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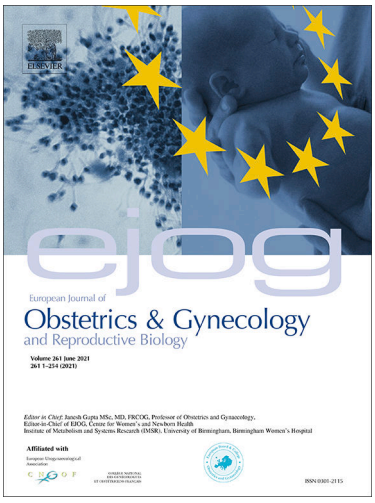

Full length article

Parents' age and total fertility rate in selected high-income countries from Europe and North America, 1990–2020

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Parents' age and total fertility rate in selected high-income countries from Europe and North America, 1990-2020

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Abstract

Objective: To provide a comprehensive picture of trends in parents' age and total fertility rate in selected most populous high-income countries from Europe and North America.

Study design: Data were retrieved from official statistics published by the United Nations, the World Bank, the European Union (EU) and by national health statistics offices.

Results: Mean maternal age at birth showed increasing trends in all considered countries; in 2020, the highest mean age was observed in Italy (32.2) and Spain (32.3), and the lowest one in the USA (28.8). Mean maternal age at first birth also showed upward trends. In the 1990s, mean age at first birth ranged from 25.5 to 26.9 years, except of the USA where it was below 25 years. The countries with the highest average maternal age at first birth were Italy and Spain, reaching 31 years over the most recent years. Data on mean paternal age at birth were scant. In Germany (2019) and the USA (2014), it was respectively 34.6 and 27.9 years. In Italy, mean paternal age increased from 34.2 in 2000 to 35.5 in 2018, in the UK from 30.7 in 1990 to 33.4 in 2017, and in Canada, a decrease was observed from 29.1 in 2006 to 28.3 in 2011. Finally, Sweden and the USA had the highest fertility rates, around two children in some years, while Italy and Spain had the lowest ones, with less than 1.5 children over the whole period.

Conclusions: Monitoring of trends in reproductive factors is crucial to gain insight into society from a cultural and sociological point of view and to analyze the impact of these changes on reproductive health and related conditions.

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Introduction

A woman's reproductive life course includes her age at menarche and menopause, the age at which she starts and stops having children and the number of children. These reproductive factors have relevant impact on diseases and conditions related to the endocrine system [1], as well as on the risk of hormone-related cancers, such as breast [2-5], endometrial [2, 6-8], and ovarian cancer [2, 9-13]. Since the incidence of some of these diseases is increasing, it is of interest to monitor the trends in reproductive factors.

Major changes in reproduction have occurred in high-income countries in Europe and North America in the last century. Average maternal and paternal ages at birth increased, family size decreased, and survival of very low birth weight infants has increased due to advancements in neonatal medicine [14, 15].

Advanced maternal age represents a risk factor for female infertility, pregnancy loss, chromosomal abnormalities, stillbirth, and obstetric complications [16]. However, women are now delaying childbearing more than ever before. Paternal age has also increased, but the impact of advanced paternal age on reproductive risks has been poorly investigated [17].

In order to provide a comprehensive picture of trends in maternal and paternal age, age at first pregnancy, and total fertility rate (i.e., the average number of children per woman) in selected most populous high-income countries from Europe and North America, we have summarized the data available in national and international databases on these trends.

Methods

Data retrieval

We searched for official statistics published by the United Nations, the World Bank, the European Union (EU) and by national health statistics offices. In particular, we retrieved data from the following databases: Istituto Nazionale di Statistica (ISTAT) for Italy; European Statistical Office (Eurostat) for the other European countries; Centers for Disease Control and Prevention and the National Center for Health Statistics for the USA and Statistics Canada and the United Nations Economic Commission for Europe (UNECE). We obtained the most recent available data and the range of years may vary from country to country. Total fertility rate is expressed as number of births among women aged 15 to 44, in the absence of consideration of cohort composition. The websites from which we retrieved the data for each country and reproductive factor considered are listed in **Supplementary Table S1**.

