Demographic and medical consequences of the postponement of parenthood

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Demographic and medical consequences of the postponement of parenthood

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BACKGROUND: Across the developed world couples are postponing parenthood. This review assesses the consequences of delayed family formation from a demographic and medical perspective. One main focus is on the quantitative importance of pregnancy postponement.

METHODS: Medical and social science databases were searched for publications on relevant subjects such as delayed parenthood, female and male age, fertility, infertility, time to pregnancy (TTP), fetal death, outcome of medically assisted reproduction (MAR) and mental well-being.

RESULTS: Postponement of parenthood is linked to a higher rate of involuntary childlessness and smaller families than desired due to increased infertility and fetal death with higher female and male age. For women, the increased risk of prolonged TTP, infertility, spontaneous abortions, ectopic pregnancies and trisomy 21 starts at around 30 years of age with a more pronounced effects >35 years, whereas the increasing risk of preterm births and stillbirths starts at around 35 years with a more pronounced effect >40 years. Advanced male age has an important but less pronounced effect on infertility and adverse outcomes. MAR treatment cannot overcome the age-related decline in fecundity.

CONCLUSIONS: In general, women have partners who are several years older than themselves and it is important to focus more on the combined effect of higher female and male age on infertility and reproductive outcome. Increasing public awareness of the impact of advanced female and male age on the reproductive outcome is essential for people to make well-informed decisions on when to start family formation.

Key words: delayed childbearing / fertility / fecundity / infertility / medically assisted reproduction

Introduction

The decline in fecundity with increasing age and its physiological basis have been described in detail in two recent papers on male and female reproductive aging (ESHRE, 2005; Sartorius and Nieschlag, 2010). This review focuses on the consequences of the continuing trend towards postponement of parenthood, in terms of its patterns across different countries and its demographic and medical consequences. The decline in female fecundity with age is primarily due to the decrease in ovarian follicle numbers and the decline in oocyte quality (ESHRE, 2005; Broekmans *et al.*, 2007), factors that cannot be controlled or changed. Increasing paternal age is associated with decreasing androgen levels, a deterioration of semen quality and an increase in pregnancy complications and adverse outcomes for offspring (Kühnert and Nieschlag, 2004; de La Rochebrochard *et al.*, 2006; Sartorius and Nieschlag, 2010). Increasing female age is also associated with increased risk of prolonged time taken to conceive (Olsen, 1990). Prolongation of time to conceive (≥12 months) has consequences, as it has been shown to result in smaller families, with an odds ratio of around 1.8 for the risk of not having a second child and around 1.6 for not having a third child (Joffe *et al.*, 2009). Infertility may thus constitute an obstacle to reaching desired family size, which averages in most European countries two children. Leridon (2004) showed, based on a Monte Carlo computer simulation model, that if women turn to IVF treatment after 2, 3 or 4 years without conception, assisted reproduction can only make up for half of the births lost by postponing attempts of pregnancy from age 30 to 35 years, and <30% of the loss after postponing from 35 to 40 years. In other words: assisted reproduction technology (ART) does not overcome the decline in fecundity by age.

Apart from the direct age-related decline in fecundity, postponement of attempts to conceive increases the risk of co-morbidity with reproductive threats to the couple. A number of diseases and conditions are either prevalent from 20 years of age (such as Chlamydia) or appears early (e.g. testicular cancer). The highest age-specific rates of Chlamydia infections is in the age group 15–24 years where the rate in Europe is 3.6%, which is most likely an under-reported prevalence (ECDC, 2009). Certain malignant diseases make an early appearance, for instance, testicular cancer in the male (Maneckska and Fitzpatrick, 2009) and breast cancer among women (Kamangar *et al.*, 2006). Testicular cancer is the most common malignancy in men aged 15–34 years and the age-standardized incidence rate is ranging from 0.5/100 000 (in Egypt) to 9.2/100 000 in Denmark (Maneckska and Fitzpatrick, 2009). Breast cancer is the most common cancer among women and it starts becoming prevalent in the late twenties and increases rapidly during the reproductive live span. The incidence is 67.8/100 000 in more developed countries (Kamangar *et al.*, 2006). Additionally, haematological diseases like Hodgkin's lymphoma occur at a young age for both sexes with age-standardized incidence rates at about 0.40/100 000 (Kamangar *et al.*, 2006). Besides these malignant diseases, other medical conditions among women reduce their fecundity. Examples of such conditions include endometriosis, which increases from >30 years of age with age-adjusted incidence rates around 13.4/100 000 (Gylfason *et al.*, 2010), myomas with a prevalence of 8–18% (Cook *et al.*, 2010) and endometrial polyps with a prevalence among premenopausal women of 5.8% (Dreisler *et al.*, 2009). Such co-morbidity will increase the risks of reproductive problems with each year of delay at attempts of pregnancy. Furthermore, lifestyle factors such as smoking and obesity among both women and men have negative effects on fecundity and these effects may be cumulative over years of exposure (Augood *et al.*, 1998; Homann *et al.*, 2007; Yilmaz *et al.*, 2009).

The work discussed in this paper was carried out on behalf of the European Society of Human Reproduction and Embryology (ESHRE) Reproduction and Society Task Force. The purpose of this paper is to provide an overview of the consequences of postponing parenthood from a demographic and medical perspective. The societal, demographic aspects presented in this paper are primarily based on large-scale quantitative data sets on fecundity and fertility (live birth rates) and mostly exclude qualitative research and smaller quantitative studies focused especially on parenthood intentions. For the medical consequences the main focus is on the quantitative importance of pregnancy postponement, i.e. the impact of postponement on fecundability, infertility and adverse reproductive outcomes. Whenever possible, research studies showing the effects of combined advanced female age and advanced male age are emphasized. The review focuses primarily on the negative consequences of delaying attempts to conceive, but it also briefly addresses some positive aspects. We find that there is a substantial need to make health professionals and the general public aware of the increased reproductive risks with advanced female and male age. Provision of this information is essential for people wishing to become parents to make well-informed decisions on when to start having children. It is of substantial importance to understand why people postpone childbearing and to gain knowledge whether different social policy incentives can be effective in countering this trend. A vast body of literature has accumulated on diverse factors contributing to the postponement of parenthood and a comprehensive literature review has recently been published on behalf of the ESHRE Reproduction and Society Task Force (Mills *et al.*, 2011). Therefore, we address the reasons for delayed parenthood only by way of a brief summary of major factors.

Methods

Multiple strategies were used to identify relevant demographic, epidemiological and clinical studies. We searched in demographic and sociological online libraries and in Pubmed using the following keywords: postponement, delayed parenthood, fertility, infertility, time to pregnancy (TTP), total fertility rate (TFR), fetal death, IVF, ICSI, IUI, trisomy, Down syndrome (DS), preterm birth, multiple pregnancies and twins, in combination with (advanced) female age and (advanced) male age. We cross-referenced papers and bibliographies in order to identify additional relevant studies. We selected studies that provided estimates for different age groups in order to assess the quantitative impact of postponing pregnancies to a greater age.

