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Complete List of Authors:	Roustaei, Zahra; Helsingin Yliopisto, Räisänen, Sari; Tampereen ammattikorkeakoulu, School of Health Care and Social Services Gissler, Mika; THL National Institute for Health and Welfare, Information; Karolinska Institutet Department of Neurobiology Care Sciences and Society, Division of Family Medicine and Primary Care Heinonen, Seppo; Naistenklinikka, Department of Obstetrics and Gynecology
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Fertility rates and the postponement of first births: a descriptive study with Finnish population data

Zahra Roustaei [1], Sari Räisänen [2], Mika Gissler [3], Seppo Heinonen [4]

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Author affiliations

1. Department of Health Sciences, University of Helsinki, 00014 Helsinki, Finland.
2. School of Health Care and Social Services, Tampere University of Applied Sciences, Tampere, Finalnd.
3. Information Services Department, National Institute for Health and Welfare (THL), Helsinki, Finland and Department of Neurobiology, Care Sciences and Society, Division of Family Medicine and Primary Care, Karolinska Institute, Stockholm, Sweden.
4. Department of Obstetrics and Gynecology, University of Helsinki and Helsinki University Hospital, Helsinki, Finland.

Correspondence to: Zahra Roustaei, +358449565764, zahra.roustaei@helsinki.fi

ABSTRACT

Objectives: We described the trend of fertility rates, age-specific fertility rates and associated factors in Finland over a 30-year period.

Design: A descriptive population-based register study.

Setting: Fertility data, including age at first birth, childlessness and educational levels were gathered from the Finnish Medical Birth Register and Statistics Finland.

Participants: All 1 792 792 live births from 1987 to 2016 in Finland.

Main outcome measures: Completed fertility rate, total fertility rate and age-specific fertility rate.

Results: The total fertility rate of Finnish women fluctuated substantially from 1987 to 2016. Since 2010, the total fertility rate has gradually declined and reached the lowest during the study period in 2016: 1.57 children per woman. The mean maternal age at first birth rose by 2.5 years from 26.5 years in 1987 to 29 years in 2016. The proportion of childless women at the age of 50 years increased from 13.6% in 1989 to 19.6% in 2016. By considering the impact of postponement and childlessness, the effect on total fertility rates was between -0.01 and -0.12 points. Since 1987 the distribution of birth has declined for women under age of 29 and increased for women aged 30 or more. However, start of childbearing after the age of 30 years was related to the completed fertility rate of less than two children per woman. The difference in completed fertility rate across educational groups was small.

Conclusions: Postponement of first births was followed by decline in completed fertility rate. Increasing rate of childlessness, besides the mean age at first birth, was an important determinant for declined fertility rates, but the relation between women educational levels and the completed fertility rate was relatively weak.

Strengths and limitations of this study

- The current study drawn from well-established population registers, including information of 1 792 792 live births.
- The data in Finnish population registers have high coverage and validity.
- The focus of study was on the total fertility rate by time and maternal age, without focus on specific exposure effect.
- In this study, we were unable to distinguish voluntary from involuntary childlessness.

INTRODUCTION

Women are postponing childbearing to a later age, mainly because of enrolling in tertiary education, focusing on employment, having housing and economic uncertainty, engaging in premarital cohabitation, and delaying marriage at later ages.[1 2] These complex trends, which affect the decision of having a child, may differ across socioeconomic groups.[3 4]

It has been well documented that female age affects negatively fecundability, and the physiological ability of couples to conceive.[5-8] The strength of the negative association between female age and fertility has found to be even stronger in women who have never conceived, since they may suffer from primary infertility.[9]

At the population level, fertility rates appear to reflect demographic trends, social changes, and family policies which may vary from country to country.[3] For example, in France, the effect of postponing pregnancy on the total fertility rate has been shown to be marginal.[10] In Finland, the total fertility rate has declined by almost one third over a century (figure 1A). The total fertility rate declined in the beginning of the 20th century with the spread of parity-specific fertility control through Finland. After the Second World War, declines in the mean age at marriage reduced the mean maternal age at first birth and contributed to the baby boom. After 1950, the total fertility rate of Finnish women declined and went below the replacement level in 1969.[11]

Finland has witnessed the lowest recorded fertility rate and the highest ever mean maternal age at first birth during the year 2017, [12] but only a few researchers have addressed the issue. Thus, this paper aims to describe temporal changes of total fertility rates and age-specific fertility rates in Finland over a 30-year period and to dissect the factors associated with the decline in fertility rates, including increased age at the first birth, the elevated proportion of childlessness, and maternal education.

METHODS

Finland is a country of 5.5 million inhabitants in northern Europe. The study population for this data encompasses all live births from 1987 to 2016, including information on 1 792 792 live

births. The data for this study were obtained from the Medical Birth Register (MBR) (Permission number THL/876/5.05.00/2017) which has been a comprehensive system for collecting birth data since 1987. The MBR, maintained by the National Institute for Health and Welfare, covers more than 99.9% of births in Finland and includes demographic and health data of mothers.[13] The MBR data were complemented with population level information on childlessness, gathered from Statistics Finland to assess changes in fertility rates.

We used general measures of fertility, including total fertility rate and age-specific fertility rate to measure fertility at the population level.[14] The crude birth rate is the total number of live births accruing in a population. The total fertility rate is the number of live births born to a hypothetical cohort of 1000 women, assuming that their mortality rate, before the end of reproduction, is zero. On the contrary of the crude birth rate, the denominator of the total fertility rate is women over their childbearing years. Therefore, the age distribution of the population has no confounding effect on fertility rate. The total fertility rate was considered to be above replacement level, if a fertility rate was at least 2.1 children per woman. The age-specific fertility rate is the ratio between the number of live births by women in a certain age group and the number of women in that age group in the given year, which is standardized to the constant effect of age. Maternal age for the age-specific fertility rate was categorized as below 20 years, 20-24 years, 25-29 years, 30-34 years, 35-39 years, 40-44 years, and 45 years or more. Sum of age-specific fertility rates for each cohort (1987-1991, 1992-1996, 1997-2001, 2002-2006, 2007-2011, and 2012-2016) was calculated as the completed fertility rate (the number of live births per women as 31 December 2016).

Data on childlessness have been available since 1989. We focused on the childlessness of women at age 35, 40, 45 and 50 years, age of 50 was considered as the end of the reproductive age. Maternal education was categorized into four groups: basic education (9 years or less), upper secondary education (10-12 years), short cycle tertiary education (13-14 years), and university degree (15 years or more).

The effects of rising rates of childlessness and postponement of childbearing on the total fertility rates were modelled by a method previously described in the study of Te Velde et al. 2011.[15] The

method was used to estimate the effects of postponement and childlessness on total fertility rates for the time periods of 1989 to 2016.

RESULTS

Mean age of women

In Finland, the mean age of women at birth increased from 28.9 to 30.7 years between 1987 and 2016. The increase was 2.5 years for first births, from 26.5 years in 1987 to 29.0 years in 2016, with a steeper rise in the last three years (figure 1B). The observed increase in the mean maternal age indicated that postponement of childbirth continued in Finland.

(Location of Figure1)

Total fertility rate

Since 1987, the total fertility rate of Finnish women has fluctuated and approached the replacement level at two peaks in 1992 with 1.85 and in 2010 with 1.87 children per woman. After a period of stability in 2010, fertility rates have declined continuously and reached 1.57 children per woman in 2016 (figure 1A).

