; Nygren et al. 2001; Nygren et al. 2002).

The proportion of single embryo transfers subsequently increased gradually; however, the most significant change occurred following a change in public health insurance reimbursement legislation in April 2012, whereby the number of reimbursed cycles was increased from three to four provided that only one embryo was transferred during each of the first two cycles (Kocourková et al. 2015). While in 2009 single embryo transfers accounted for one-fifth of all fresh IVF/ICSI transfers, by 2011 the proportion had risen to 29%, and in 2012 it jumped sharply year-on-year to 47.4% (Ferraretti et al. 2013; The European IVF-Monitoring Consortium [EIM] for the European Society of Human Reproduction and Embryology [ESHRE] for the European Society of Human Reproduction and Embryology [ESHRE] et al. 2016b; The European IVF-Monitoring Consortium [EIM] for the European Society of Human Reproduction and Embryology [ESHRE] et al. 2016a). By 2019, the share of single embryo transfers of IVF/ICSI cycles had reached 80% (EIM for ESHRE et al. 2023). In contrast, transfers of

three or more embryos gradually declined to 2.9% in 2012 and just 0.2% of IVF/ICSI cycles in 2019 in Czechia (EIM for ESHRE et al. 2016a; EIM for ESHRE et al. 2023). The changes in clinical practice, supported by the change in reimbursement conditions, were immediately reflected in the proportion of multiple deliveries, even though the mean age at birth continued to rise (Fig. 4). After reaching a peak of 21.4 multiple deliveries per 1,000 deliveries in 2010, a significant decline was observed to 12 per 1,000 in 2023 (Fig. 4).

A closer investigation revealed that the twinning rate varied significantly across maternal age groups, and the sharp increase observed in the second half of the 1990s did not apply uniformly across all age groups (Fig. 5). The lowest twinning rates were determined for women under the age of 25, with only a minimal increase during the 1990s. This pattern reflects the fact that the use of ART by this age group is relatively rare (Kocourková et al. 2023). In contrast, women aged 30–39 evinced the highest twinning rates; moreover, this group also experienced the most substantial growth in the twinning rate in the late 1990s. Between the early 1990s and 1999, the twinning rate in this group almost doubled – from under 15 twin deliveries per 1,000 deliveries to 26 per 1,000 deliveries for women aged 30–34, and to 30 per 1,000 deliveries for those aged 35–39.

Regarding women aged 40 and over, the twinning rate exhibited considerable fluctuation – even when applying a three-year moving average – due to the