As in demography, we use the term 'fertility' as a measure of reproductive performance (live birth rates). The TFR is a period fertility indicator, showing the average number of children each woman would deliver in her lifetime if the fertility rates by age observed in a given period remained constant. The term 'fecundity' refers to the capacity or ability to bear children. Fecundity depends on fecundability (the probability of conceiving during a menstrual cycle among sexually active couples without the use of contraception), on the rate of pregnancy loss (fetal deaths, spontaneous abortions and extrauterine pregnancies) and the probability of being permanently unable to conceive (Leridon and Slama, 2008). TTP is the time taken to conceive. The term 'infertility' is used as in clinical and epidemiological studies meaning 'a disease of the reproductive system defined by the failure to achieve a clinical pregnancy after 12 months or more of regular unprotected sexual intercourse' (Zegers-Hochschild *et al.*, 2009). Medically assisted reproduction (MAR) includes all kinds of different *in vivo* and *in vitro* treatments, and ART encompasses all treatments and procedures that include *in vitro* handling of oocytes/sperm/embryos (Zegers-Hochschild *et al.*, 2009). 'Fetal death' in this paper includes spontaneous abortions, ectopic pregnancies and stillbirths.

Demographic aspects of postponed parenthood

Delayed parenthood: causes and trends

Across the developed world, couples have been delaying parenthood to an ever-later age during the last three decades. This trend has become so pervasive that demographers proposed the term 'postponement transition' (Kohler *et al.*, 2002; Goldstein *et al.*, 2009). In many countries, the increase in the mean age at first birth among women was concomitant with the spread of the contraceptive pill, rising female employment, expansion of university education, deteriorating economic position of young adults and delays in leaving home, partnership formation and marriage (Blossfeld and Huinink, 1991; Goldin and Katz, 2002; Kohler *et al.*, 2002; Adsera, 2005; Mills and Blossfeld, 2005; Billari *et al.*, 2006; Goldin, 2006; Sobotka, 2010; Beets *et al.*, 2011; Mills *et al.*, 2011). Modern contraception, especially the contraceptive pill spreading since the late 1960s, vastly improved women's abilities to plan their pregnancy and postpone childbearing to a later age (Goldin and Katz, 2002; Van de Kaa, 2011). Women may now enjoy a long period of sexually active life, little affected by the fear of becoming pregnant. At the same time, rapid expansion of tertiary education and rising female employment provided incentives to shift childbearing to a later age (Rindfuss *et al.*, 1988; Joshi, 2002; Goldin, 2006). These trends have been accompanied by a rapid shift in family values, marked by a retreat of marriage, rise of

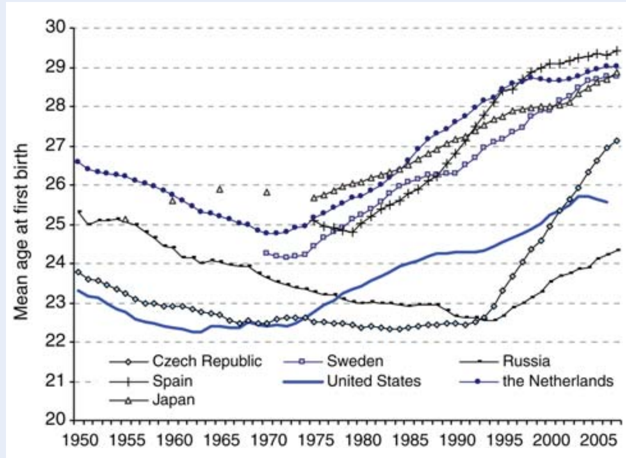

Figure 1 Mean age of mother at first birth, selected countries, 1950–2007. *Sources:* Council of Europe (2006), Human Fertility Database, and own computations based on Eurostat (2009) and national statistical offices.

divorce, increased tolerance of voluntary childlessness and a spread non-traditional living arrangements (Lesthaeghe, 1995; Thornton and Young-deMarco, 2001), as well as a rise in gender equality and women's earning power that made women much less dependent on their male partners (Goldin, 2006; Gerson, 2010). The question of when to have children rose in prominence; the right timing of childbearing became a 'coordination problem' between interrelated education, partnership, work and family 'careers' (Sobotka, 2010; van de Kaa, 2011). This issue is most pertinent for the women with tertiary education who have most to lose in terms of their work career, income and social status by becoming mothers (Blossfeld and Huinink, 1991; Thomson *et al.*, 2009) and therefore postpone childbearing more than their lower educated counterparts (McLanahan, 2004; Lappegård and Rønsen, 2005; Gustafsson and Kalwij, 2006, see also below). Adding to these factors was a rise in unemployment and job instability among young adults, especially in southern Europe (Adsera, 2005; Mills *et al.*, 2005; Esping-Andersen, 2009) as well as perceived difficulties of many women of finding a right partner, which are often cited as important reasons for remaining childless, especially among women (Keizer *et al.*, 2008; Sobotka and Testa, 2008).

In western, southern and northern Europe as well as Japan the mean age of first-time mothers reached around 28–29 years in 2008, an increase of 4–5 years when compared with the 1970s (Fig. 1). Only in eastern Europe—especially in the former Soviet Union—and in the USA are first-time mothers considerably younger, on average 24–26 years old. In the USA, this earlier pattern of childbearing is linked to high rates of teenage pregnancies and a general pattern of early births in some populations, especially among Hispanic, Black and lower-educated women (McLanahan, 2004; Mathews and Hamilton, 2009).

In many countries, the majority of all births now take place among women over the age of 30, with Spain having the highest proportion (60%) of birth rates above age 30 since 2002 (Spain is also the only country in Europe where just over 50% of first birth rates took

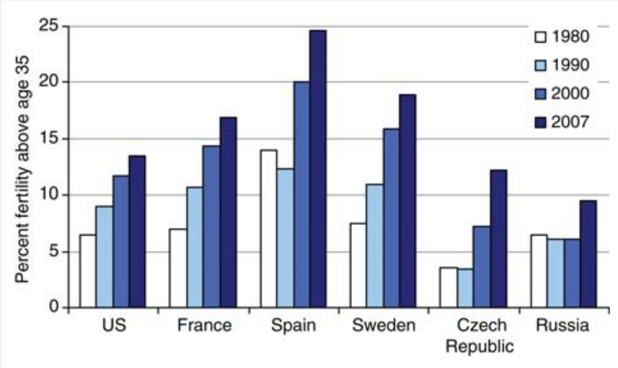

Figure 2 Per cent birth rates by women aged 35 and higher, selected countries, 1980–2007. *Sources:* Own computations based on Eurostat (2009) and national statistical offices.

place after that age in 2008). In France, the >30 proportion of total birth rates has doubled from 24% in 1980 to 49% in 2008, while in the Czech Republic it has changed dramatically from 14% in 1990 to 46% in 2009. Fertility rates are rising most rapidly among women over 35 years old (Fig. 2). However, the frequency of births at 40+—between 3 and 5% of total fertility in most developed countries—remains well below historical levels reached in the 19th century (Prioux, 2005), i.e. prior to the demographic transition. In societies where fertility is little regulated by birth control and large family size is common, typically well over a tenth of the fertility rate is realized above age 40: for instance, the share of fertility rates to women aged 40+ reached 16% in Sweden in 1860, implying that every sixth child was born to an 'old' mother (Billari *et al.*, 2007).

A population of Hutterite married women, in which no contraception is used, had on average 1.43 births after age 40 (adopted from Sheps, 1965: Table 2), that is, they realized as many births after that age as women in the lowest fertility countries of Europe and East Asia realize over their whole reproductive life today. Using these data, Sobotka *et al.* (2007) computed that contemporary 'late' fertility rates were as low as 2% (Japan and Russia) to 7% (Ireland) of the theoretical reproductive capacity for women aged 40+. Due to oocyte donation, births have also been increasing at extreme reproductive ages (Salihu *et al.*, 2003; Sobotka *et al.*, 2007), but their numbers remain marginal: for instance, in the USA, 514 births to mothers aged 50+ were registered in 2007 compared with 144 in 1997 (data from NCHS, 2010).