Since the databases used in this study are publicly available, no ethical approval was required for the current analyses. No human participant was involved and the informed consent was waived.

Results

Table 1 reports the mean maternal age at birth in selected countries from 1990 to the most recent available data for each subsequent calendar quinquennium, corresponding data per single calendar year are given in **Figure 1** and **Supplementary Table S2**. This information was available for the entire period under consideration for most countries except Germany and the USA. There was an increasing trend in all countries; in 2020, the highest mean

age of mothers was observed in Italy (32.2) and Spain (32.3), and the lowest one in the USA (28.8). In the USA, maternal age at birth increased from 26.4 years in 1990 to 28.8 years in 2018-2020, while it exceeded 30 years elsewhere in most recent calendar years.

Mean maternal age at first birth shows similar findings, and upward trend emerged in all countries. In the 1990s, the mean age at first birth ranged between 25.5 and 26.9 years, for most countries, except for the USA with a value below 25 years. The countries with the highest average maternal age at first birth were Italy and Spain, reaching 31 years over the most recent period. In the other countries, it gradually increased but did not reach 30 years (**Table 2** by subsequent calendar quinquennium, **Figure 2** and **Supplementary Table S3** by year).

Table 3 shows the mean paternal age (years) at birth in selected countries with available information and calendar years. In Germany, data were only available for 2019 (34.6 years) and in the USA only for 2014 (27.9 years). In Italy, paternal age increased from 34.2 to 35.5 years between 2000 and 2018. In the UK, it increased from 30.7 to 33.4 years between 1990 and 2017. In Canada, it was 29.1 in 2006 and 28.3 in 2011.

Table 4 reports the total fertility rate every five calendar years, **Figure 3** and **Supplementary Table S4** by single year. France, Sweden and the USA reported the highest fertility rates, reaching on average two children in some years, while Italy and Spain the lowest ones, with less than 1.5 children over the entire period considered.

Discussion

We observed a linear and continuous increase in the average maternal age at birth and at first birth in all countries considered, as well as in paternal age, though data were scantier. Fertility rates also tended to decline, though with some exceptions. There were noticeable differences across countries, with Southern European ones showing the highest maternal ages and the US a markedly lower one. In 2020 the lowest fertility rates were around 1.2 in Italy and Spain, and the highest one (1.8) in France.

Changes in human reproduction occurring in high-income countries reflect profound changes in the society. In particular, women tend to delay childbirth due to the pursuit of educational and career goals, and a lack of social services to support working mothers. Additionally, the increased divorce and remarriage rates, as well as the availability of assisted reproductive technologies, contribute to the growing number of late births.

Advanced maternal age was defined as over 35 years, due to the convergence of the increased risk for chromosomal anomalies. There is no universal definition of advanced maternal age and a different age limit could be determined for each adverse perinatal outcome [18]. Advanced maternal age represents a risk factor for female infertility, pregnancy loss, chromosomal abnormalities, stillbirth, and obstetric complications [16]. Moreover, advancing age is related to an increased risk of gestational diabetes [19] and hypertensive disorders [20]. Some of these conditions, such as chromosomal abnormalities, are now controlled by prenatal tests [21-23]. However, women aged 40 or more have been reported to have favorable pregnancy and neonatal outcomes, not appreciably different to younger ones [24].

Delaying childbearing also resulted in older fathers. Female biological fertility declines with age due to a constant and substantial decrease in the number and quality of oocytes, while men continue to produce sperm throughout their lifespan; although their quantity and

quality may decline. Advanced paternal age has been associated with infertility and other reproductive risks, even if this topic has been less studied [25].

Delaying childbirth involves a decrease in the number of children. The total fertility rate dropped drastically in many countries over the last decades [26]. Beyond the availability of family planning programs, the total fertility rate is also affected by cohort effects (not considered in the present work), level of education, social and religious status, and contraceptive use. All these aspects undergo strong changes over time and vary across countries.

