Peaks in twin births? An international comparison of trends in twinning rates in 30 developed countries

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Short abstract

The twinning rate has increased dramatically over the last four decades in developed countries because of two main factors: (a) delayed childbearing, as older women tend to have twins more frequently than younger women, and (b) the expansion of medically assisted reproduction (MAR), which carries an increased risk of multiple births. In some developed countries, however, the twinning rate reached a peak in the early 2000s and has since decreased. This reversal has been observed in more and more developed countries since. It is linked to changes in MAR policies and practices following concerns raised by the increase of the frequency of twin deliveries, twin babies being more fragile than singletons. Using the Human Multiple Births Database (HMBD) and databases on MAR policies and practices, this paper describes twinning-rate trends in 30 developed countries. It examines several questions for particular peaks: at which level did the twinning rate peak in each country? When did it peak? Which factors might explain the recent drop and the lower level attained? For countries that have not yet peaked, when might this occur and at what level?

Extended abstract

1. Introduction

The twinning rate has increased dramatically over the last four decades in nearly all countries for which vital statistics are available [1-4]. For example, it has increased in the United States from 9.5 twin deliveries per 1,000 deliveries in 1975 to 16.7 in 2015 [5]. Over the same period, it has practically doubled in many developed countries, e.g. from 9.9 to 16.1 in England and Wales, from 9.2 to 18.4 in Germany, from 9.3 to 17.5 in France, from 9.6 to 16.7 in Denmark, and from 5.9 to 9.9 in Japan (Human Multiple Births Database [6]).

Two main factors have driven this increase: delayed childbearing, as older women tend to have twins more frequently than younger ones, and the expansion of medically assisted reproduction (MAR), which carries an increased risk of multiple births [2].

MAR refers to a broader set of treatments than the often-used term Assisted Reproductive Technology (ART), which consists of treatments in which both sperm and oocytes are handled outside (i.e., in vitro) of the woman's body and embryos are transferred to establish a pregnancy. ART includes, but is not limited to, in vitro fertilization (IVF) and its variant, intracytoplasmic sperm injection (ICSI). MAR, however, also includes simpler techniques, like ovarian stimulation alone and artificial insemination. Techniques like ovarian stimulation and in vitro fertilization are associated with increased numbers of multiple births [7, 8].

This significant rise constitutes an important public health challenge because multiple babies are more fragile than singleton ones. Compared to singletons, they tend to have lower birth weight, more complications at birth, and are more often born premature, which are all associated with many long-term health implications [9-11]. Stillbirth and infant mortality rates are also much higher among twins and other multiple children [12-15]. Multiple-child pregnancies can have negative impacts on the parents as well. For instance, these pregnancies are associated with higher risk of gestational diabetes, pre-eclampsia, post-partum depression, and divorce [16-19].

These health and wellbeing concerns led to changes in MAR policies and practices from the turn of the century onward, in particular reduction of the number of embryos transferred to the uterus [20]. Consequently, twinning rates reached a peak in the early 2000s in several developed countries and have since decreased further. This reversal has been observed in more and more developed countries, but not in all of them. New MAR practices have not been implemented equally everywhere, and the number of treatments has continued to increase.

This paper describes the trends of the twinning rate in developed countries and examines several questions about peaks: at which level did the twinning rate peak in each country? When did it peak? How much has it dropped since? How quickly? Did the twinning rate fall to the 'natural' rate (the rate expected if only the distribution of maternal age at birth had an influence)? More generally, which factors might explain the peak, the drop, and the lower level attained recently? For countries that have not yet peaked, when might it occur, and at what level?

In the next section, we describe the data sources and methods used. In section 3, we describe how twinning rates have changed in developed countries over recent decades, with a special focus on peaks and changes occurring afterwards. In section 4, we examine whether the trends and reversals can be explained by changes in age at childbearing and the spread of infertility treatments. We estimate each factor's contribution to the increase up to the peak, and their influence on the level attained in the last year for which statistics are available (often 2019). We also examine the relationships between trends, reversals, and changes in MAR policies and practices. The last section focuses on countries that have yet to witness a peak, examining when it might occur and at what level.

2. Data and methods

The Human Multiple Births Database (HMBD)

Our main source of information is the Human Multiple Births Database (HMBD) [6], which provides national, annual time series of the number of deliveries by multiplicity (singletons, twins, triplets, quadruplets, and more) and the twinning and multiple rates. Twins are by far the most frequent among multiple deliveries; deliveries of triplets or more represent only a small fraction. For example, in France in 2010–2015, 97.9% of all multiple deliveries were those involving twins; the proportion of multiple deliveries of triplets and quadruplets and more was respectively 2.0% and 0.1% [6]. In the United States over the same period, the corresponding proportions were 96.5%, 3.3%, and 0.2%. Consequently, the HMBD focuses on twin deliveries, although it does provide information on other multiple deliveries.

Only countries with available complete or nearly complete birth registration and data documentation are included in the HMBD. As of October 2021, the online database comprises 20 countries across Europe, North America, Oceania, and Asia. The annual series start as early as the mid- or late-19th century for some countries, and in the early- or mid-20th century for most of the others. The database is recent, and new countries are added regularly. It is expected that about 10 more countries will be included by mid-2021, at which time the HMDB will cover approximately 30 countries.