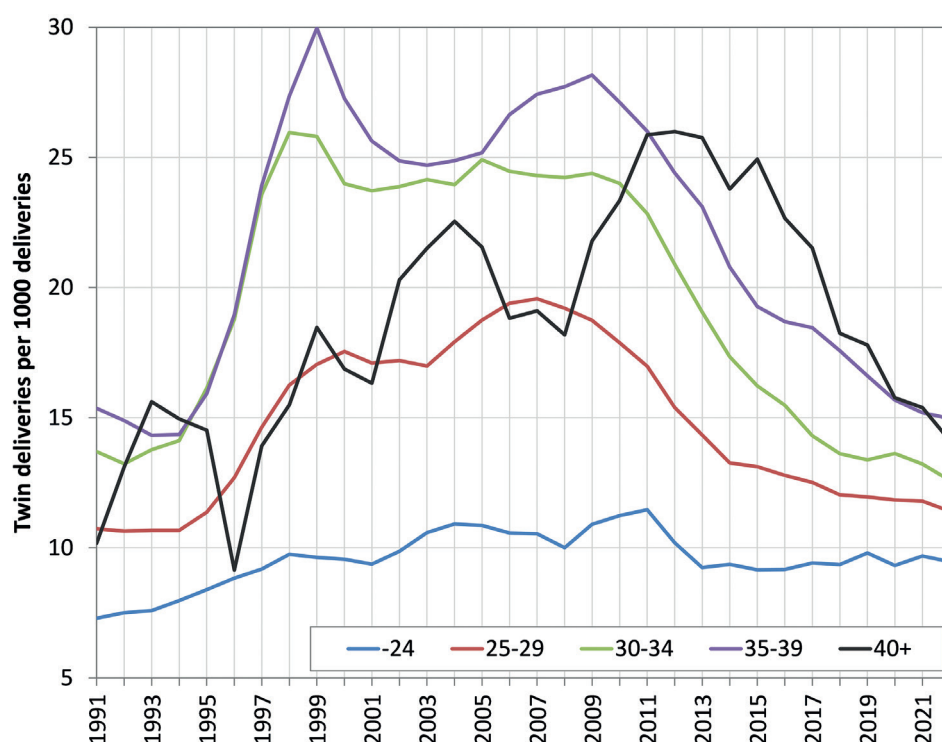


Fig. 5 Twinning rate by the age group of mothers, Czechia, 1990–2023, 3-year moving average.
Source: CZSO (2025), authors' calculations.

relatively low number of births to women in this age group. Despite the volatility, an upward trend was observed up to around 2015 driven largely by the increasing number of ART cycles provided for women aged 40+ (IHIS CZ 2022; Kocourková et al. 2023), even though this group was no longer entitled to claim reimbursement from the public health insurance system for ART treatment.

Towards the end of the observation period, a gradual decline in the twinning rate was observed across all the 25+ age groups to between 12 to 15 twin deliveries per 1,000 deliveries.

4.3 The role of ART and the maternal age in the structure of newborns from multiple deliveries

The analysis of live births provided a more detailed insight into the impact of ART. Employing anonymised individual-level data for Czechia covering live births in the period 2013–2020, we investigated the relationship between the use of ART and the share of children born from multiple pregnancies, as well as the structure of newborns by the age of the mother and the mode of conception (with and without the use of