The differences across countries may at least in part be due to different investments in family policies, as well as to the type of implemented family policies. In Europe, family policy spending was above 3% of the Gross domestic product (GDP) in the Nordic countries, France, Great Britain, and some Eastern European countries, while in some Southern Mediterranean countries it was below 2% of the GDP [27]. Different types of family policies may have differential effects. In an analysis of data from 20 countries over the period 1997 to 2007, Billingsley and colleagues [28] concluded that expanding social investment-oriented policies is related to higher first conception probabilities, whereas expanding passive family support leads to lower first conception probabilities. He argued that policies that offer to stay out of the labour market for a long time, as passive family support policies do, may be seen by women as harmful for their future employability.

Continuous monitoring of the temporal trends of reproductive habits, apart from representing an insight into society from a cultural and sociological point of view, is of fundamental relevance for analyzing the impact of these changes on reproductive health and related conditions.

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References

1. Swaen GMH, Boffetta P, Zeegers M: Impact of changes in human reproduction on the incidence of endocrine-related diseases. Crit Rev Toxicol 2018, 48(9):789-795.

2. La Vecchia C, Negri E, Franceschi S, Parazzini F: Long-term impact of reproductive factors on cancer risk. Int J Cancer 1993, 53(2):215-219.

3. Parazzini F, Lavecchia C, Negri E, Franceschi S, Tozzi L: Lifelong Menstrual Pattern and Risk of Breast-Cancer. Oncology 1993, 50(4):222-225.

4. Talamini R, Franceschi S, La Vecchia C, Negri E, Borsa L, Montella M, Falcini F, Conti E, Rossi C: The role of reproductive and menstrual factors in cancer of the breast before and after menopause. Eur J Cancer 1996, 32A(2):303-310.

5. Rosato V, Bosetti C, Negri E, Talamini R, Dal Maso L, Malvezzi M, Falcini F, Montella M, La Vecchia C: Reproductive and hormonal factors, family history, and breast cancer according to the hormonal receptor status. Eur J Cancer Prev 2014, 23(5):412-417.

6. Ali AT: Reproductive factors and the risk of endometrial cancer. Int J Gynecol Cancer 2014, 24(3):384-393.

7. Jordan SJ, Na R, Weiderpass E, Adami HO, Anderson KE, van den Brandt PA, Brinton LA, Chen C, Cook LS, Doherty JA et al: Pregnancy outcomes and risk of endometrial cancer: A pooled analysis of individual participant data in the Epidemiology of Endometrial Cancer Consortium. Int J Cancer 2021, 148(9):2068-2078.

8. Zucchetto A, Serraino D, Polesel J, Negri E, De Paoli A, Dal Maso L, Montella M, La Vecchia C, Franceschi S, Talamini R: Hormone-related factors and gynecological conditions in relation to endometrial cancer risk. European Journal of Cancer Prevention 2009, 18(4):316-321.

9. Koushik A, Grundy A, Abrahamowicz M, Arseneau J, Gilbert L, Gotlieb WH, Lacaille J, Mes-Masson AM, Parent ME, Provencher DM et al: Hormonal and reproductive factors and the risk of ovarian cancer. Cancer Causes Control 2017, 28(5):393-403.

10. Parazzini F, Chatenoud L, Chiantera V, Benzi G, Surace M, La Vecchia C: Population attributable risk for ovarian cancer. Eur J Cancer 2000, 36(4):520-524.

11. Chiaffarino F, Pelucchi C, Parazzini F, Negri E, Franceschi S, Talamini R, Conti E, Montella M, La Vecchia C: Reproductive and hormonal factors and ovarian cancer. Ann Oncol 2001, 12(3):337-341.

12. Schuler S, Ponnath M, Engel J, Ortmann O: Ovarian epithelial tumors and reproductive factors: a systematic review. Arch Gynecol Obstet 2013, 287(6):1187-1204.

13. La Vecchia C: Ovarian cancer: epidemiology and risk factors. European Journal of Cancer Prevention 2017, 26(1):55-62.