Because a higher level of education is closely linked to postponing parenthood (Martin, 2000), postponement of childbearing is fuelled by the long-lasting trend of a rising proportion of men and women undergoing tertiary education. A comparative study of fertility differentials by education in the Nordic countries (Andersson *et al.*, 2008) found that one half of tertiary educated women born in 1965–1969 became mothers between age 28.9 (Norway) and 30.6 (Sweden), which was about 3 years later than women with upper secondary education (between 24.7 in Norway and 27.4 in Denmark). Highly educated women also have increased probabilities of having a first or a second child after the age of 35. Besides education, economic circumstances are also important: in England and Wales women who were in the top-quartile earning category and who postponed childbearing to their thirties were most likely to give birth at high reproductive ages (Berrington, 2004). In France, women in high occupational positions experienced the sharpest rise in fertility rates above age 35 (Toulemon, 2005).

The data for male fertility are published only for a few developed countries such as Australia, England and Wales, France and the Nordic countries. Men have delayed having children to an extent similar to women (Coleman, 2000; SCB, 2002; Prioux, 2005; Population Trends, 2009) and remain on average about 3 years older than women when having a child; for instance in England and Wales the mean age of fathers reached 32.4 in 2007 (Population trends, 2009: 104, Table 1) compared with the mean age of mothers of 29.3. As men do not face a strict biological 'deadline' for having children, far more men than women have children in their 40s (typically, about 10% of fathers in the countries with available data, e.g. Prioux, 2005), but the number of men who father a child above age 50 remains low. In 2007, the proportion of fathers aged 50+ contributing to the total male fertility rate was 0.8% in Denmark and 1.3% in England and Wales (calculated from Population Trends, 2009: 104, Table 1 and Statistics Denmark, 2008: 32, Table 2.15).

Research on fertility intentions indicates that an increasing number of women and men desire to have children over the age of 35. In England and Wales, the average number of children intended later in life for women aged 33–35 rose fivefold from 0.07 in 1979–1991 to 0.36 in 2001–2002 (Smallwood and Jefferies, 2003). In particular, women with higher education and high earnings expressed their intention to have a child when childless at the age of 35 (Berrington, 2004). In Austria in 2001, women aged 35–40 still desired 0.19 children on average in the future; the figure was 0.32 for women with higher secondary education and 0.36 for women with tertiary education (Sobotka, 2009). The Austrian 'Generation and Gender Survey' of 2008 found that 28% of women and 46% of men aged 35–39 still intended (certainly or probably) to have a child in the future. These figures were 12 and 24% at age 40–45 (Buber and Sobotka, 2008/09) and were much higher among the childless women (57% at age 35–39 and 28% at age 40–45). These data indicate that many people have intentions to have children during age periods where there is a substantial increased risk of infertility, spontaneous abortions and other adverse reproductive outcomes.

Effects on completed fertility and on permanent childlessness

There are two main effects of fertility postponement on births and fertility rates. The first effect arises when couples postpone childbearing to higher ages during a certain period and fewer births take place than in the absence of such postponement. This effect has been called the 'tempo effect' in the demographic literature (e.g. Bongaarts, 2002). The second is a negative effect of fertility postponement on completed fertility and increased childlessness attributable to the age-related increase in infertility. The 'tempo effect' has had a strong and long-lasting influence on period fertility rates across the developed world since the 1970s. If, for instance, all couples delayed childbearing by three months in one calendar year, observed fertility rates and the number of births in that year would be reduced by a quarter (i.e. 3/12). Such intensity of fertility postponement was not unusual in many low-fertility countries during the 1990s and generated a negative 'tempo effect' that pushed the period TFRs in many countries to

Table I Period TFR, observed and estimated in the absence of fertility postponement, in 2006 in major European regions, USA and Japan.

	Population (2006, in million)	Observed TFR (2006)	Estimated TFR without postponement (around 2006)	Tempo effect
Western Europe	153.3	1.88	2.05	−0.17
Northern Europe	24.6	1.86	1.96	−0.10
Germany, Austria, Switzerland	98.2	1.34	1.62	−0.28
Southern Europe	125.4	1.37	1.46	−0.09
Central-eastern Europe	77.4	1.30	1.60	−0.30
South-eastern Europe	39.5	1.36	1.61	−0.25
Eastern Europe (incl. Russia)	204.0	1.29	1.52	−0.23
EU-27	**491.4**	1.59	1.79	−0.20
USA (2004)	299.2	2.05	2.14	−0.09
Japan	127.8	1.29	1.44	−0.15

Source: own computations from VID (2008 and 2010). The bold value represents a total population of the European Union (in million, excluding French overseas departments on January 1, 2006, as reported by Eurostat. No significance value has been computed or provided.

extreme low levels below 1.3 (Kohler *et al.*, 2002; Sobotka, 2004; Goldstein *et al.*, 2009). Table I compares the observed TFR in European regions, the USA and Japan in 2006 and the hypothetical TFR that would have been observed in the absence of changes in fertility timing, estimated using Bongaarts and Feeney's (1998) adjustment method (VID, 2010). In Europe, fertility rates were most depressed in regions with the lowest TFRs, namely central Europe, German-speaking countries and south-eastern Europe, where the tempo-corrected TFRs were 0.2–0.3 births per woman (i.e. ∼20%) higher than the observed TFRs of 1.29–1.36. For the EU the observed TFR of 1.53 was 0.2 lower than the TFR estimated in the absence of birth postponement. Even considering tempo effects, fertility rates remain low in all regions except the USA, western Europe, northern Europe, Australia and New Zealand, where TFRs reached 1.9–2.1 in 2008 (Goldstein *et al.*, 2009). Across most of the developed world, fertility rates increased between 1998 and 2008, reaching levels not seen since the 1970s in some countries (Hoorens *et al.*, 2011). A diminishing pace of fertility postponement—and the concomitant decline in the tempo effect—was the most important reason for this increase (Goldstein *et al.*, 2009).

The influence of the effect of fertility postponement on completed cohort fertility and childlessness is harder to quantify. First, when fertility rates are declining, as was the case for the cohorts born in the 1950s and 1960s across almost all developed countries, it is methodologically difficult to distinguish what proportion of that decline can be attributed to infertility due to birth postponement and what proportion would occur even in the absence of postponement because couples intended to have fewer children. Secondly, completed fertility rates of the women born in the 1970s and early 1980s, who continue to shift childbearing to a later age, will only be known once the women reach the end of their reproductive span. The decline in cohort fertility due to postponement has been mostly studied using data on age at first birth and subsequent fertility as well as models of fecundity, pregnancy loss and time to conception by age.