Age-specific fertility rates

After stratifying total fertility rates by the age group, it was illustrated that women aged 15-19, 20-24 years and 25-29 years in 1987 respectively, had more than 2.1, 1.5 and 1.2 times as many children in comparison to women in selected groups in 2016 (figure 2A). From 1987 to 2006 the fertility rate of women aged 25-29 years fluctuated at the highest level among all age groups and after that decreased to the lowest of all time in 2016. By considering the importance of postponing maternity, the fertility rate of women aged 30-34 years has been highest among all age groups since 2007. Moreover, the fertility rate of women aged 35-39 years surpassed the fertility rate of women aged 20-24 years in 2010.

Figure 2B depicts the completed fertility rate for two cohorts after five follow up periods, assuming that women have completed their childbearing (see supplementary figure 1). The completed fertility rate of women was negatively associated with the mean maternal age at first

birth. Women who gave birth to their first child before age of 30 years were able to maintain fertility rates above replacement level. As completed fertility rate of almost three live born was observed, when women had their first child under age of 21 years. The slight increase in the ultimate number of children at the end of childbearing ages is explained by use of assisted reproductive technologies (ART) and a higher multiple pregnancy rate.

The relationship of completed fertility rate and the mean maternal age at first birth by educational levels is given in Figure 2C and supplementary figure 2. As figures 2B and 2C illustrate, the later childbearing was related to the lower completed fertility rate, and similarly in each educational group. The differences in completed fertility rates, however, were relatively small across educational groups.

(Location of Figure 2)

The effect of rising childlessness rate and postponement of first birth on total fertility rates

As a result of postponing childbearing to the end of reproductive ages, the proportion of childless women at age 50 has increased by 6 percent units, from 1989 to 2016. In 2016, 19.6% of women remained childless at the age of 50 (figure 3A). The childlessness rate for women aged 35 years in the same period has grown by 9.5 percent units from 19.2 to 28.7%. Furthermore, without delay since 1989, the increase in total fertility rates mainly started after 1996. Delay of childbearing from 1989 reduced the total fertility rate by 0.05 to 0.12 children in the last two years (figure 3B) (see supplementary table 1). For instance, the total fertility rate in 2016 (1.57) would have been between 1.62 and 1.69 children per woman, if the increase in the mean maternal age had stopped in 1989.

(Location of Figure 3)

DISCUSSION

The results of the present study indicated that the total fertility rate of Finnish women has declined by 0.3 children from 2010 to 2016, and further to 1.49 in 2017, the lowest ever in Finland.[12] The decline appeared to be associated with the increase in the mean maternal age at first birth by 9.4% and childlessness by 44.1%. The completed fertility rate declined by age at first childbirth, similarly in all educational groups. Modelling the fertility trends suggested that if the rising level of childlessness and postponement had stopped in 1989, total fertility rates would have been higher between 1996 and 2016. Postponement of childbearing also changed the age distribution of births. Fertility rates of women aged 30 or more increased, but nulliparous women above the age of 30 years were not able to maintain the completed fertility rate at two children or more.

As proposed by Blomberg Jensen et al. 2015, older women have been found to be able to sustain fertility rates above the replacement so that having a child between the ages 30 to 40 years is in biological limit.[16] However, high fertility rates of women above 30 years of age were due to giving birth to several children, which occurs rarely nowadays. This change in fertility pattern emanates from the decision of having lower number of children due to cultural, economic, and social circumstances or results from childbearing postponement.[17 18] The present results suggested, that if maternal age at first births was 30 years or above, women had less time to give birth to two children, whereas in other cohorts later childbearing has not always been associated with fewer children (lower quantum).[19] Our findings are in line with previous studies that maternal age at first birth is interrelated with the ultimate number of children.[20 21] Sweden, Denmark , and France were among the countries with the highest fertility rates in Europe, even though the mean maternal age at first birth in these countries was high.[22] In the Finnish population, the increase in the mean maternal age at first birth has been gradual, but sufficient enough to decline fertility rates especially in recent years. If all women postpone childbearing to the later age, the effect of postponement on the total number of children will be significant.[23] Because, not all women who postpone pregnancy will have a child mainly due to unstable partnership, expansion of education, participation in the workforce, and the decline in fecundability with increasing female age.[2 23 24]

The current study is descriptive in nature and drawn from well-established population registers which have shown to have high coverage and validity.[25] However, the results of this study need to be interpreted with caution, since the focus was on the total fertility rate by time and maternal age, without focus on specific exposure effect. Therefore, it was not possible to evaluate the causal effect of age or childlessness on fertility rates, and further studies are needed to dissect specific exposure effects rather than focusing on occurrence measures. In this study, we were unable to distinguish voluntary from involuntary childlessness.

Apart from the effect of postponement on fertility rates, the overall trend in fertility rates reflects complex changes we have faced with in our modern industrialized societies. Some of these temporal changes are inevitable, but family-friendly policies may have the potential to compensate the negative impact of demographic changes on fertility rates.[26 27] Although generous family policies have probably prevented Finland to be one of the countries with the lowest-low fertility with a total fertility rate below 1.3,[28] there may still be room for improvement. Awareness of family policies that encourage motherhood at earlier ages and influence spacing between first and second and higher order births, might increase fertility rates. Availability of assisted reproductive treatment may also play a role since only half of couples, who fail to conceive naturally, are seeking infertility advice or treatment, partly due to the limited infertility services.[29] The role of ART is known to be more important among older couples than other groups. [8 30] Currently, around 5% of newborns are born after ART treatment in Finland.[31] There are, however, no information on the number of ART service users who do not get a child.

Studies indicated that the ideal family size among the majority of Finnish young adults was two children and only a minority expressed that they wanted no children.[32 33] This discrepancy between the ideal family size and total/completed fertility rate further emphasizes the importance of policies to help couples to reach their perceived ideal family size. The present study suggests that in this effort encouraging young motherhood is one of the key determinants to be improved.

FOOTNOTES

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Contributors

ZR did the literature search and drafted the manuscript, with critical input from SR, MG, SH. MG and SH designed the survey, with contributions and advice from SR. MG and ZR analyzed the data and interpreted the results. All authors reviewed the manuscript. All authors have read and approved the final draft.

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Competing interests

None declared.

Patient consent

Not required.

Ethical approval

The ethical approval was gained from THL (Permission number THL/876/5.05.00/2017) which is required by the national data protection legislation. For using publicly available data of Statistics Finland, permission was not required.

Data sharing

Due to national data protection rules, the register data cannot be shared. Researchers can apply similar data from the Medical Birth Register. No additional data are available.

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Figure legends

Figure 1. A: The total fertility rate and crude birth rate, from 1900 to 2017 in Finland. B: The mean maternal age at birth and mean maternal age at first birth, from 1987 to 2016 in Finland.

Figure 2. A: Age-specific fertility rates, 1987-2016. B: Completed fertility rate by age at first birth C: Completed fertility by age at first birth and educational level.

Figure 3. A: The proportion of childless women at the age of 35, 40, 45 and 50 years, from 1989 to 2016 in Finland. B: The estimated effect of postponing pregnancy on total fertility rate without delay since 1989 in Finland. *Total Fertility Rate (TFR).

Supplementary figure 1. Completed fertility rate, by age at first birth. A: Completed fertility rate after two follow up periods. B: Completed fertility rate after three follow up periods. C: Completed fertility rate after four follow up periods.

Supplementary figure 2: Completed fertility rate, by age at first birth and maternal education. A: Completed fertility rate after two follow up periods. B: Completed fertility rate after three follow up periods. C: Completed fertility rate after four follow up periods. D: Completed fertility rate after five follow up periods.