14. Lee HC, Liu J, Profit J, Hintz SR, Gould JB: Survival Without Major Morbidity Among Very Low Birth Weight Infants in California. Pediatrics 2020, 146(1).

15. Soll RF, Edwards W: Continually Improving Outcomes for Very Low Birth Weight Infants. Pediatrics 2020, 146(1).

16. Frick AP: Advanced maternal age and adverse pregnancy outcomes. Best Pract Res Clin Obstet Gynaecol 2021, 70:92-100.

17. Kaltsas A, Moustakli E, Zikopoulos A, Georgiou I, Dimitriadis F, Symeonidis EN, Markou E, Michaelidis TM, Tien DMB, Giannakis I et al: Impact of Advanced Paternal Age on Fertility and Risks of Genetic Disorders in Offspring. Genes-Basel 2023, 14(2).

18. Klemetti R, Gissler M, Sainio S, Hemminki E: At what age does the risk for adverse maternal and infant outcomes increase? Nationwide register-based study on first births in Finland in 2005-2014. Acta Obstet Gynecol Scand 2016, 95(12):1368-1375.

19. Li Y, Ren X, He L, Li J, Zhang S, Chen W: Maternal age and the risk of gestational diabetes mellitus: A systematic review and meta-analysis of over 120 million participants. Diabetes Res Clin Pract 2020, 162:108044.

20. Attali E, Yogev Y: The impact of advanced maternal age on pregnancy outcome. Best Pract Res Clin Obstet Gynaecol 2021, 70:2-9.

21. Wald NJ, Lau KW, Bestwick JP, Old RW, Huttly WJ, Cheng R: Specifying a Gold Standard for the Validation of Fetal Fraction Estimation in Prenatal Screening. Clin Chem 2018, 64(9):1394-1399.

22. Bestwick JP, Wald NJ: Cost and efficacy comparison of prenatal recall and reflex DNA screening for trisomy 21, 18 and 13. PLoS One 2019, 14(7):e0220053.

23. Vale SH, Huttly WJ, Wald NJ: Antenatal screening for Down's syndrome: Revised nuchal translucency upper truncation limit due to improved precision of measurement. J Med Screen 2021, 28(2):88-92.

24. Favilli A, Pericoli S, Acanfora MM, Bini V, Di Renzo GC, Gerli S: Pregnancy outcome in women aged 40 years or more. J Matern Fetal Neonatal Med 2012, 25(8):1260-1263.

25. Brandt JS, Cruz Ithier MA, Rosen T, Ashkinadze E: Advanced paternal age, infertility, and reproductive risks: A review of the literature. Prenat Diagn 2019, 39(2):81-87.

26. Cheng H, Luo W, Si S, Xin X, Peng Z, Zhou H, Liu H, Yu Y: Global trends in total fertility rate and its relation to national wealth, life expectancy and female education. BMC Public Health 2022, 22(1):1346.

27. Filguiera F, Rossel C: Family Policies Across the Globe. In: The Palgrave Handbook Of Family Policy. edn. Edited by Rense N, Wim VL; 2020.

28. Billingsley S, Neyer G, Wesolowski K: Social Investment Policies and Childbearing Across 20 Countries: Longitudinal and Micro-Level Analyses. Eur J Popul 2022, 38(5):951-974.

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Highlights

- Monitoring of trends in reproductive factors is crucial to gain insight into society from a cultural and sociological point of view and to analyze the impact of these changes on reproductive health and related conditions.
- Reproductive factors have relevant impact on diseases and conditions related to the endocrine system, as well as on the risk of hormone-related cancers, such as breast, endometrial, and ovarian cancer.
- Mean maternal and paternal age at birth show increasing trends in high-income countries from Europe and North America.
- Delaying childbirth involves a decrease in the number of children.
- Sweden and the USA had the highest fertility rates, around two children in some years, while Italy and Spain had the lowest ones, with less than 1.5 children over the whole period.

Table 1. Mean maternal age at any birth in selected countries and calendar year.