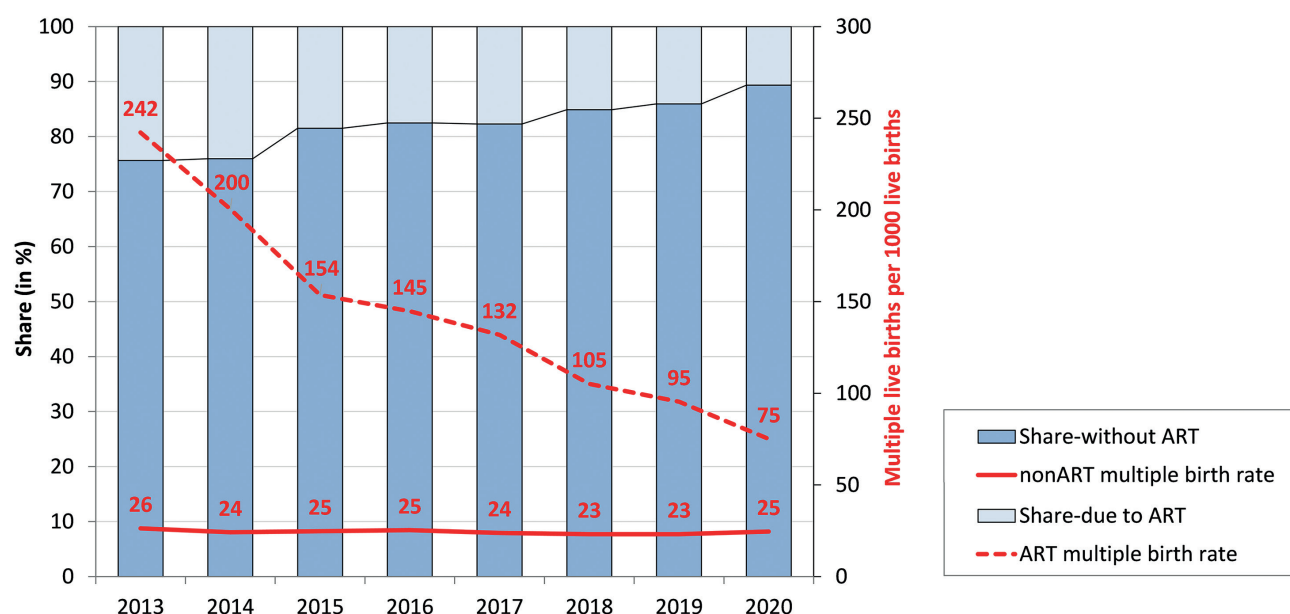


Fig. 6 Multiple live births according to ART use (in %) and the multiple birth rate (non-ART multiple births per 1000 non-ART live births and ART multiple births per 1000 ART births), Czechia, 2013–2020.

Source: authors' calculations.

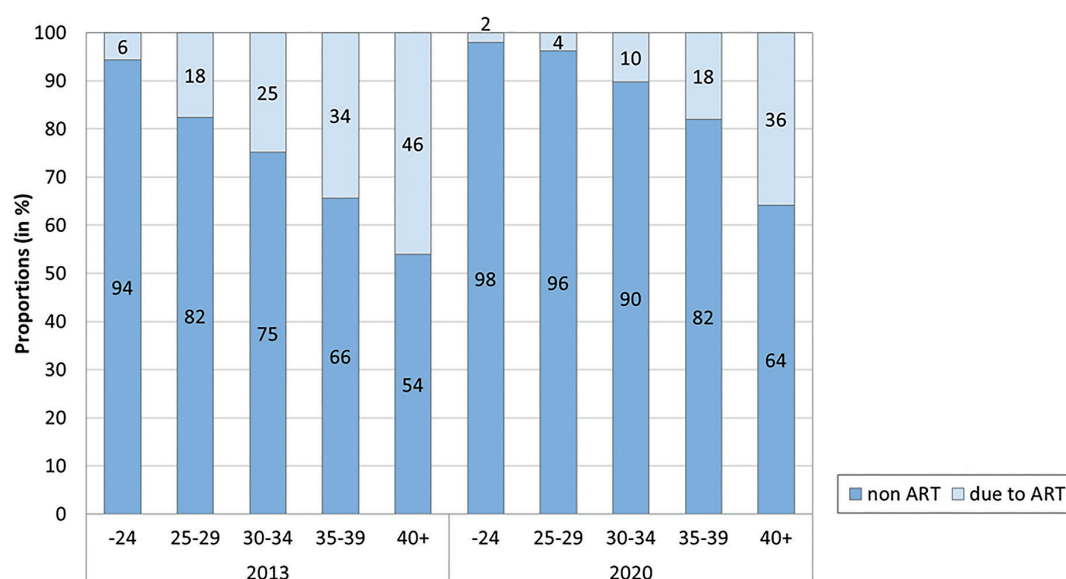


Fig. 7 Multiple live births according to ART use and age of the mother at birth, Czechia, 2013 and 2020 (in %).

Source: authors' calculations.

ART). We focused in detail on the period from 2013, for which detailed individual-level data are available, thus allowing for the analysis of live births according to whether conception followed the use of ART or not (for more details on fertility with and without ART, see Kocourková et al. 2023). This period covered those years in which significant changes in medical practice regarding embryo transfer came into full effect, supported by the amendments to public health insurance reimbursement legislation introduced in 2012.

As a result, the proportion of ART-multiple live births of all multiple live births decreased from 24.3% in 2013 to 10.7% in 2020 (Fig. 6). Similarly, the ART multiple birth rate decreased by more than two-thirds – from 242 multiple births per 1,000 total live births following ART in 2013 to 75‰ in 2020. In contrast, the non-ART multiple birth rate remained unchanged (23–26 multiple births per 1,000 total live births without ART).