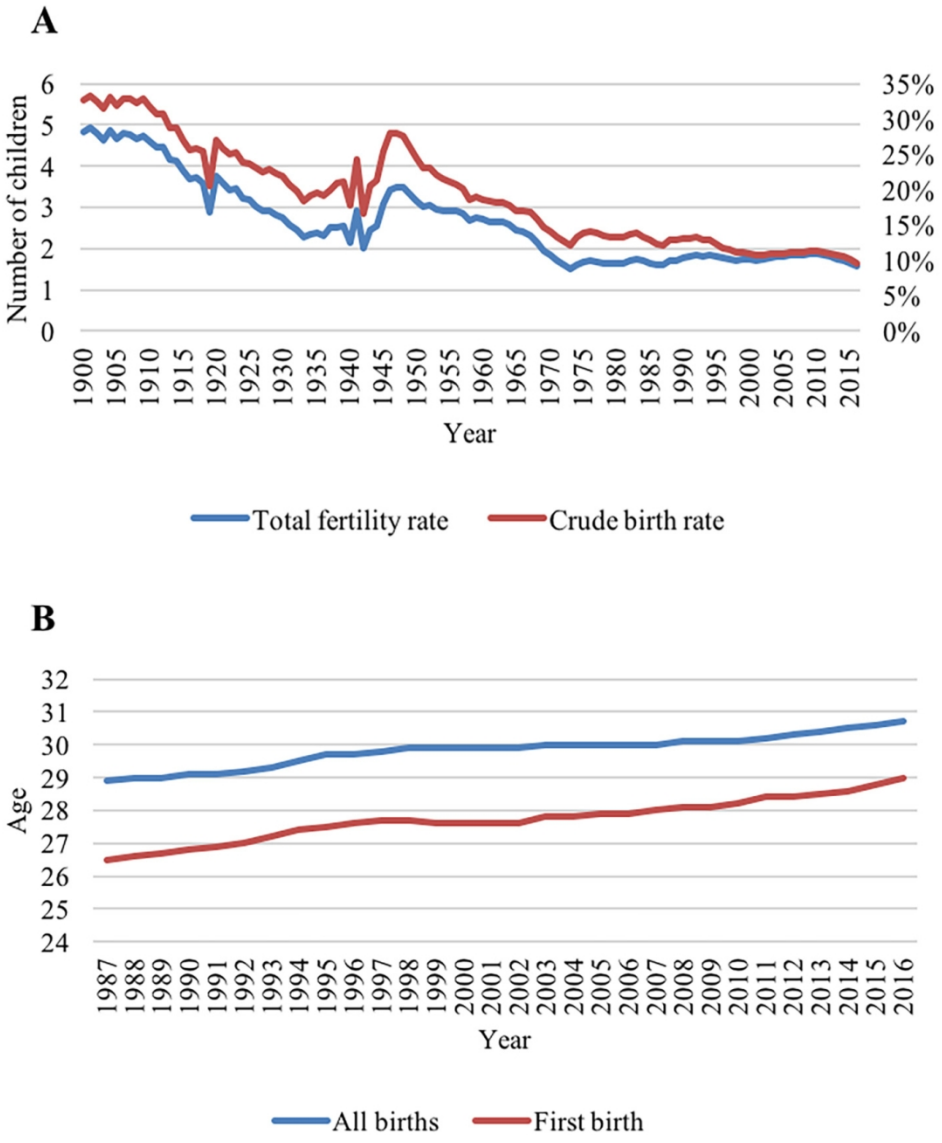

Figure 1. A: The total fertility rate and crude birth rate, from 1900 to 2017 in Finland. B: The mean maternal age at birth and mean maternal age at first birth, from 1987 to 2016 in Finland. Note: below-replacement fertility: The total fertility rate lower than 2.1 children per women.

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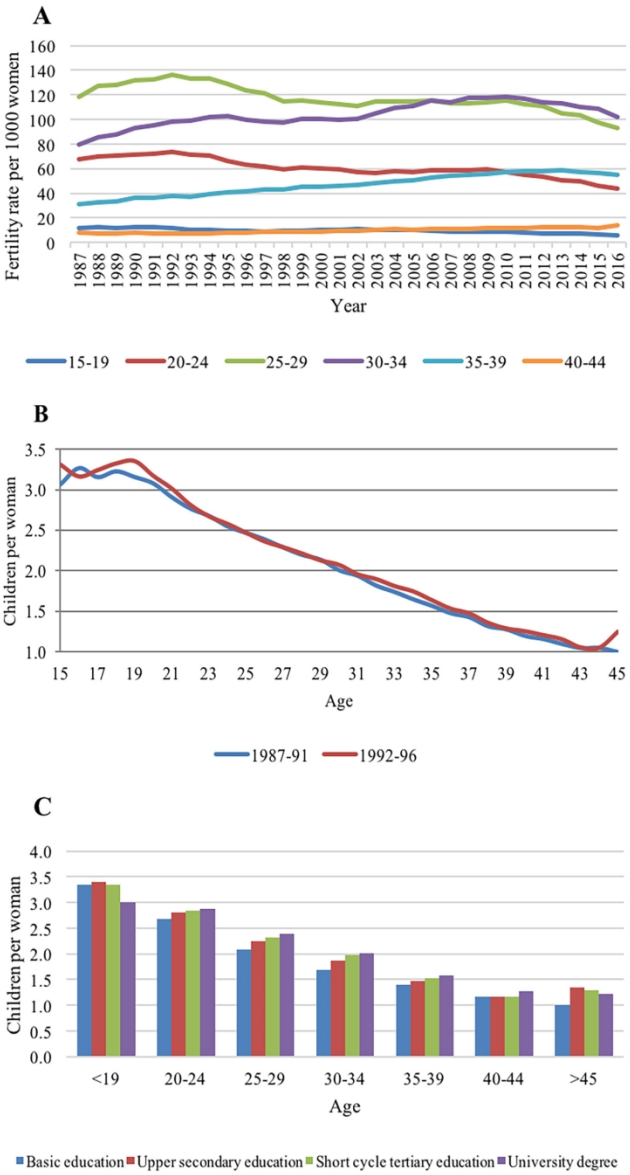