The method for separating the influences of the two main factors of the twinning rate

Two main factors are responsible for the increase in twinning rates since the 1970s: the increase in maternal age at childbearing and the development of MAR [2]. To assess how much of twinning-rate increase can be attributed to each of these factors, we use a simulation method [2].

In short, we first make the (broadly accepted) assumption that the monozygotic (MZ) twinning rate (the rate of identical twins) is constant and equals 4 per 1,000. Second, we suppose that the dizygotic (DZ) twinning rate (the rate of fraternal twins), in the absence of MAR, increases monotonously from 0 at age 15 to a maximum at age 37 and then decreases monotonously to 0 at age 50 [2, 21]. The only factor that thereby differs among the countries is the maximum at age 37. Third, this maximum is estimated for each country as the best fit: when we derive the age-specific twinning rate function from this level and apply it to the observed age distribution of deliveries in 1970, our estimated twinning rate equals the observed rate for

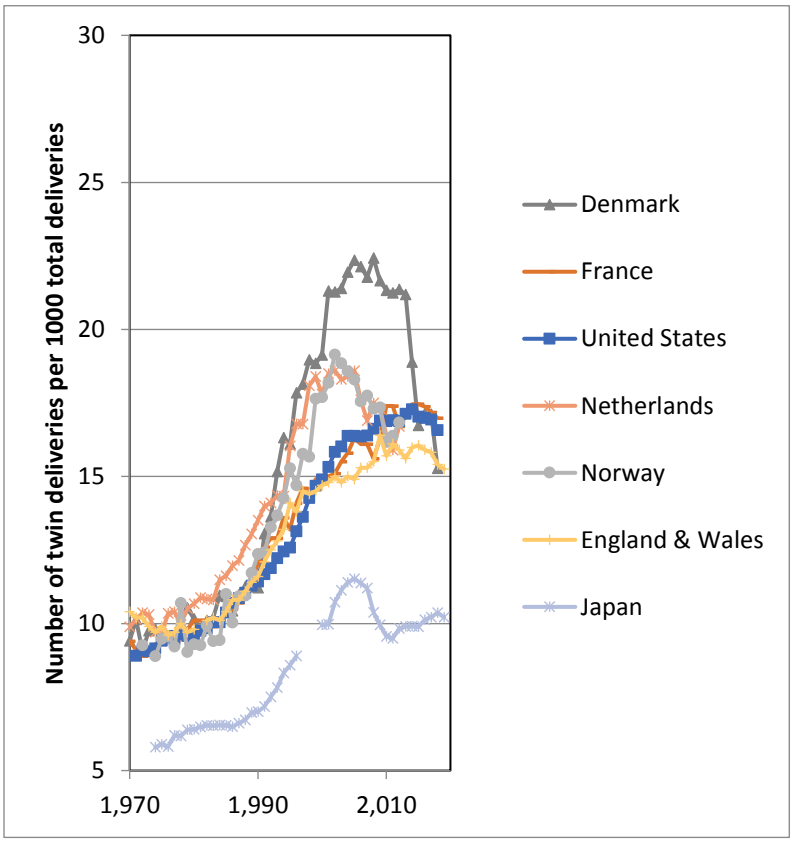
1970. Fourth, we apply the estimated age-specific twinning rate function to the observed distribution of birth by mother's age for each year in each country, to obtain predicted overall twinning rates. Data on births by maternal age come from national statistics, the Human Fertility Database (HFD) [22], and the United Nations World Population Prospects [23]. More details on the method are provided in [2].

In our previous study, we applied this method to 32 countries for which we had estimates of the twinning rate since 1970 and until 2005. We found that if age at childbearing had not changed and only MAR had been in action, the twinning rate would have increased only by 40% to 50% on average from 1970 to 2005 in the countries considered [2]. If, however, only age at childbearing had changed and MAR had not developed, the increase of the twinning rate would have been only 15% on average. On average, we found that over the period 1970–2005, the effect of MAR was thus about three times greater as the effect of delayed childbearing. However, we found large differences between countries: in Japan, the effect of MAR was more than ten times that of delayed childbearing; in Poland, it was much smaller, at one third of the effect of delayed childbearing; in Hungary and in New Zealand, both effects were similar.

3. Trends and reversals of the twinning rate in developed countries

Figure 1 shows the trends of the twinning rate since 1970 in a selection of developed countries based on the data from the HMBD [6].

Figure 1. Evolution of the twinning rate in selected developed countries, 1970 to 2019



Source: Human Multiple Births Database (2021) [6]. French Institute for Demographic Studies - INED (distributor). Extracted from: https://www.twinbirths.org (24/10/2021).