Simple cross-country comparisons do not show a negative aggregate association between age at first birth and fertility. Many European

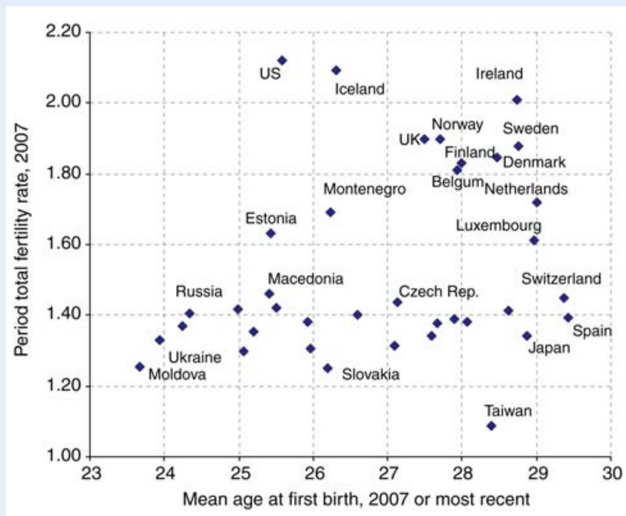

Figure 3 Mean age at first birth and TFR, 37 developed countries of Europe, East Asia and the USA. *Sources:* Council of Europe (2006), Eurostat (2009), VID (2008) and national statistical offices.

countries that are characterized by a late first birth pattern—e.g. Denmark, France, Ireland, the Netherlands and Sweden—also display the highest fertility rates in Europe, whereas some countries with early first births, such as Moldova and the Ukraine, have very low fertility (Fig. 3). Analysing cohort fertility data, Toulemon (2005: Fig. 2) showed that those European countries that experienced the most intensive delay of first birth paradoxically had the smallest declines in completed fertility among the 1950s and 1960s cohorts. In France and Sweden, rising age at first birth did not result in any decline in the observed progression rates to the second and subsequent births (Toulemon and Mazuy, 2001; Sobotka, 2008).

The overall effect of delaying first birth on completed fertility rates is a combination of the impact of infertility and other, mostly behavioural

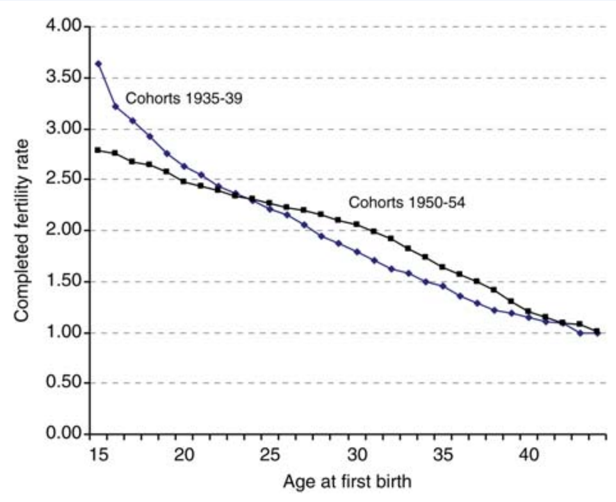

Figure 4 Age at first birth and completed fertility rate, Swedish women born in 1935–1939 and 1950–1954. *Source:* Andersson *et al*. (2008: 49, Table 12d).

but also health-related, components. Among women born around 1954, first-birth postponement by 1 year led to a reduction in completed fertility of 1.6% in Sweden, 2.9% in Italy and 3.8% in Spain. Stronger effects were reported by Billari and Borgoni (2005), who applied sample selection models to estimate the effects of age at first birth on fertility in Italy, Hungary, Spain and Sweden. One year of first-birth delay reduced completed fertility by 2.8% in Sweden and 4.6% in Spain. However, much stronger effects were found for second birth progression rates, which declined between 7.2% (Sweden) and 11.7% (Spain) with first-birth postponement by 1 year (Billari and Borgoni, 2005, Table 5). A 5-year postponement of first-birth reduced completed fertility between 0.14 (Sweden) and 0.23 (Spain) children per woman.

Considerable effect differences between countries indicate that factors other than infertility and health-related factors, such as low career- and family compatibility for women, influence the strength of this association. The association between age at first birth and completed fertility was considerably weaker among the younger cohorts (Kohler *et al*., 2002). Andersson *et al*. (2008) showed that Swedish women born in 1950–1954 had fewer children than women born in 1930–1934 when they had their first child before age 24, but had more children than earlier cohorts when they had their first child at age 24–44. Those aged 30 still had over two children (2.06) on average compared with 1.79 among the older cohort of 1935–1939 (see Fig. 4). In the USA, Morgan and Rindfuss (1999) reported that between 1950 and 1989 the proportion of women who had a second child within 36 months of the first birth has become less associated with age. In the latest period analysed, 1975–1989, these proportions were 0.38–0.39 for women with their first birth at age $\leq$24 years, 0.34 at age 25–34 and 0.31 at age 35–39.

In most countries, later childbearing is linked to a higher rate of childlessness and the rise of indecision and ambivalence about childbearing, not only due to rising infertility with age, but also because many couples 'perpetually' postpone the decision to have a child until they realize they are too old for parenthood or get used to their childless status (Rindfuss *et al*., 1988; Berrington, 2004; Kneale and Joshi, 2008). It is difficult to assess the effects of parenthood postponement on involuntary childlessness in the absence of detailed and regularly repeated surveys. Leridon's (2008) model estimates the percentage of women remaining permanently childless when starting a pregnancy attempt as 6.0% at the age of 30, 14.0% at the age of 35, 34.8% at the age of 40 and 78.9% at the age of 45 (Leridon, 2008). The estimated rise in permanent childlessness was largely due to an increase in the risk of fetal death and only partly attributable to the decline in fecundability (the monthly probability of conception whatever the outcome).

Consequences for children and for intergenerational relations

Delayed parenthood affects the relationships, emotional distance and communication between parents and their children as well as their relationship with grandparents. Later parenthood can also be seen as a part of the pervasive trend towards stretching and rescaling the life course, marked by a long-term expansion of life expectancy and longevity (Lee and Goldstein, 2003).

Due to methodological differences, research often yields contradictory findings about the effects of late parenthood on the parent–child relationship and on general well-being. A broad finding is that delayed parenthood is not associated with consistently strong and negative outcomes for the psychological and emotional well-being of children (e.g. Boivin *et al*., 2009 for ART births) or family functioning (Garrison *et al*., 1997). Several studies reported that children of older mothers showed better education, intellectual and psychological outcomes at the age of 10 and above (Conger *et al*., 1984; Pollock, 1996; Fergusson and Woodward, 1999; Miller, 2009), whereas no clear results have emerged for very young children (Philliber and Graham, 1981). Some of these effects may be related to unmeasured socio-economic characteristics of older parents. Heuvel (1988) reported that higher parental age at first birth was linked to higher prevalence of marital happiness, which in turn had a positive effect on mother–daughter and father–son perceptions of closeness to parents among adolescents. Some studies, however, found that older parents may experience more child-rearing problems when their children reach teenage years (Rossi, 1980), as the large age gap between parents and their children may increase the discrepancies in their values, beliefs, interests and physical strength.