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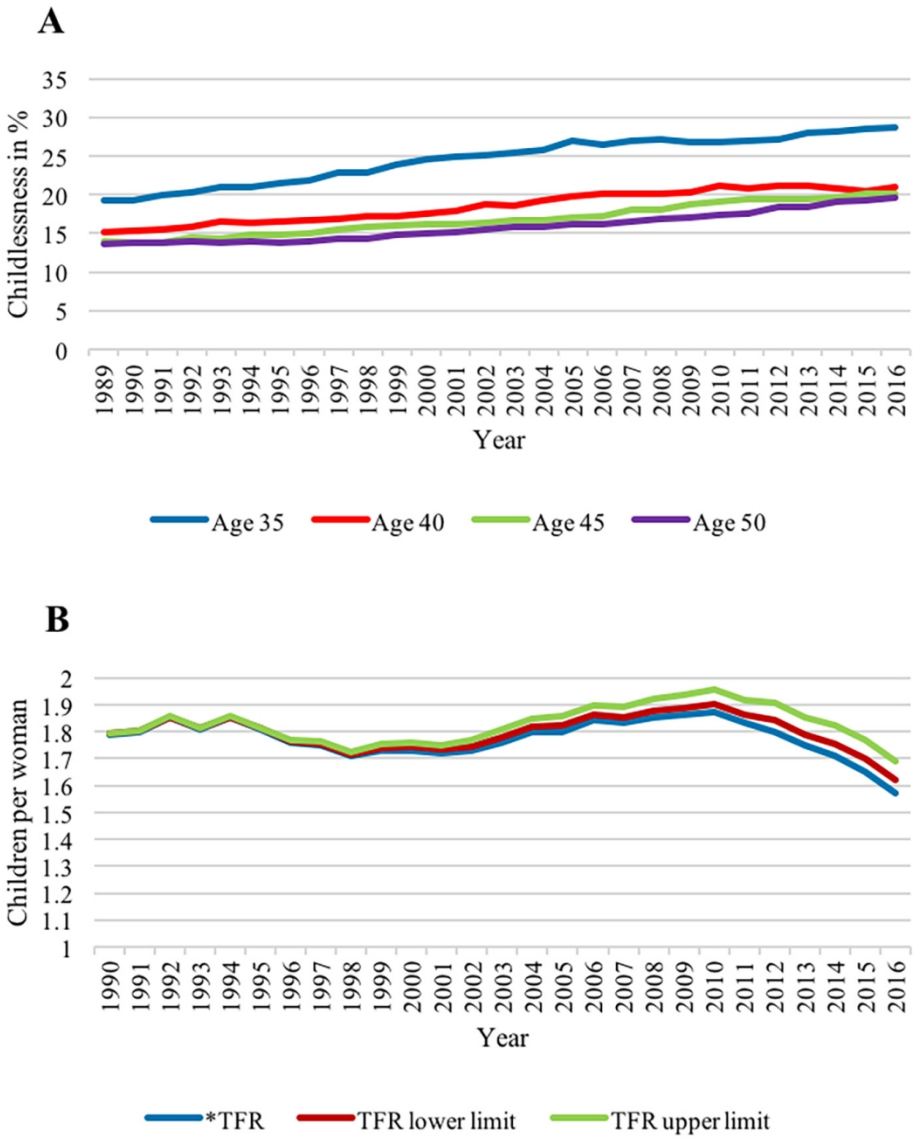

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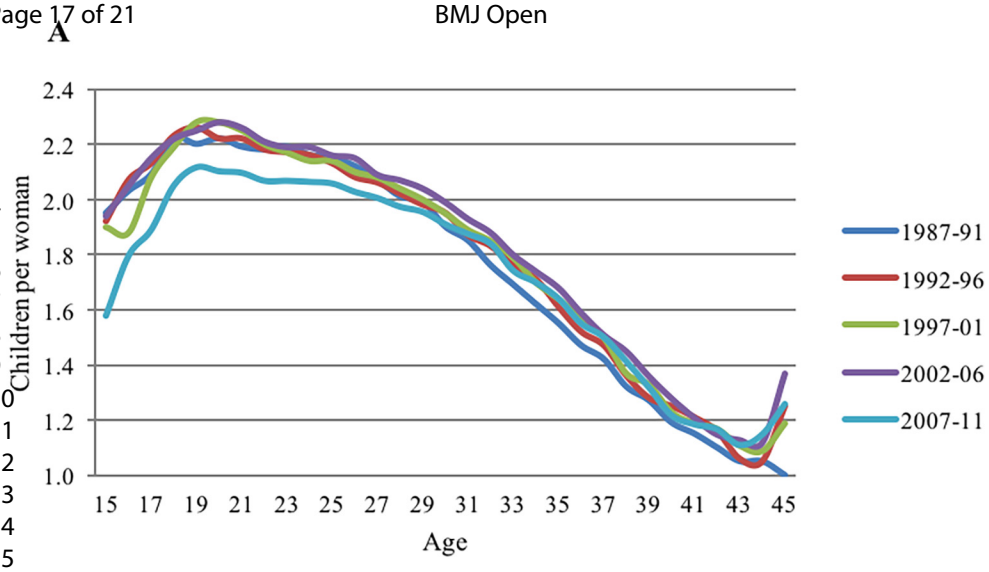