Fig. 7 shows that with regard to multiple births, the proportion conceived following ART treatment varied markedly by the maternal age. Not only was the overall incidence of multiple births lower for young mothers (see Fig. 5), but more than 90% were conceived without ART treatment. With increasing maternal ages, multiple births conceived via ART accounted for a progressively higher share of all multiple live births. However, the impact of policies that limited the transfer of more than one embryo is also evident over the observed time period. In 2013, nearly half of all multiples born to women aged 40 and over were conceived via ART, and multiple births due to ART represented approximately one-third of all multiple births for women aged 35–39 years. By 2020, the proportions had declined to 36% and 18%, respectively (Fig. 7).

5. Conclusions

This study examined trends in the incidence of twin and multiple births in the international comparative context, focusing particularly on Czechia. We explored the interplay between the expansion of assisted reproductive technology (ART) since the 1990s and the subsequent promotion of single embryo transfer. The results revealed substantial heterogeneity in terms of the evolution of twinning rates across countries. While Czechia was found to be one of a number of countries in which the promotion of single embryo transfer in clinical practice was followed by a rapid decline in the twinning rate, other European countries displayed markedly different trends – ranging from stagnation (e.g. Germany) to a continuous increase in twin births up to the present day (e.g. Greece). The analysis indicated that the significant variation between countries was driven primarily by differences in national ART practices, including the prevalence of multiple embryo transfers over single embryo transfers, rather than the overall volume of

ART care provided. It was also most likely influenced by the role of non-ART medically-assisted reproduction (Pison et al. 2015), which we were unable to examine due to the limited availability of statistics on MAR methods other than in vitro fertilisation.

The 2012 revision of reimbursement legislation in Czechia, which linked an increase in the number of ART cycles subsidised by the public health insurance system to single embryo transfers in the first two attempts, led to a sharp rise in the share of single embryo transfers and the almost complete elimination of transfers involving three or more embryos (Ferraretti et al. 2013; EIM for ESHRE et al. 2016a; EIM for ESHRE et al. 2016b; EIM for ESHRE et al. 2023). These changes in clinical practice were quickly reflected in a substantial decline in the twinning rate, which fell from a peak of 21.4 per 1,000 deliveries in 2010 to 12 per 1,000 in 2023.

Despite the overall decline in the number of ART-related multiples in Czechia, the results of the study highlight the marked heterogeneity of multiple birth rates across maternal age groups: the lowest and most stable rates were observed for women under 25, while women aged 30 and over consistently recorded the highest rates. The analysis of live births revealed that, despite the decline in the overall number of multiple births, women aged 35 and over accounted for a substantial share of multiple live births conceived via ART; as recently as in 2020, 18% and over one-third of multiple live births resulted from ART treatment concerning the 35–39 and 40+ age groups, respectively.

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References

- Blondel, B., Macfarlane, A., Gissler, M., Breart, G., Zeitlin, J. (2006): General obstetrics: Preterm birth and multiple pregnancy in European countries participating in the PERISTAT project. *An International Journal of Obstetrics & Gynaecology* 113(5), 528–35, <https://doi.org/10.1111/j.1471-0528.2006.00923.x>.
- Blondel, B., Lelong, N., Kermarrec, M., Goffinet, F. (2012): Trends in perinatal health in France from 1995 to 2010. Results from the French National Perinatal Surveys. *Journal de Gynécologie Obstétrique et Biologie de la Reproduction* 41(4), e1–e15, <https://doi.org/10.1016/j.jgyn.2012.04.014>.
- Bønnelykke, B. (1990): Maternal Age and Parity as Predictors of Human Twinning. *Acta geneticae medicae et gemellologiae: twin research*, 39(3), 329–34, <https://doi.org/10.1017/S0001566000005237>.
- Bortolus, R., Parazzini, F., Chatenoud, L., Benzi, G., Bianchi, M. M., Marini, A. (1999): The epidemiology of multiple