Delayed parenthood reduces the chance that both parents will survive until their children reach adulthood, marry or become parents themselves and thus counter to some extent the effects of longer life, which has increased the number of generations surviving at any one point in time (Hagestad and Herlofson, 2005). Computations for France, based on the 2007 mortality data from Human Mortality Database (2009), illustrate how delayed childbearing may affect parents' survivorship until important milestones in the lives of their children (Table II). Given the contemporary low mortality pattern, almost all parents survive until their children reach adulthood and until they become grandparents if the age at childbearing is 25 years: only 1% of women and 2% of men would die before their children reach 18; 2% of women and 5% of men would die before becoming grandparents (ignoring the possibility that their children remain permanently childless). However, if both parents and their children

Table II Estimated probabilities of dying before own child reaches adulthood and before having a grandchild: a comparison of different birth timing patterns (computations based on mortality tables for France, 2007)

	Having a child at age				
	25	30	35	40	45
Women					
Not surviving until child's 18 birthday (%)	1.0	1.6	2.6	3.8	5.5
Not surviving to become a grandparent (%)					
Age when the child becomes a parent					
25	2.2	3.4	5.0	7.1	9.9
30	3.5	5.2	7.4	10.4	15.1
35	5.3	7.6	10.7	15.6	23.8
40	7.7	10.9	15.9	24.3	38.4
45	11.0	16.1	24.5	38.8	60.1
Men					
Not surviving until child's 18 birthday (%)	2.2	3.3	5.4	8.3	12.1
Not surviving to become a grandparent (%)					
Age when the child becomes a parent					
25	4.6	7.2	10.7	15.3	21.4
30	7.6	11.2	16.0	22.3	30.9
35	11.5	16.4	22.8	31.7	44.4
40	16.7	23.2	32.2	45.0	61.8
45	23.6	32.5	45.4	62.2	80.3

Source: Own computations based on Human Mortality Database (www.mortality.org), accessed 17 December 2009.

shift the childbearing to the age of 35, the likelihood of dying before experiencing grandparenthood reaches 11% for women and 23% for men. For 'late fathers' having children above the age of 40 the likelihood of dying before their children reach adulthood and parenthood is particularly high (Table II).

Rising parental age also influences the potential availability of grandparents for childcare help. A majority of grandparents in Europe (59%) look after their grandchildren, at least occasionally (Fokkema *et al.*, 2008). The rise of female participation in the workforce implies that grandmothers are not available for regular childcare until they retire. With the effective retirement age of 62 years for women and 63 years for men across developed countries in 2007 (OECD, 2009), an 'optimal' strategy appears to postpone having children until just above the age of 30, so that childbirth roughly coincides with the grandparents' retirement. On the other hand, late parenthood implies a higher risk of a need to care for both one's own children and frail parents who may require more help when they age, as children remain important carers for their ageing parents (Hareven, 1994). In the 1990s, relatively few women (10% in the EU) and even fewer men had overlapping responsibilities for both their children and their parents (Dykstra, 1997, cited in Hagestad and Herlofson, 2005). However, this proportion is likely to increase with the continuing postponement of births. The need for regular intergenerational support is strongly shaped by different transfer systems, welfare arrangements and cultural norms. It is particularly strong in southern Europe, where familial obligations remain strong, the majority of older people live in proximity to their children and public welfare is less developed (Hagestad and Herlofson, 2005).

Advantages of delayed parenthood

Although delayed parenthood is commonly perceived as a negative trend, especially in the medical literature (e.g. Lansac, 1995; Heffner, 2004; Bewley *et al.*, 2005), it has some positive consequences and implications. It is associated with a more stable family environment, higher socio-economic position, higher income and better living conditions, as well as better parenting practices.

Having children later in life is a rational strategy from an economic and career perspective. Later parenthood gives couples more time to accumulate material resources, which is a common rationale for fertility postponement (Kravdal, 1994). Childless Canadian men and women aged 20–44 mentioned financial security as an important factor influencing the timing of childbearing in 85% (women) and 87% (men) of all cases (Tough *et al.*, 2007). Later parenthood implies higher wages and more stable job position for men and lower 'opportunity costs' of childbearing for women. Especially for higher-educated women, later motherhood is associated with lower income loss and lower skill depreciation (Taniguchi, 1999; Joshi, 2002; Drolet, 2002), in part because they have more time to invest in their education and career earlier in life (Blackburn *et al.*, 1993). For the USA, Miller (2011) reported that delaying motherhood by 1 year at the age of 21–34 was associated with an increase in earnings by 10% (partly due to longer working hours) and the positive effect of birth postponement was largest for college-educated women.

Positive aspects of later parenthood extend beyond economic and career advantages. Young mothers often live without a stable partner. In England and Wales in 2006, the proportion of women who did not live with a partner at the time of giving birth was 56% at age 15–19, 28% at age 20–24, 12% at age 25–29 and 7% at age 30–34 (ONS, 2007, tables 3.6, 3.8 and 3.10). Partnerships and marriages that were formed early in life have high dissolution rates (e.g. Wilson and Smallwood, 2008); therefore, children with 'younger' parents often experience parental divorce and are more likely to live with only one parent or with a stepparent before reaching adulthood. In addition, children born to older parents are usually strongly desired and are born into a more stable family environment. Men who become fathers after age 30 become more involved with their children and express more positive feelings about fatherhood (Cooney *et al.*, 1993). Couples that have their first child after age 35 were more satisfied with their marital life, experienced less parenting stress, and reported better family functioning (Garrison *et al.*, 1997).

Medical consequences of postponed parenthood

Fecundability and fertility

Postponing attempts to achieve parenthood to an advanced reproductive age is associated with increased risk of infertility, prolonged TTP and a range of adverse pregnancy outcomes.

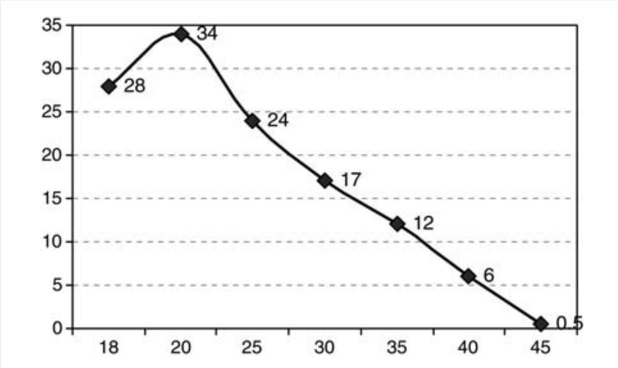

Figure 5 Graph based on calculations of the monthly hazard of live birth conception among Hutterite women (Larsen and Yan, 2000).

Dunson *et al.* (2002) investigated the probability of a clinical pregnancy among healthy couples using natural family planning methods. When adjusted for the male partner's age, the fecundability for women was 0.54 in the age group 19–26, 0.40 in the age group 27–29, 0.35 in the age group 30–34 and 0.28 in the age group 35–39. This is a decline of almost 50% between women in their early 20s and women in their late 30s. For women aged 35 years with a partner of similar age, the probability of achieving a clinical pregnancy following intercourse on the most fertile day was 0.29; when a 35-year-old woman had a 40-year-old partner the estimated probability dropped to 0.18.

The number of live born children also declines with increasing female age. Menken *et al.* (1986) analysed data from 10 different demographic studies and showed how fertility consistently declined from the mid-30s. Based on a sample of 544 Hutterite couples, a Christian sect strongly opposed to deliberate fertility control, Larsen and Yan (2000) calculated the fecundability resulting in live birth by the age of the woman (Fig. 5); the monthly rate was 24% among 25-year-old women and decreased to 17% at the age of 30, 12% at the age of 35 and 5% at the age of 40.

Van Balen *et al.* (1997) measured the cumulative pregnancy rate, defined as the chance of achieving a pregnancy that leads to a live birth, in a sample of women aged 25–49 years. The 6-month cumulative pregnancy rate was 65–70% among women aged 22–33 years and decreased to around 50% at age 34–35. Within 12 months, almost 90% of 20–28-year-old women, but only 75% of women around the age of 35 had achieved pregnancy.

In a study of women in Week 36 of a pregnancy, female age was significantly correlated to delayed TTP (Olsen, 1990). The odds ratio of TTP $\geq$ 1 year was 2.43 (95% CI 1.54–3.81) among women in the age group 25–29 years, 3.25 (95% CI 1.96–5.38) in the age group 30–34 years, 4.49 (95% CI 2.34–8.59) in the age group 35–39 years and 20.06 (95% CI 5.75–69.99) in the age group $\geq$40 years when compared with 15–19-year-old women. In this study parental age was not significantly associated with prolonged TTP (Olsen, 1990).