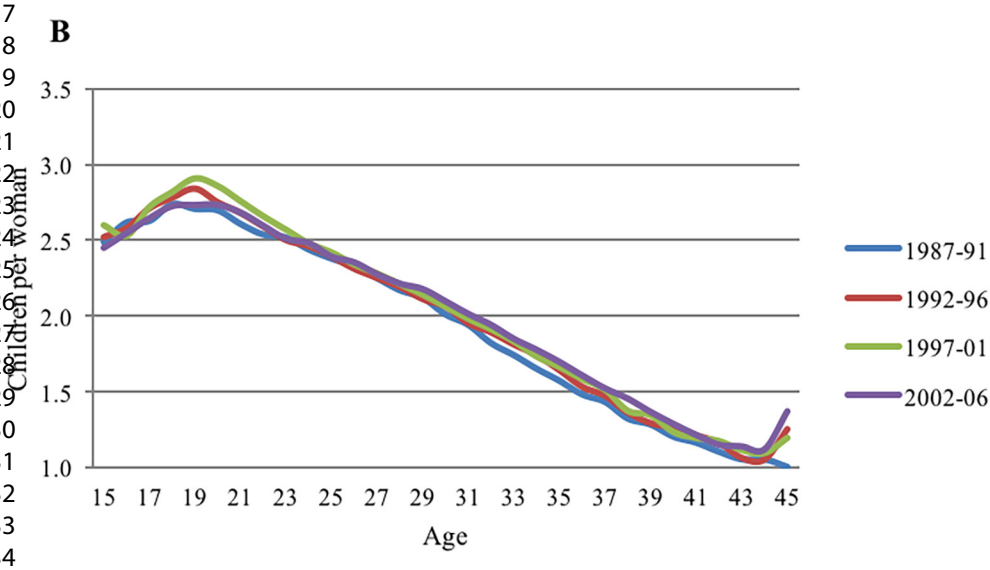

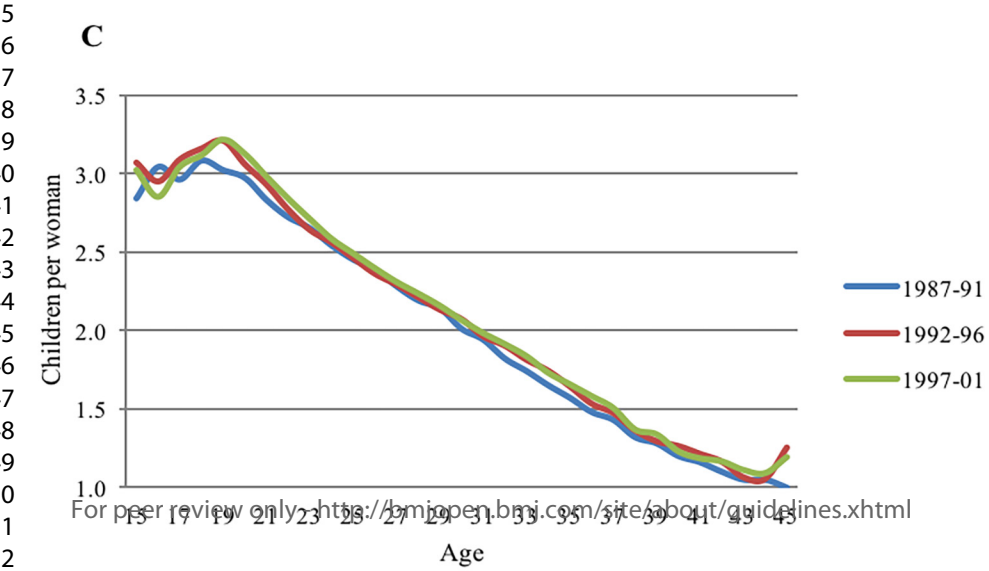

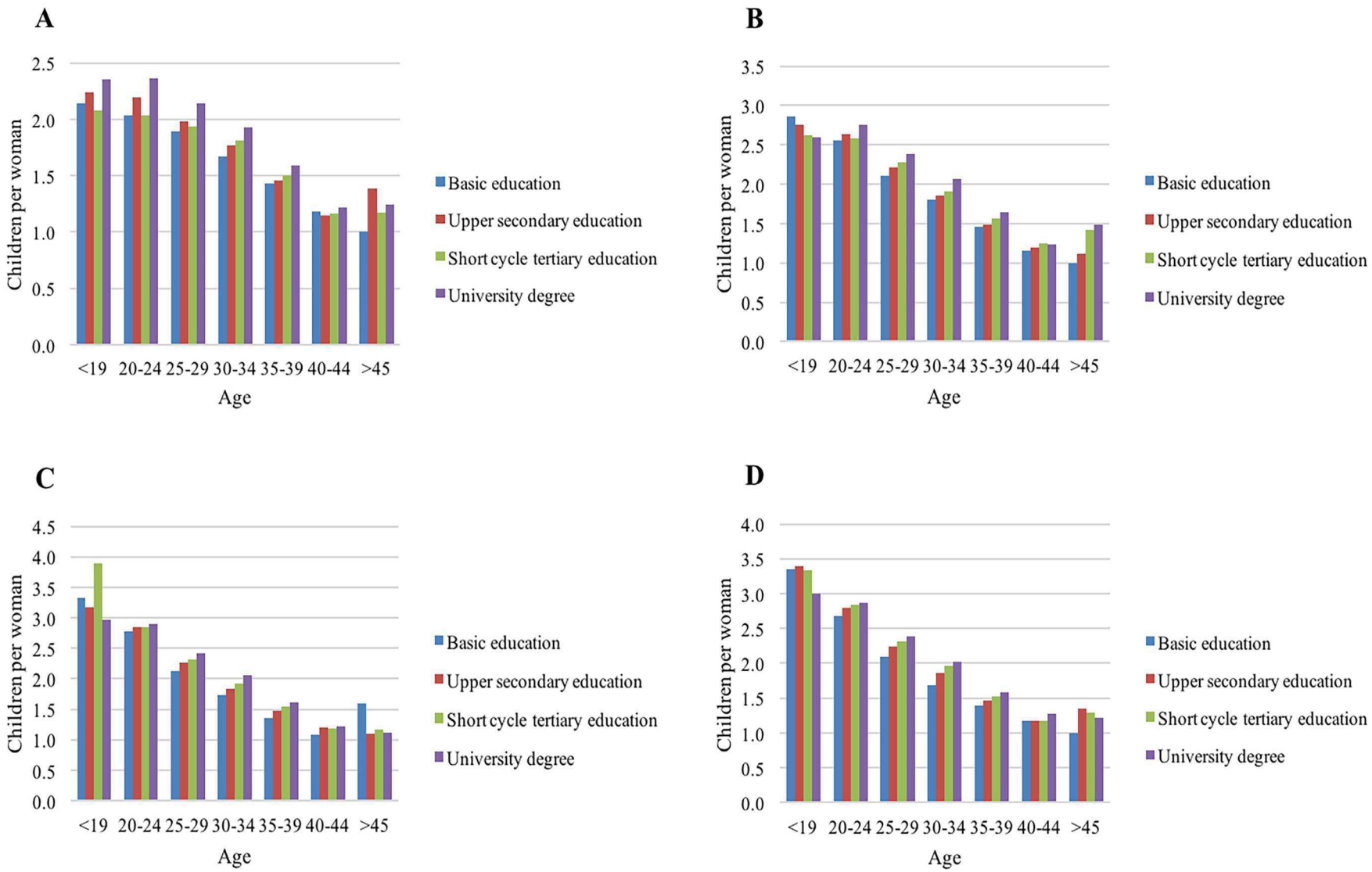
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Upper secondary education
Short cycle tertiary education
University degree

Supplementary table 1 The estimated effect of postponing pregnancy on total fertility rates without delay since 1989 in Finland.

Year	Childlessness rate in each year in %	The rise in childlessness rate at the age 50 since 1989 in %	TFR*	Estimated TFR Without delay since 1989	The increase in TFR without delay since 1989
1989	36.6	-	1.71	-	-
1990	36.1	0.1	1.79	1.79-1.79	0.00-0.00
1991	35.7	0.2	1.80	1.80-1.80	0.00-0.00
1992	35.2	0.4	1.85	1.85-1.86	0.00-0.01
1993	34.8	0.1	1.81	1.81-1.81	0.00-0.00
1994	34.4	0.4	1.85	1.85-1.86	0.00-0.01
1995	34.1	0.2	1.81	1.81-1.81	0.00-0.00
1996	33.8	0.3	1.76	1.76-1.77	0.00-0.01
1997	33.6	0.7	1.75	1.76-1.76	0.01-0.01
1998	33.4	0.7	1.71	1.72-1.72	0.01-0.01
1999	33.3	1.2	1.73	1.74-1.75	0.01-0.02
2000	33.2	1.4	1.73	1.74-1.76	0.01-0.03
2001	33.1	1.5	1.72	1.73-1.75	0.01-0.03
2002	32.9	1.9	1.73	1.75-1.77	0.02-0.04
2003	32.8	2.3	1.76	1.78-1.81	0.02-0.05
2004	32.7	2.3	1.80	1.82-1.85	0.02-0.05
2005	32.6	2.6	1.80	1.82-1.86	0.02-0.06
2006	32.5	2.6	1.84	1.86-1.90	0.02-0.06
2007	32.5	2.9	1.83	1.85-189	0.02-0.06
2008	32.5	3.3	1.85	1.88-1.90	0.03-0.07
2009	32.5	3.4	1.86	1.89-1.94	0.03-0.08
2010	32.5	3.7	1.87	1.90-1.95	0.03-0.08
2011	32.4	3.9	1.83	1.86-1.92	0.03-0.09
2012	32.4	4.8	1.80	1.84-1.91	0.04-0.11
2013	32.4	4.8	1.75	1.79-1.85	0.04-0.10
2014	32.4	5.4	1.71	1.76-1.82	0.05-0.11
2015	32.4	5.7	1.65	1.70-1.77	0.05-0.12
2016	32.5	6.0	1.57	1.62-1.69	0.05-0.12

*TFR: Total Fertility Rate

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Report on page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 3
Methods			
Study design	4	Present key elements of study design early in the paper	Page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	
Participants	6	Give the eligibility criteria, and the sources and methods of selection of participants	Page 4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 4
Bias	9	Describe any efforts to address potential sources of bias	Page 4
Study size	10	Explain how the study size was arrived at	Page 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 4
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 4,5
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	NA
		(*d*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 5,6
		(b) Indicate number of participants with missing data for each variable of interest	NA
		Report numbers of outcome events or summary measures	Page 5, 6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 6
		(*b*) Report category boundaries when continuous variables were categorized	Page 4
Other analyses	17	Report other analyses done—eg analyses of subgroups and	NA

		interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarize key results with reference to study objectives	Page 7
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 7, 8
Generalisability	21	Discuss the generalizability (external validity) of the study results	Page 8
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 9

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Fertility rates and the postponement of first births: a descriptive study with Finnish population data

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Fertility rates and the postponement of first births: a descriptive study with Finnish population data

Zahra Roustaei [1], Sari Räisänen [2], Mika Gissler [3], Seppo Heinonen [4]

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Author affiliations

1. Department of Health Sciences, University of Helsinki, 00014 Helsinki, Finland.
2. School of Health Care and Social Services, Tampere University of Applied Sciences, Tampere, Finland.
3. Information Services Department, National Institute for Health and Welfare (THL), Helsinki, Finland and Department of Neurobiology, Care Sciences and Society, Division of Family Medicine and Primary Care, Karolinska Institute, Stockholm, Sweden.
4. Department of Obstetrics and Gynecology, University of Helsinki and Helsinki University Hospital, Helsinki, Finland.