- births. *Human Reproduction Update* 5(2), 179–187, <https://doi.org/10.1093/humupd/5.2.179>.
- Bulmer, M. G. (1970): *The Biology of Twinning in Man*. Oxford: Clarendon Press, 205 p.
- CZSO (2025): Demographic Yearbook, table Births and Children Born from Twins and Triplets by Sex and Mother's Age. Available online: https://csu.gov.cz/casova_rada_demografie (accessed on 1 January 2025).
- ESHRE Guideline Group on the Number of Embryos to Transfer, Alteri, A., Arroyo, G., Baccino, G., Craciunas, L., De Geyter, Ch., Ebner, T., Koleva, M., Kordic, K., Mcheik, S., Mertes, H., Pavicic Baldani, D., Rodriguez-Wallberg, K. A., Rugescu, I., Santos-Ribeiro, S., Tillemann, K., Woodward, B., Vermeulen, N., Veleva, Z. (2024): ESHRE guideline: number of embryos to transfer during IVF/ICSI. *Human Reproduction* 39(4), 647–657, <https://doi.org/10.1093/humrep/deae010>.
- Fait, T., Štátná, A., Kocourková, J., Waldaufová, E., Šídlo, L., Kníže, M. (2022): Has the cesarean epidemic in Czechia been reversed despite fertility postponement? *BMC Pregnancy and Childbirth* 22: 469, <https://doi.org/10.1186/s12884-022-04781-1>.
- Ferraretti, A. P., Goossens, V., Kupka, M., Bhattacharya, S., de Mouzon, J., Castilla, J. A., Erb, K., Korsak, V., Nyboe Andersen, A., The European IVF-Monitoring (EIM) Consortium for the European Society of Human Reproduction and Embryology (ESHRE), Strohmer, H., Bogaerts, K., Kyurkchiev, S., Vrcic, H., Pelekanos, M., Rezabek, K., Erb, K., Gissler, M., Royere, D., Bühler, K., Tarlatzis, B. C., Kosztolanyi, G., Bjorgvinsson, H., Mocanu, E., Scaravelli, G., Lokshin, V., Araj, M., Gudleviciene, Z., Lazarevski, S., Moshin, V., Motrenko Simic, T., Hazekamp, J. T., Kurzawa, R., Calhaz-Jorge, C., Rugescu, I., Korsak, V., Radunovic, N., Tomazevic, T., Hernandez Hernandez, J., Karlström, P. O., Weder, M., Lambalk, C., Veselovsky, V., Baranowski, R. (2013): Assisted reproductive technology in Europe, 2009: results generated from European registers by ESHRE. *Human Reproduction* 28(9), 2318–2331, <https://doi.org/10.1093/humrep/det278>.
- Frejka, T., Sobotka, T. (2008): Overview Chapter 1: Fertility in Europe: Diverse, delayed and below replacement. *Demographic Research* 19(3), 15–46, <https://doi.org/10.4054/DemRes.2008.19.3>.
- Hoekstra, Ch., Zhao, Z. Z., Lambalk, C. B., Willemsen, G., Martin, N. G., Boomsma, D. I., Montgomery, G. W. (2008): Dizygotic twinning, *Human Reproduction Update* 14(1), 37–47, <https://doi.org/10.1093/humupd/dmm036>.
- Human Fertility Database (2025): Max Planck Institute for Demographic Research (Germany) and Vienna Institute of Demography (Austria). Available online: www.humanfertility.org (accessed on 5 April 2025).
- Human Multiple Births Database (2025): French Institute for Demographic Studies – INED (distributor). Available online: <https://www.twinbirths.org> (accessed on 1 June 2025).
- IHIS CZ (2022): Assisted reproduction in the Czech Republic in 2020. Available online: www.uzis.cz/res/f/008420/asistreprodukce2020.pdf (accessed on 5 April 2025).
- Kocourková, J., Fait, T. (2009): Can increased use of ART retrieve the Czech Republic from the low fertility trap? *Neuro Endocrinology Letters* 30(6), 739–748, <https://pubmed.ncbi.nlm.nih.gov/20038934>.