Ford *et al.* (2000) studied TTP in relation to male age in a longitudinal cohort of parents after a planned pregnancy. Men who took >12 months to impregnate their partner were significantly older than men who took $\leq$12 months. Analysis of the impact of male age on their partner becoming pregnant within 12 months showed the following decreasing odds ratios (when controlled for the partner's age, among other factors): 25–29 years, OR = 0.83 (95% CI 0.54–1.28); 30–34 years, OR = 0.62 (95% CI 0.40–0.98); 35–39 years, OR = 0.50 (95% CI 0.31–0.81); and $\geq$40 years, OR = 0.51 (95% CI 0.31–0.86) when compared with the age group $\leq$24 years. The odds ratio for a conception within 12 months leading to a birth decreased by 3% per year of increasing male age.

In conclusion, fecundability, defined as the monthly chance of a clinical pregnancy or a live birth, starts declining in the late 20s for women, with a substantial decline by the late 30s. Among men the chances of achieving successful conception are less affected by age. However, advanced male age is an independent risk factor of reduced fecundability and prolonged time to conception.

Infertility

The female and male decline in fecundability with age is reflected in the increase of the prevalence of infertility with advanced age. When comparing studies about the prevalence of infertility, it is important to take into account whether the researchers have estimated the prevalence of women/couples who have not achieved a clinical pregnancy after >12 months or estimated the prevalence of those who have not achieved a pregnancy leading to a live birth. As a proportion of pregnancies ended with fetal death, the latter infertility prevalence rates are considerably higher compared with prevalence rates focusing on the non-achievement of a clinical pregnancy.

Van Balen *et al.* (1997) reported that around 10% of women aged 20–28 years were infertile and around 25% of 35-year-old women had not achieved a pregnancy leading to the birth of a first child within 12 months. In contrast, Gnoth *et al.* (2003) found no age differences in infertility (clinical pregnancy) in a study among 346 couples using natural family planning in order to conceive: the mean age of women was 29.0, SD = 3.6 and 8% failed to conceive within 12 cycles.

In a prospective fecundability study among couples who were not using contraception, Dunson *et al.* (2004) showed that the percentage of infertility, defined as more than 12 months without clinical pregnancy, increased from 8% among women aged 19–26 years, to 13–14% at age 27–34, to 18% at age 35–39. For men younger than 35 there was no effect, but, starting in the late 30s, the impact of male age was pronounced. For a couple in which the woman was 35 years old, the 12-month infertility prevalence (clinical pregnancy) was 18% if the male partner was 35 and increased to 28% if the male partner was 40 years old. However, this study population was biased, as the couples were recruited from centres for natural family planning and these couples may have experienced more regular cycles and ovulations when compared with the average population.

A review study on paternal age and reproduction concluded that a paternal age above the late 30s is a risk factor for infertility (de La Rochebrochard *et al.*, 2003). Sartorius and Nieschlag (2010) concluded in their recent review that increasing paternal age is a risk factor for reduced fertility, at least in couples where the men are older than 40 years and women are at least 35 years old. Hence, postponement of childbearing increases the risk of infertility and the necessity of fertility treatment in order to achieve parenthood which, however, has a limited success rate at higher ages; see below.

Leridon (2004) used a computer simulation model of human reproduction, combining the monthly probability of conceiving and the risks of miscarriage, to estimate age-related chances for delivery. The study showed that under natural conditions, 75% of women starting to try to conceive at age 30 would have a conception ending in a live birth within 12 months; this dropped to 66% at the age of 35 and 44% at the age of 40. When a 48-month observation period was used, 94% of women starting to try to conceive at the age of 30 would achieve a conception leading to a live birth. The corresponding figures were 86% at the age of 35 and 65% at the age of 40.

Increasing paternal age is associated with declining androgen levels and deterioration in sperm quality and also influences the DNA integrity of the sperm (review in Sartorius and Nieschlag, 2010). The present increase in paternal age may cause a decrease in the couples' fecundity, which may contribute to the rise in the number of couples seeking fertility treatment with ART, especially ICSI (Nyboe Andersen *et al*., 2008). One estimate of the quantitative effect suggests that an increase in male age from 30 to 50 years would lower the monthly fertility rate by 25% (Kidd *et al*., 2001). A recent review of the effect of paternal age on the assisted reproductive outcome showed a significant decrease in the percentage of embryos that developed to blastocysts with increasing paternal age, but no clear correlation between advanced paternal age and rates of fertilization and implantation (Dain *et al*., 2011). In line with this Frattarelli *et al.* (2008) found a significant decrease in blastocyst formation rate in men >50 years of age in couples undergoing anonymous oocyte donation cycles. A cohort study of 487 couples in ART reported that, for each year of increase in male age, the probability of achieving a live birth was significantly reduced (OR = 0.96, 95% CI 0.93–1.00, $P = 0.04$) when controlled for female age and female BMI (Pinborg *et al*., 2011).

Studies on the decline in fecundity by age could also be influenced by co-morbidity and lifestyle factors such as smoking and obesity, but these factors are outside the scope of this paper.

Fetal death

Spontaneous abortions

The increased risk of spontaneous abortions with age is well documented both after natural conception and after assisted conception involving ovulation induction, intrauterine insemination and ART. Based on national population register data from Denmark for 1978–1992 covering all registered pregnancy outcomes (live births, stillbirths, spontaneous abortions, induced abortions, ectopic pregnancies), the miscarriage rate after natural conception was 9.2% in the female age group of 20–29 years, 12.0% at age 30–34, 19.7% at age 35–39, 40.1% at age 40–44 and 74.7% at age ≥ 45 when adjusted for induced abortions (Nybo Andersen *et al*., 2000). Data from the Czech Republic for 2008–2009 showed a similar increase in spontaneous abortion rates with female age: 9.4% at 20–29 years, 9.8% at 30–34 years, 15.0% at 35–39 years, 32.0% at 40–44 years and 55.0% at >45 years (Sobotka, own calculations, data excluded induced abortions). In a review, Leridon (2004) reported that the rate of spontaneous abortions increased from 13.6% at age 25–29, to 16.0% at age 30–34, 20.0% at age 35–39 and 27.0% at age 40–44. In a longitudinal cohort study, the miscarriage rates remained more or less constant between 10.3 and 13.5% up to 34 years of maternal age, but increased to 17.5% in the age group 35–39 (Blohm *et al*., 2008).

Abortion risks in pregnancies after ART are good models to study the risk of spontaneous abortions, as these pregnancies are all intended, have a well-defined gestational period and are closely monitored by serum hCG and sonography. Based on all clinical pregnancies following the first autologous fresh cycles in Australia from 2002 to 2005, it was shown that the risk of spontaneous abortions of clinical pregnancies was almost constant around 10–15% in the age groups below 35 years of age. In the age group 37–38 it reached 20% and increased further to 25–30% in the age group 39–40 (Wang *et al*., 2008). Based on all women who had a positive beta hCG 2 weeks after embryo transfer in the USA, the miscarriage rate below 35 years of maternal age was 22.4% and increased to 27.1% at age 35–37, 36.6% at age 38–39 and to 51.2% at age 41–42 (Farr *et al*., 2007).