Note: The twinning rate is much lower in Japan than in the other countries. The frequency of dizygotic (DZ) twin births (fraternal twins) is highly variable according to the region or country. It has always been low in East Asia (about 2–4 per 1,000 total deliveries before the development of MAR), high in sub-Saharan Africa (about 15 per 1,000), and at an intermediate level in Europe and the United States (about 7 per 1,000). The development of MAR has mostly influenced the DZ twinning rate, without much changing the monozygotic (MZ) twinning rate (the rate of identical twins), which has remained at around 4 per 1,000 total deliveries everywhere. Nearly all the changes in the twinning rate are therefore due to the changes in the DZ twinning rate.

Figure 1 shows that, as mentioned above, the twinning rate has increased dramatically since the 1970s in the seven countries selected. It also shows that the twinning rate has reached a peak or a plateau and has subsequently decreased. However, there are important differences between the countries regarding the timing and the level of the peak. This is also shown in Table 1, where all the countries included in the HMBD as of October 2021 are included. It shows the year and the level when the twinning rate peaked in each country. The peak is observed first in Finland (1998), then in Sweden (1998, Australia, New Zealand and Norway (2002), Japan and the Netherlands (2005), Iceland (2006), Denmark and Scotland (2008), Canada and England and Wales (2009), Czech Republic (2010), Austria (2011), Spain and the United States (2014), France (2015) and Germany and Italy (2017). In Greece, twinning rate has not yet peaked and it is still increasing in 2019.

The twinning rate is in general much lower in Japan than in other countries, a feature of East-Asia compared to Europe and North America [21](see also note of Figure 1).

Table 1. Year and level when the maximum twinning rate was observed, by country

Country	Max. Twinning Rate	
	Year	Rate*
Finland	1998	17,0
Sweden	1999	16,6
Australia	2002	16,5
New Zealand	2002	16,8
Norway	2002	19,1
Japan	2005	11,5
Netherlands	2005	18,6
Iceland	2006	21,2
Denmark	2008	22,4
UK-Scotland	2008	16,0
Canada	2009	16,5
UK-England and Wales	2009	16,2
Czech Republic	2010	21,3
Austria	2011	17,6
Spain	2014	22,7
United States	2014	17,3
France	2015	17,5
Germany	2017	18,7
Italy**	2017	*17,3*
Greece***	-	-

Notes
* Definition of twinning rate: Number of twin deliveries divided by the total number of deliveries, per 1,000 deliveries.
** Multiple rate instead of twinning rate - for Italy, the twinning rate is not available for years 1997 and after.
*** Country where twinning rate has not peaked and is still increasing (up to 2019).

If the year of the peak, or the period of the plateau, varies from one country to the other, so does the level attained by the twinning rate at the peak, the speed at which it occurs, and the speed and scale of the subsequent drop. For example, a clear reversal point can be identified in some countries with a fast decrease afterwards, whereas in other countries the decrease after the peak has been more gradual. Japan is the only country where the twinning rate has increased again following a decline after 2005 to a low level in 2011.

Reasons for a trend reversal

Pregnancies obtained through MAR result much more frequently in multiple births compared to pregnancies obtained naturally. One reason is that in the first decades of ART, medical doctors often transferred several embryos. In 2000, over two-thirds of women in the United States undergoing ART had three or more embryos transferred into their uterus. Around 35% of these pregnancies resulted in multiple delivery, and 53% of all ART infants were born as twins or triplets [24].

As mentioned, the high rates of multiple deliveries after ART were considered problematic because of negative health outcomes infants and mothers [25, 26]. Consequently, medical

professionals proposed new criteria for evaluating the success of ART, centered on successful singleton live birth delivery. They suggested BESST (Birth Emphasizing a Successful Singleton at Term) as an indicator [27]. Single embryo transfers became favored by health authorities and legislation because studies indicated that the chances of birth after elective single embryo transfer (eSTET)[1] are identical to the chances of success after the transfer of two fresh embryos [27]. ART multiple delivery rates then started to decline gradually in most of the developed countries during the 2000s, falling to 30% in the USA in 2009 and 20% in Europe in 2010 [24, 28].

However, this decline did not result in a reversal of the twinning-rate trend among the total population of all these countries because of the continuous increase in the use of ART and non-ART ovarian stimulation [28] and the ongoing shift towards childbearing at later ages.

4. The role of changes in age at childbearing and in infertility treatments

The full paper describes the trends of the twinning rate in all the developed countries for which statistics are available. It examines whether the trends and reversals can be explained by changes in age at childbearing and the spread of infertility treatments. Using the method presented above, we estimate each factor's contribution to the increase up to the peak and their influence on the level attained in the last year for which statistics are available (often 2019). We also examine the relationships between trends, reversals, and changes in MAR policies and practices as described by the literature.

Through a systematic examination of peaks, we try to bring answers to the following questions: for a particular country, why did the twinning rate peaked a particular year? Why at this level? How much has it dropped since? How quickly? Did the twinning rate fall to the 'natural' rate (the rate expected if only the distribution of maternal age at birth had an influence)? More generally, which factors might explain the peak, the drop, and the lower level attained recently. For countries that have not yet witnessed a peak, when might it occur, and at what level? And for those that experienced a peak and a subsequent drop, will the rate increase again after attaining a low level, as observed in Japan?

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[1] One fresh embryo is transferred, and a second one is frozen for a second single embryo transfer if necessary.

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