- Kocourková, J., Konečná, H., Burcin, B., Kučera, T. (2015): How old is too old? A contribution to the discussion on age limits for assisted reproduction technique access. *Reproductive BioMedicine Online* 30, 482–492, <https://doi.org/10.1016/j.rbmo.2015.01.017>.
- Kocourková, J., Štátná, A., Burcin, B. (2023): The influence of the increasing use of assisted reproduction technologies on the recent growth in fertility in Czechia. *Scientific Reports* 13: 10854, <https://doi.org/10.1038/s41598-023-37071-7>.
- Marleen, S., Kodithuwakku, W., Nandasena, R., Mohideen, S., Allotey, J., Fernández-García, S., Gaetano-Gil, A., Ruiz-Calvo, G., Aquilina, J., Khalil, A., Bhide, P., Zamora, J., Thangaratinam, S. (2024): Maternal and perinatal outcomes in twin pregnancies following assisted reproduction: a systematic review and meta-analysis involving 802 462 pregnancies. *Human Reproduction Update* 30(3), 309–322, <https://doi.org/10.1093/humupd/dmae002>.
- McKelvey, A., David, A., Shenfield, F., Jauniaux, E. (2009): The impact of cross-border reproductive care or 'fertility tourism' on NHS maternity services. *BJOG: An International Journal of Obstetrics and Gynaecology* 116(11), 1520–1523, <https://doi.org/10.1111/j.1471-0528.2009.02294.x>.
- Němečková, M. (2016): Vícečetných porodů je již méně (Multiple births are becoming less common). *Statistika&My*. Available online: <https://statistikaamy.csu.gov.cz/vicecetnych-porodu-je-jiz-mene> (accessed on 5 April 2024).
- Nygren, K. G., Nyboe Andersen, A., The European IVF-monitoring programme (EIM) for the European Society of Human Reproduction Embryology (ESHRE) (2001): Assisted reproductive technology in Europe, 1998. Results generated from European registers by ESHRE. *Human Reproduction* 16(11), 2459–2471, <https://doi.org/10.1093/humrep/16.11.2459>.
- Nygren, K. G., Nyboe Andersen, A., The European IVF-monitoring programme (EIM) (2002): Assisted reproductive technology in Europe, 1999. Results generated from European registers by ESHRE. *Human Reproduction* 17(12), 3260–3274, <https://doi.org/10.1093/humrep/17.12.3260>.
- Pison, G., Monden, Ch., Smits, J. (2015): Twinning Rates in Developed Countries: Trends and Explanations. *Population and Development Review* 41(4), 629–649, <https://doi.org/10.1111/j.1728-4457.2015.00088.x>.
- Santana, D. S., Cecatti, J. G., Surita, F. G., Silveira, C., Costa, M. L., Souza, J. P., Mazhar, S. B., Jayaratne, K., Qureshi, Z., Sousa, M. H., Vogel, J. P. MD on behalf of the WHO Multicountry Survey on Maternal and Newborn Health Research Network (2016): Twin Pregnancy and Severe Maternal Outcomes: The World Health Organization Multicountry Survey on Maternal and Newborn Health. *Obstetrics & Gynecology* 127(4), 631–641, <https://doi.org/10.1097/AOG.0000000000001338>.
- Smits, J., Monden, C. (2011): Twinning across the Developing World. *PLoS ONE* 6(9): e25239, <https://doi.org/10.1371/journal.pone.0025239>.
- The European IVF-Monitoring Consortium (EIM) for the European Society of Human Reproduction and Embryology (ESHRE), Calhaz-Jorge, C., de Geyter, C., Kupka, M. S., de Mouzon, J., Erb, K., Mocanu, E., Motrenko, T., Scaravelli, G., Wyns, C., Goossens, V.,