Higher paternal age has also been related to an increased rate of miscarriage. In spontaneous conceptions, the abortion rate, when adjusted for maternal age, was related to paternal age of over 40 years: the risk of miscarriage had an odds ratio of 2.8 (CI 1.86–4.45) when the female partner was below 35 years of age but the OR was as high as 5.65 (CI 3.20–9.98) when the paternal age was above 40 and the maternal age above 35 (de La Rochebrochard and Thonneau, 2002). In a study of more than 17 000 intrauterine inseminations, Belloc (2008) found that the odds ratios for miscarriage were 1.71 when the paternal age was 35–44 and 1.75 when paternal age exceeded 44 years. Based on a cohort study among 23 821 pregnant women, Nybo Andersen *et al.* (2004) found the risk of fetal death (spontaneous abortion and stillbirth) to be almost twice as high when fathered by men ≥50 compared with men younger than 50 years old, when adjusted for several confounders including maternal age. Based on studies among couples treated with assisted reproduction, a review reported one study (Fratterelli *et al*., 2008) that showed a significant increase in pregnancy loss in men >50 years (41.5% for >50 years and 24.4% for ≤50 years), while the other studies reviewed found no association between paternal age and spontaneous abortion (Dain *et al*., 2011).

Ectopic pregnancies

The risk of ectopic pregnancies also increases with female age. Based on a large national register data set from Denmark, the risk of an ectopic pregnancy almost doubles, from 1.4% of all pregnancies at the age of 21, for every 10 years of female age until the end of the reproductive lifespan at age 45 (Nybo Andersen *et al*., 2000). A case–control study from France found a similar increase in the risk of ectopic pregnancies with an odds ratio of 1.5 (95% CI 1.2–1.9) among women aged 30–34 years, 2.1 (95% CI 1.6–2.8) in the age group 35–39 years and 5.7 (95% CI 3.2–10.2) in the age group ≥40 years when compared with women 25–29 years old (Bouyer *et al*., 2003).

Stillbirths

Female age is also a risk factor in stillbirth (Silver, 2007). A population-based study of all singleton pregnancies at ≥28 weeks of gestation in Sweden in 1983–1989 showed a stillbirth rate of 3.2/1000 births among women 20–34 years old and 4.6/1000 births among women 35+ (Raymond *et al*., 1994). The estimated odds ratio of stillbirth was 1.4 (95% CI 1.3–1.6) for stillbirth among women ≥35 years compared with women aged 20–34 years (odds ratio of 1.0) (Raymond *et al*., 1994). The increased risk of stillbirth with increasing

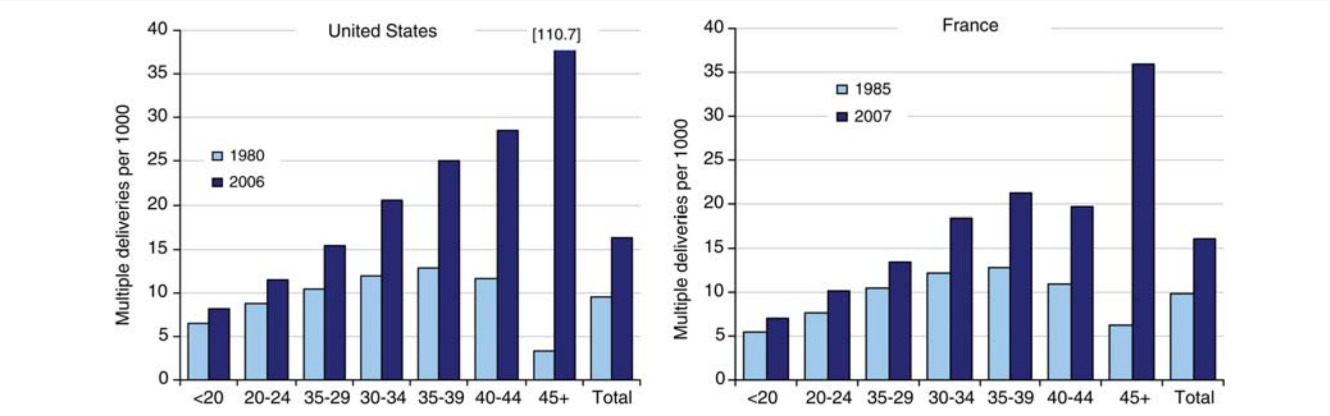

Figure 6 Multiple deliveries per 1000 births by maternal age. USA (1980 and 2006) and France (1985 and 2007). *Sources:* USA: Own computations based on Table 2 in Martin and Park (1999) and Martin *et al*. (2009). France: Table 33 in INSEE (2009).

female age persisted after excluding women with hypertension, diabetes, placental complications and growth retardation. In a hospital-based cohort study (1978–1996), Huang *et al*. (2000) reported an adjusted odds ratio for unexplained fetal death of 1.57 (95% CI 0.78–3.18) among women 35–39 years old and an odds ratio of 3.69 (95% CI 1.28–10.58) among women aged ≥40 years when compared with women 20–34 years old.

To summarize, studies on spontaneous conceptions as well as assisted conceptions show that the risk of spontaneous abortions remains relatively stable up to a maternal age of 35 years. From age 35 to age 40 the abortion rate increases from around 15–30%, and a rate of 50% is reached at around 42 years of age. Thus, in relation to spontaneous abortion, a delay in female childbearing age of up to around 35 years of age will have no significant impact, but the rate doubles over the next 5-year age interval. In comparison, the effect of male age on spontaneous abortions is less pronounced but male age >50 nearly doubles the risk.

Trisomy

Advanced maternal age has long been known to be associated with increased risk of trisomy 21/DS (Tabor, 1988), which is the leading cause of birth defects (Sherman *et al*., 2007). Hultén *et al*. (2010) proposed that the maternal age effect in DS is caused by a differential behaviour of trisomy 21 in relation to disomy 21 oocytes from fetal life to adulthood. Tabor's review (1988) of four studies showed an average risk for DS per 1000 live births of 0.81 at age 25–29 years, 1.39 at age 30–34, 3.50 at age 35–39, 13.17 at age 40–44 and 32.52 at ≥45 years.

There is some evidence that DS may also be associated with paternal age but much less strongly than maternal age (Kazaura and Lie, 2002). In a case–control study De Souza *et al*. (2009) found an odds ratio of 1.13 (95% CI 0.85–1.52) for DS with a 10-year increase in paternal age. Analysis of trisomy anomalies in a large register study involving 22 congenital anomaly registers in 12 countries showed a statistically significant increase in Klinefelter syndrome with advanced paternal age, and a small positive association of paternal age with trisomy 13 and 18, which is similar to that of DS (De Souza *et al*., 2010). However, prenatal diagnostics and elective abortion may reduce the frequency of DS, thus countering the effect of increasing age at childbearing. Khoshnood *et al*. (2004) show that the DS prevalence in pregnant women in Paris increased from <15 per 10 000 in 1981 to >30 in the late 1990s, but the actual prevalence of DS among live born children declined by about 3% per calendar year.