Correspondence to: Zahra Roustaei, +358449565764, zahra.roustaei@helsinki.fi

ABSTRACT

Objectives: We described the trend of fertility rates, age-specific fertility rates and associated factors in Finland over a 30-year period.

Design: A descriptive population-based register study.

Setting: Fertility data, including age at first birth, childlessness and educational levels were gathered from the Finnish Medical Birth Register and Statistics Finland.

Participants: All 1 792 792 live births from 1987 to 2016 in Finland.

Main outcome measures: Completed fertility rate, total fertility rate and age-specific fertility rate.

Results: The total fertility rate of Finnish women fluctuated substantially from 1987 to 2016. Since 2010, the total fertility rate has gradually declined and reached the lowest during the study period in 2016: 1.57 children per woman. The mean maternal age at first birth rose by 2.5 years from 26.5 years in 1987 to 29 years in 2016. The proportion of childless women at the age of 50 years increased from 13.6% in 1989 to 19.6% in 2016. By considering the impact of postponement and childlessness, the effect on total fertility rates was between -0.01 and -0.12 points. Since 1987 the distribution of birth has declined for women under age of 29 and increased for women aged 30 or more. However, start of childbearing after the age of 30 years was related to the completed fertility rate of less than two children per woman. The difference in completed fertility rate across educational groups was small.

Conclusions: Postponement of first births was followed by decline in completed fertility rate. Increasing rate of childlessness, besides the mean age at first birth, was an important determinant for declined fertility rates, but the relation between women educational levels and the completed fertility rate was relatively weak.

Strengths and limitations of this study

- The current study drawn from well-established population registers, including information of 1 792 792 live births.
- The data in Finnish population registers have high coverage and validity.
- The focus of study was on the total fertility rate by time and maternal age, without focus on specific exposure effect.
- In this study, we were unable to distinguish voluntary from involuntary childlessness.

INTRODUCTION

Women are postponing childbearing to a later age, mainly because of enrolling in tertiary education, focusing on employment, having housing and economic uncertainty, engaging in premarital cohabitation, and delaying marriage at later ages.[1 2] In addition, men play an important role in delaying parenthood because of having inadequate knowledge about reproductive lifespan and postponing forming partnerships and parenting with women.[3] These complex trends, which affect the decision of having a child, may differ across socioeconomic groups.[4 5]

It has been documented that advanced maternal and paternal age affects negatively fecundability, and the physiological ability of couples to conceive.[6-10] The strength of the negative association between female age and fertility has found to be even stronger in women who have never conceived, since they may suffer from primary infertility.[11]

At the population level, fertility rates appear to reflect demographic trends, social changes, and family policies which may vary from country to country.[4] For example, in France, the effect of postponing pregnancy on the total fertility rate has been shown to be marginal.[12] In Finland, the total fertility rate has declined by almost one third over a century (figure 1A). The total fertility rate declined in the beginning of the 20th century with the spread of parity-specific fertility control through Finland. After the Second World War, declines in the mean age at marriage reduced the mean maternal age at first birth and contributed to the baby boom. After 1950, the total fertility rate of Finnish women declined and went below the replacement level of 2.1 children per woman in 1969.[13]

Finland has witnessed the lowest recorded fertility rate and the highest ever mean maternal age at first birth during the year 2017, [14] but only a few researchers have addressed the issue. Thus, this paper aims to describe temporal changes of total fertility rates and age-specific fertility rates in Finland over a 30-year period and to dissect the factors associated with the decline in fertility rates, including increased age at the first birth, the elevated proportion of childlessness, and maternal education.

METHODS

Finland is a country of 5.5 million inhabitants in northern Europe. The study population for this data encompasses all live births from 1987 to 2016, including information on 1 792 792 live births. The data for this study were obtained from the Medical Birth Register (MBR) (Permission number THL/876/5.05.00/2017) which has been a comprehensive system for collecting birth data since 1987. The MBR, maintained by the National Institute for Health and Welfare, covers more than 99.9% of births in Finland and includes individual-level demographic and health data of mothers.[15] The MBR data were complemented with population level information on childlessness, gathered from Statistics Finland to assess changes in fertility rates. Individual-level register data cannot be publicly available, because of data protection laws and the sensitive nature of the data. The data on variables in registers are complete and their content is in accordance with reality.[16] Moreover, the quality of the register data has been constantly improved due to active use of data in research and decision-making.[17] Thus, we believe that the data of registers are valid and reliable.

We used general measures of fertility, including total fertility rate and age-specific fertility rate to measure fertility at the population level.[18] We provided the information on the total fertility rate and maternal age as the background information. We calculated age-specific fertility rate by maternal age at first birth, age-specific fertility by maternal age at first birth across educational groups, and the effect of postponement and childlessness on total fertility rates by use of register-based data.

The crude birth rate is the total number of live births accruing in a population. The total fertility rate is the number of live births born to a hypothetical cohort of 1000 women, assuming that their mortality rate, before the end of reproduction, is zero. On the contrary of the crude birth rate, the denominator of the total fertility rate is women over their childbearing years. Therefore, the age distribution of the population has no confounding effect on fertility rate. The total fertility rate was considered to be above replacement level, if a fertility rate was at least 2.1 children per woman. The age-specific fertility rate is the ratio between the number of live births by women in a certain age group and the number of women in that age group in the given year, which is standardized to the constant effect of age. Maternal age for the age-specific fertility rate was categorized as below 20 years, 20-24 years, 25-29 years, 30-34 years, 35-39 years, 40-44 years, and 45 years or more. Sum of age-specific fertility rates for each cohort (1987-1991, 1992-1996,

1997-2001, 2002-2006, 2007-2011, and 2012-2016) was calculated as the completed fertility rate (the number of live births per women as 31 December 2016).

Data on childlessness have been available since 1989. We focused on the childlessness of women at age 35, 40, 45 and 50 years, age of 50 was considered as the end of the reproductive age. We were unable to distinguish between voluntary and involuntary childlessness, because the data were not originally gathered for the current research. Maternal education was categorized into four groups: basic education (9 years or less), upper secondary education (10-12 years), short cycle tertiary education (13-14 years), and university degree (15 years or more).

The effects of rising rates of childlessness and postponement of childbearing on the total fertility rates were modelled by a method previously described in the study of Te Velde et al. 2011.[19] The method was used to estimate the effects of postponement and childlessness on total fertility rates for the time periods of 1989 to 2016.

Patient and Public Involvement

Patients and the public were not involved in any aspect of this study.

RESULTS

Mean age of women

In Finland, the mean age of women at birth increased from 28.9 to 30.7 years between 1987 and 2016. The increase was 2.5 years for first births, from 26.5 years in 1987 to 29.0 years in 2016, with a steeper rise in the last three years (figure 1B). The observed increase in the mean maternal age indicated that postponement of childbirth continued in Finland.