- Gliozheni, O., Strohmer, H., Petrovskaya, E., Tishkevich, O., Bogaerts, K., Antonova, I., Vrcic, H., Ljiljak, D., Rezabek, K., Markova, J., Lemmen, J., Söritsa, D., Gissler, M., Tiitinen, A., Royere, D., Tandler-Schneider, A., Uszkoriet, M., Loutradis, D., Tarlatzis, B. C., Urbancsek, J., Kosztolanyi, G., Bjorgvinsson, H., Mocanu, E., Scaravelli, G., Lokshin, V., Ravil, V., Gudleviciene, Z., Belo Lopes, G., Moshin, V., Motrenko Simic, T., Vukicevic, D., Romundstad, L. B., Kurzawa, R., Calhaz-Jorge, C., Laranjeira, A. R., Rugescu, I., Doroftei, B., Korsak, V., Radunovic, N., Tabs, N., Tomazevic, T., Virant-Klun, I., Hernandez Hernandez, J., Tomazela Alcalá, J. A., Bergh, C., Weder, M., De Geyter, C., Smeenk, J. M. J., Gryshchenko, M., Baranowski, R. (2016a): Assisted reproductive technology in Europe, 2012: results generated from European registers by ESHRE, *Human Reproduction* 31(8), 1638–1652, <https://doi.org/10.1093/humrep/dew151>.
- The European IVF-Monitoring Consortium (EIM) for the European Society of Human Reproduction and Embryology (ESHRE), Kupka, M. S., D'Hooghe, T., Ferraretti, A. P., de Mouzon, J., Erb, K., Castilla, J. A., Calhaz-Jorge, C., De Geyter, C., Goossens, V. (2016b): Assisted reproductive technology in Europe, 2011: results generated from European registers by ESHRE, *Human Reproduction* 31(2), 233–248, <https://doi.org/10.1093/humrep/dev319>.
- The European IVF-monitoring programme (EIM), for the European Society of Human Reproduction and Embryology (ESHRE) (2000): Assisted reproductive technology in Europe, 1997. Results generated from European registers by ESHRE, *Human Reproduction* 16(2), 384–391, <https://doi.org/10.1093/humrep/16.2.384>.
- The European IVF-Monitoring Consortium (EIM) for the European Society of Human Reproduction and Embryology (ESHRE), Smeenk, J., Wyns, C., De Geyter, C., Kupka, M., Bergh, C., Cuevas Saiz, I., De Neubourg, D., Rezabek, K., Tandler-Schneider, A., Rugescu, I., Goossens, V. (2023): ART in Europe, 2019: results generated from European registries by ESHRE, *Human Reproduction* 38(12), 2321–2338, <https://doi.org/10.1093/humrep/dead197>.
- Torres, C., Pison, G., Caporali, A. (2023): The Human Multiple Births Database (HMBD): An international database on twin and other multiple births. *Demographic Research* 48(4), 89–106, <https://doi.org/10.4054/DemRes.2023.48.4>.
- Volejníková, A., Šťastná, A., Kocourková, J. (2025): Cross-border Reproductive Care in Czechia: Insights from National Registry Data. *Comparative Population Studies* 50, 183–204, <https://doi.org/10.12765/CPoS-2025-12>.
- Whittaker, M., Greatholder, I., Kilby, M. D., Heazell, A. E. P. (2023): Risk factors for adverse outcomes in twin pregnancies: a narrative review. *The Journal of Maternal-Fetal & Neonatal Medicine* 36(2), <https://doi.org/10.1080/14767058.2023.2240467>.
- Zegers-Hochschild, F., Adamson, G. D., Dyer, S., Racowsky, C., de Mouzon, J., Sokol, R., Rienzi, L., Sunde, A., Schmidt, L., Cooke, I. D., Simpson, J. L., van der Poel, S. (2017): The International Glossary on Infertility and Fertility Care. *Human Reproduction* 32(9), 1786–1801, <https://doi.org/10.1093/humrep/dex234>.