Multiple birth rates

Data from Europe, the USA, Canada and Asia show that multiple birth rates started increasing from the mid-1980s with a rapid increase after 1990 (Imaizumi, 1998; Pison and d'Addato, 2006). Around the mid-1980s, European countries and the USA had a twinning rate of 8–12 per 1000 deliveries (Pison and d'Addato, 2006); within 20 years the twinning rate doubled and reached 14–24 per 1000 deliveries in 2005–2008 (e.g. England and Wales: 15.5, France: 16.1, USA: 16.6, Czech Republic: 20.5, Denmark: 22.9; data based on national vital statistics). The observed increase in twinning rates is largely attributable to two factors: postponement of childbearing and the rising use of assisted reproduction (Pinborg, 2005). Maternal age is linked to an increased prevalence of multiple birth rates (Bartolus *et al*., 1999), owing to greater multiple follicle growth with age (Beemsterboer et al., 2006). A US study stated that 20% of the observed increase in the twin birth rate was attributable to the increasing age of women giving birth, 40% to ovulation induction and 40% to IVF (Jones, 2003). A Swedish register study (Bergh *et al*., 1999) estimated that one-third of the rise in twin deliveries was explained by the increase in female childbearing age, one-third to MAR not including ART, and one-third to ART treatment. Similarly, a detailed study for France attributed two-thirds of the increase in the multiple birth rate to MAR treatments and one-third to the later age at childbearing (Pison and Couvert, 2004).

Because of the high prevalence of assisted reproduction using multiple-embryo transfers at advanced reproductive ages, multiple birth rates with increase of maternal age has sharply increased in many developed countries. Figure 6 illustrates this with the data for the USA and France. In 1980 (1985 for France), the data show a typical age pattern of multiple deliveries in the absence of ART: a gradual rise from 5–6 deliveries per 1000 at maternal ages <20 years to 12–13 per 1000 at age 35–39 and then a subsequent decline. The recent data for 2006–2007 depict a sharp rise, starting from 7–8 per 1000 at maternal age <20 years. In France, multiple deliveries rose above 20 per 1000 at maternal age 35–39, whereas in the USA the increase is even greater, to above 20 at maternal age 30–34, 29 at age 40–44 and 110 at age >45 (Martin, 2000; Smulian *et al.*, 2004). The latter value is extreme and may be attributed to ART. The number of multiple live births at maternal age 45+ increased by a factor of 150 in the USA, from 9 in 1980 to 1479 in 2006.

In the most recent years several countries have implemented guidelines for elective single embryo transfer (eSET) and an increasing proportion of couples in ART accept eSET. For example eSET in the UK has increased from 6.6% in 2008 in women under 35 years to 22.1% in 2010 (HFEA, 2011). Following this increase, the multiple pregnancy rate after ART has fallen from 31.2 to 23.9% (HFEA, 2011). In line with this a study from a Finnish fertility clinic showed that eSET increased from 4.2% in 1995–1999 to 46.2% in 2000–2004, and accordingly the cumulative multiple birth rate was significantly reduced from 19.6 to 8.9% (Veleva *et al.*, 2009). A recent meta-analysis showed that eSET at the cleavage stages reduces the likelihood of multiple birth by 94% (Gelbaya *et al.*, 2010). The use of eSET is most pronounced among couples where the woman is <38 years. Hence the proportion of the multiple pregnancy rates owing to ART is decreasing among the youngest mothers but the decrease among the older mothers is expected to be minor.

Preterm birth

The frequency of preterm births (<37 weeks) by maternal age shows a U-shaped curve with the lowest risk at the age of 29 years. The unadjusted rate of preterm birth is 4.7% for the age group 25–29 years, 6.0% at age 30–34, 7.8% at age 35–39 and 12.7% in women ≥40 (Voigt *et al.*, 2010). Preterm birth is associated with several risk factors, including previous abortions, stillbirth, parity, overweight and social position. A review by Carolan and Frankowska (2010) found a positive association between later maternal age and increased rates of preterm birth with odds ratios varying between 1.4 and 1.8 among women >40 years of age compared with women 35–40 years old.

Studies on paternal age and preterm birth are contradictory. Several studies from Canada and the USA showed no effect of advanced paternal age, but studies from Italy and Denmark reported an effect of paternal age on preterm birth (review in Sartorius and Nieschlag, 2010).

Psychological consequences of infertility and involuntary childlessness

A substantial number of studies have repeatedly shown that infertility and its treatment are severe multidimensional low-control stressors. The treatment itself is most likely to evoke anxiety, while the unpredictable outcome of treatment is another major stressor, more likely to evoke feelings of depression (Dunkel-Schetter and Lobel, 1991). Most studies comparing the levels of depression and general anxiety in couples initiating fertility treatment with norm groups find no differences (Greil, 1997; Verhaak *et al.*, 2007a; Williams *et al.*, 2007). MAR using own gametes cannot fully compensate for the reduced fecundity with increasing age and a substantial proportion of fertility patients remain childless after having terminated treatment. This has been clearly shown in a simulation model by Leridon (2004: Table II). For women unable to conceive at the age of 30 and initiating ART treatment at the age of 34, one-half of those would eventually achieve a live birth through ART (excluding potential spontaneous conceptions). This falls to 25% for those infertile at the age of 35 and starting a treatment at the age of 38 and to a mere 3% of those infertile at the age of 40 and initiating treatment at the age of 42.

A recent register-based study reported that infertile women who did not give birth had higher hospitalizations for all psychiatric diagnoses compared with infertile women who gave birth (Yli-Kuha *et al.*, 2010). Only a few long-term longitudinal studies have prospectively investigated the development of levels of depression and/or anxiety after unsuccessful treatment. At a 1-year follow-up among couples in unsuccessful treatment Lund *et al.* (2009) reported that 15% of the women and 6% of the men had developed severe depressive symptoms since the start of treatment. Verhaak *et al.* (2005, 2007b) found that women showed an increase in both depression and anxiety levels after unsuccessful treatment and a decrease after successful treatment. Johansson *et al.* (2009) found that men and women who terminated unsuccessful IVF treatment 4–5.5 years prior to the study and were still childless reported more depression, less positive well-being, lower self-confidence and general health, and a lower sense of coherence in contrast to those who had become parents. Involuntary childlessness, often resulting from childbearing postponement, also causes significant long-lasting psychological distress among women not undergoing the treatment and not adopting a child (McQuillan *et al.*, 2003).

In conclusion, sparse research on long-term mental health of the involuntarily childless indicates that involuntary childlessness is a risk factor for reduced mental well-being among both men and women.

Conclusions

For several decades, people across Europe have been postponing parenthood. As a consequence, an increasing proportion of couples are experiencing infertility, prolonged TTP and a range of adverse pregnancy outcomes including fetal death. Despite widespread availability of high-quality MAR in many countries, these treatments cannot fully compensate for the loss of fecundity linked to greater maternal and paternal age. The impact of maternal age on infertility and adverse pregnancy outcomes is more profound and better documented than the effect of advanced male age. For women, the increased risk of prolonged TTP, infertility, spontaneous abortions and trisomy 21 have a pronounced effect >35 years, whereas the increased risk of preterm births and stillbirths have a pronounced effect >40 years. Among men there is a pronounced effect on infertility and adverse reproductive outcome >50 years. However, as women in general have partners who are several years older than themselves, it is important to focus more on the combined effect of advanced female and advanced male age on reproductive outcomes in the future.

An increasing proportion of couples plan to have children at advanced ages, probably without being aware of the increased risk of infertility and adverse reproductive outcomes. There is a substantial need to inform health professionals and the general public about the increased reproductive risks across a variety of outcomes associated with advanced female and male age. Provision of this information is essential to enable people wishing to become parents make qualified decisions on when to start having children. In the future multiple strategies for preventing infertility should be combined with securing easy and equal access to high-quality ART for those who need treatment in order to achieve parenthood.

Authors' roles

L.S. drafted the manuscript, whereas T.S. was responsible for the demographic sections and A.N.A. and J.G.B. for the parts on infertility and age, as well as age-related results of ART. All authors contributed to subsequent revisions of the text.

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Conflict of interest

None declared.

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