(Location of Figure1)

Total fertility rate

Since 1987, the total fertility rate of Finnish women has fluctuated and approached the replacement level at two peaks in 1992 with 1.85 and in 2010 with 1.87 children per woman. After a period of stability in 2010, fertility rates have declined continuously and reached 1.57 children per woman in 2016 (figure 1A).

Age-specific fertility rates

After stratifying total fertility rates by the age group, it was illustrated that women aged 15-19, 20-24 years and 25-29 years in 1987 respectively, had more than 2.1, 1.5 and 1.2 times as many children in comparison to women in selected groups in 2016 (figure 2A). From 1987 to 2006 the fertility rate of women aged 25-29 years fluctuated at the highest level among all age groups and after that decreased to the lowest of all time in 2016. By considering the importance of postponing maternity, the fertility rate of women aged 30-34 years has been highest among all age groups since 2007. Moreover, the fertility rate of women aged 35-39 years surpassed the fertility rate of women aged 20-24 years in 2010.

Figure 2B depicts the completed fertility rate for two cohorts after five follow up periods, assuming that women have completed their childbearing (see supplementary figure 1). The completed fertility rate of women was negatively associated with the mean maternal age at first birth. Women who gave birth to their first child before age of 30 years were able to maintain fertility rates above replacement level. As completed fertility rate of almost three live born was observed, when women had their first child under age of 21 years. The slight increase in the ultimate number of children at the end of childbearing ages is explained by use of medically assisted reproduction and a higher multiple pregnancy rate.

The relationship of completed fertility rate and the mean maternal age at first birth by educational levels is given in Figure 2C and supplementary figure 2. As figures 2B and 2C illustrate, the later childbearing was related to the lower completed fertility rate, and similarly in each educational group. The differences in completed fertility rates, however, were relatively small across educational groups.

(Location of Figure 2)

The effect of rising childlessness rate and postponement of first birth on total fertility rates

As a result of postponing childbearing to the end of reproductive ages, the proportion of childless women at age 50 has increased by 6 percent units, from 1989 to 2016. In 2016, 19.6% of women remained childless at the age of 50 (figure 3A). The childlessness rate for women aged 35 years

in the same period has grown by 9.5 percent units from 19.2 to 28.7%. Furthermore, without delay since 1989, the increase in total fertility rates mainly started after 1996. Delay of childbearing from 1989 reduced the total fertility rate by 0.05 to 0.12 children in the last two years (figure 3B) (see supplementary table 1). For instance, the total fertility rate in 2016 (1.57) would have been between 1.62 and 1.69 children per woman, if the increase in the mean maternal age had stopped in 1989.

(Location of Figure 3)

DISCUSSION

The results of the present study indicated that the total fertility rate of Finnish women has declined by 0.3 children from 2010 to 2016, and further to 1.49 in 2017, the lowest ever in Finland.[14] The decline appeared to be associated with the increase in the mean maternal age at first birth by 9.4% and childlessness by 44.1%. The completed fertility rate declined by age at first childbirth, similarly in all educational groups. Modelling the fertility trends suggested that if the rising level of childlessness and postponement had stopped in 1989, total fertility rates would have been higher between 1996 and 2016. Postponement of childbearing also changed the age distribution of births. Fertility rates of women aged 30 or more increased, but nulliparous women above the age of 30 years were not able to maintain the completed fertility rate at two children or more.

As proposed by Blomberg Jensen et al. 2015, older women have been found to be able to sustain fertility rates above the replacement so that having a child between the ages 30 to 40 years is in biological limit.[20] However, high fertility rates of women above 30 years of age were due to giving birth to several children, which occurs rarely nowadays. This change in fertility pattern emanates from the decision of having lower number of children due to cultural, economic, and social circumstances or results from childbearing postponement.[21 22] The present results suggested, that if maternal age at first births was 30 years or above, women had less time to give birth to two children, whereas in other cohorts later childbearing has not always been associated with fewer children (lower quantum).[23] Our findings are in line with previous studies that maternal age at first birth is interrelated with the ultimate number of children.[24 25] Sweden,

Denmark , and France were among the countries with the highest fertility rates in Europe, even though the mean maternal age at first birth in these countries was high.[26] In the Finnish population, the increase in the mean maternal age at first birth has been gradual, but sufficient enough to decline fertility rates especially in recent years. If all women postpone childbearing to the later age, the effect of postponement on the total number of children will be significant.[27] Because, not all women who postpone pregnancy will have a child mainly due to unstable partnership, expansion of education, participation in the workforce, and the decline in fecundability with increasing female age.[2 27 28]

Previous studies on the association between women educational level and completed fertility rate suggested that women with higher educational levels tend to have fewer children than women with short education.[29-31] In the Nordic countries, the median maternal age at first birth has increased across all educational groups, with the largest postponement of first birth among highly educated women.[23] The result of current study indicated that in Finland, as a welfare state with compatibility of employment and family formation, the negative impact of women's educational attainment on the total number of children was relatively weak. This may be also attributed to the fertility recuperation at higher ages among highly educated women in Finland.[23 32]

The current study is descriptive in nature and drawn from well-established population registers which have shown to have high coverage and validity.[16] However, the results of this study need to be interpreted with caution, since the focus was on the total fertility rate by time and maternal age, without focus on specific exposure effect. Therefore, it was not possible to evaluate the causal effect of age or childlessness on fertility rates, and further studies are needed to dissect specific exposure effects rather than focusing on occurrence measures. In this study, we were unable to distinguish voluntary from involuntary childlessness.

Apart from the effect of postponement on fertility rates, the overall trend in fertility rates reflects complex changes we have faced with in our modern industrialized societies. Some of these temporal changes are inevitable, but family-friendly policies may have the potential to compensate the negative impact of demographic changes on fertility rates.[33 34] Although generous family policies have probably prevented Finland to be one of the countries with the lowest-low fertility with a total fertility rate below 1.3,[35] there may still be room for improvement. Awareness of family policies that encourage both fatherhood and motherhood at earlier ages, support young couples, and influence spacing between first and second and higher

order births, might increase fertility rates. Availability of medically assisted reproduction may also play a role since only half of couples, who fail to conceive naturally, are seeking infertility advice or treatment, partly due to the limited infertility services.[36] The role of medically assisted reproduction is known to be more important among older couples than other groups. [9 37] Currently, around 5% of newborns are born after these treatments in Finland.[38] There are, however, no information on the number of medically assisted reproduction users who do not get a child.

According to the studies of Virtala et al. 2006 and 2011, the ideal family size among the majority of Finnish university students was two children and only a minority expressed that they wanted no children.[39 40] This discrepancy between the ideal family size and total/completed fertility rate further emphasizes the importance of policies to help couples to reach their perceived ideal family size. The present study suggests that in this effort encouraging young motherhood is one of the key determinants to be improved.

FOOTNOTES

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Contributors

ZR did the literature search and drafted the manuscript, with critical input from SR, MG, SH. MG and SH designed the survey, with contributions and advice from SR. MG and ZR analyzed the data and interpreted the results. All authors reviewed the manuscript. All authors have read and approved the final draft.

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Competing interests

None declared.

Patient consent

Not required.

Ethical approval

The ethical approval was gained from THL (Permission number THL/876/5.05.00/2017) which is required by the national data protection legislation. For using publicly available data of Statistics Finland, permission was not required.

Data sharing

Due to national data protection rules, the register data cannot be shared. Researchers can apply similar data from the Medical Birth Register. No additional data are available.