	Country										
Year	**France**	**Germany**	**Italy**	**Spain**	**Denmark**	**Finland**	**Norway**	**Sweden**	**UK**	**USA**	**Canada**

1990	28.3[1]	-	28.9	28.9	28.5	28.9	28.1	28.6	27.7	26.4	27.8
1995	28.9	-	29.8	30.0	29.2	29.3	28.8	29.2	28.2	26.9	28.3
2000	29.4	28.8	30.4	30.7	29.7	29.6	29.3	29.9	28.5	27.2	29.0
2005	29.7	29.5	30.9	30.9	30.2	29.9	29.8	30.5	29.1	27.4	29.7
2010	30.0	30.4	31.3	31.2	30.6	30.2	30.1	30.7	29.5	27.7	30.2
2015	30.4	30.9	31.7	31.9	31.0	30.6	30.7	31.0	30.3	28.5	30.7
2020	30.8	31.3	32.2	32.3	31.4	31.2	31.4	31.3	30.6[2]	28.8	-

[1] France metropolitan; [2] The last year available is 2018.

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Table 2. Mean maternal age at first birth in selected countries and calendar year.

	Country										
Year	**France**	**Germany**	**Italy**	**Spain**	**Denmark**	**Finland**	**Norway**	**Sweden**	**UK**	**USA**	**Canada**
1990	-	26.9	26.9	26.8	26.3	26.5	25.8[1]	26.3	25.5	24.2	25.8
1995	28.1	28.1	28.0	28.4	27.3	27.2	26.4	27.3	26.1	24.5	26.4
2000	27.8	29.0	28.6	29.1	28.1	27.4	26.9	28.2	26.5	24.9	27.0
2005	28.5	29.6	29.6	29.3	28.8	27.9	27.7	29.0	27.2	25.2	27.5
2010	28.1	28.9	30.3	29.8	29.0	28.3	28.0	28.9	27.7	25.4	27.8
2015	28.4	29.5	30.8	30.7	29.2	28.8	28.9	29.2	28.7	26.4	28.7
2020	28.9	29.9	31.4	31.2	29.8	29.5	29.8	29.7	29.0[2]	27.0[3]	29.4[3]

[1] First year available is 1991; [2] The last year available is 2018; [3] The last year available is 2019.

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Table 3. Mean paternal age at birth in selected countries and calendar year.

	Country				
Year	**Germany**	**Italy**	**UK**	**USA**	**Canada**
1990	-	-	30.7	-	-
1995	-	-	31.3	-	27.8
2000	-	34.2	31.7	-	-
2005	-	34.6	32.2	-	29.1[4]
2010	-	35.0	32.5	-	28.3[5]
2015	-	35.3	33.2	27.9[3]	-
2018	34.6	35.5[1]	33.4[2]	-	-

[1] The last year available is 2018; [2] The last year available is 2017; [3] The only year available is 2014; [4] The year available is 2006; [5] The last year available is 2011.

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Table 4. Total fertility rate (average number of children) in selected countries and calendar year.

	Country										
Year	**France**	**Germany**	**Italy**	**Spain**	**Denmark**	**Finland**	**Norway**	**Sweden**	**UK**	**USA**	**Canada**
1990	1.77	1.45	1.33	1.36	1.67	1.78	1.93	2.13	1.83	2.08	1.83
1995	1.74	1.25	1.19	1.16	1.80	1.81	1.87	1.73	1.71	1.98	1.67
2000	1.89	1.38	1.26	1.22	1.77	1.73	1.85	1.54	1.64	2.06	1.51
2005	1.94	1.34	1.34	1.33	1.80	1.80	1.84	1.77	1.76	2.06	1.57
2010	2.03	1.39	1.46	1.37	1.87	1.87	1.95	1.98	1.92	1.93	1.64
2015	1.96	1.50	1.35	1.33	1.71	1.65	1.72	1.85	1.80	1.84	1.60
2020	1.83	1.53	1.24	1.23	1.67	1.37	1.48	1.66	1.56	1.64	1.40

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