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Figure legends

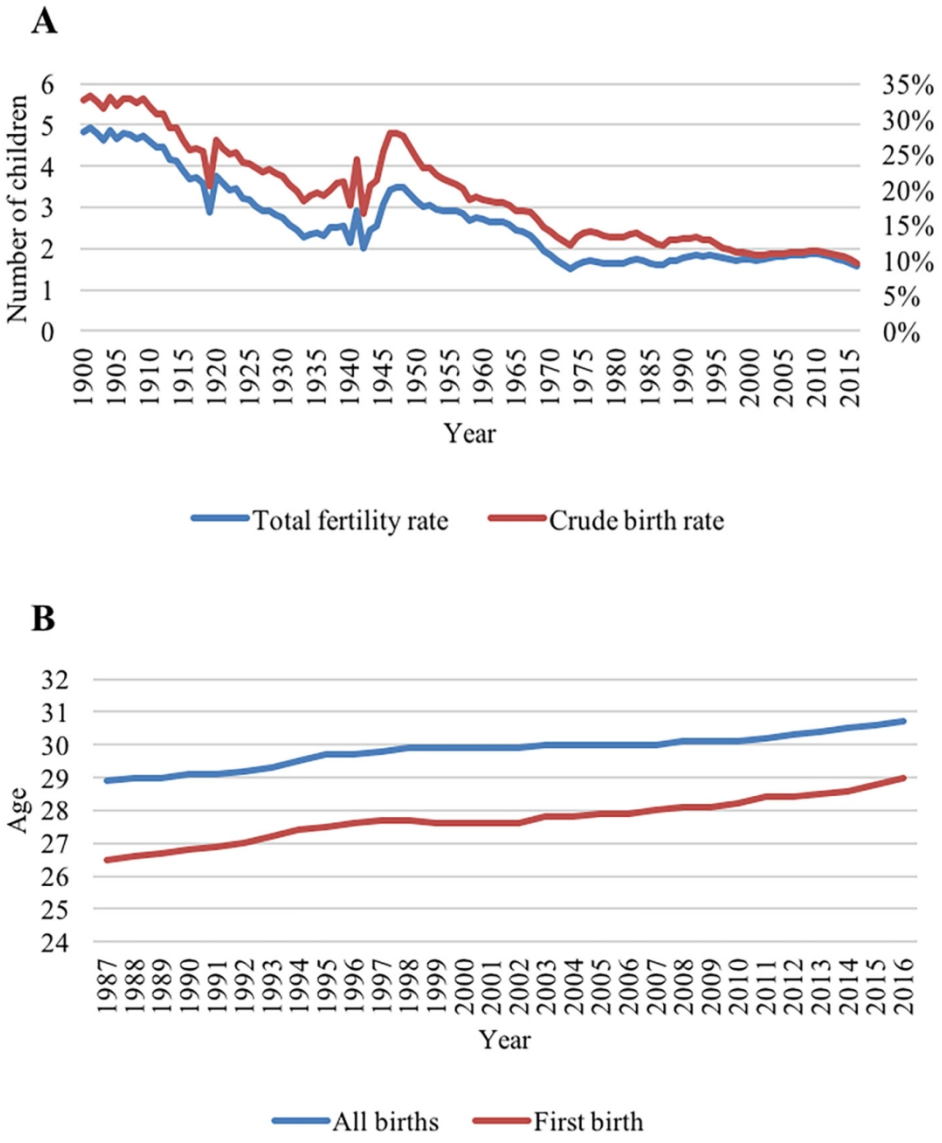
Figure 1. A: The total fertility rate and crude birth rate, from 1900 to 2017 in Finland. B: The mean maternal age at birth and mean maternal age at first birth, from 1987 to 2016 in Finland. Note: below-replacement fertility: The total fertility rate lower than 2.1 children per women.

Figure 2. A: Age-specific fertility rates, 1987-2016. B: Completed fertility rate by age at first birth C: Completed fertility by age at first birth and educational level. Note: below-replacement fertility: The total fertility rate lower than 2.1 children per women.

Figure 3. A: The proportion of childless women at the age of 35, 40, 45 and 50 years, from 1989 to 2016 in Finland. B: The estimated effect of postponing pregnancy on total fertility rate without delay since 1989 in Finland. *Total Fertility Rate (TFR). Note: below-replacement fertility: The total fertility rate lower than 2.1 children per women.

Supplementary figure 1. Completed fertility rate, by age at first birth. A: Completed fertility rate after two follow up periods. B: Completed fertility rate after three follow up periods. C: Completed fertility rate after four follow up periods.

Supplementary figure 2: Completed fertility rate, by age at first birth and maternal education. A: Completed fertility rate after two follow up periods. B: Completed fertility rate after three follow up periods. C: Completed fertility rate after four follow up periods. D: Completed fertility rate after five follow up periods.



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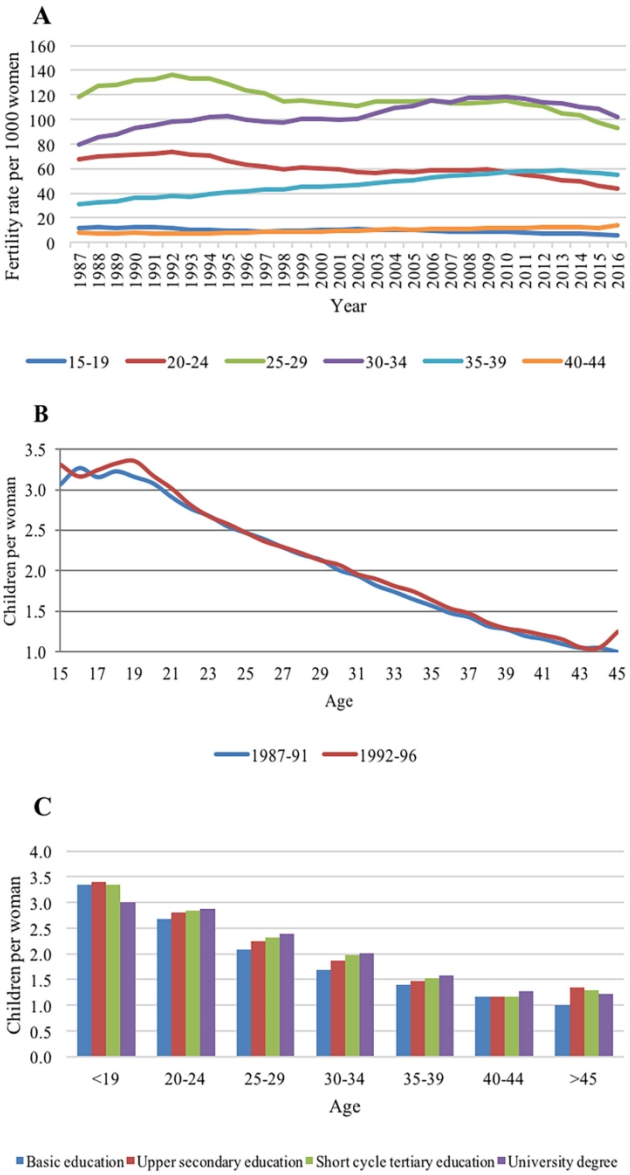


Figure 2. A: Age-specific fertility rates, 1987-2016. B: Completed fertility rate by age at first birth C: Completed fertility by age at first birth and educational level. Note: below-replacement fertility: The total fertility rate lower than 2.1 children per women.

124x220mm (300 x 300 DPI)

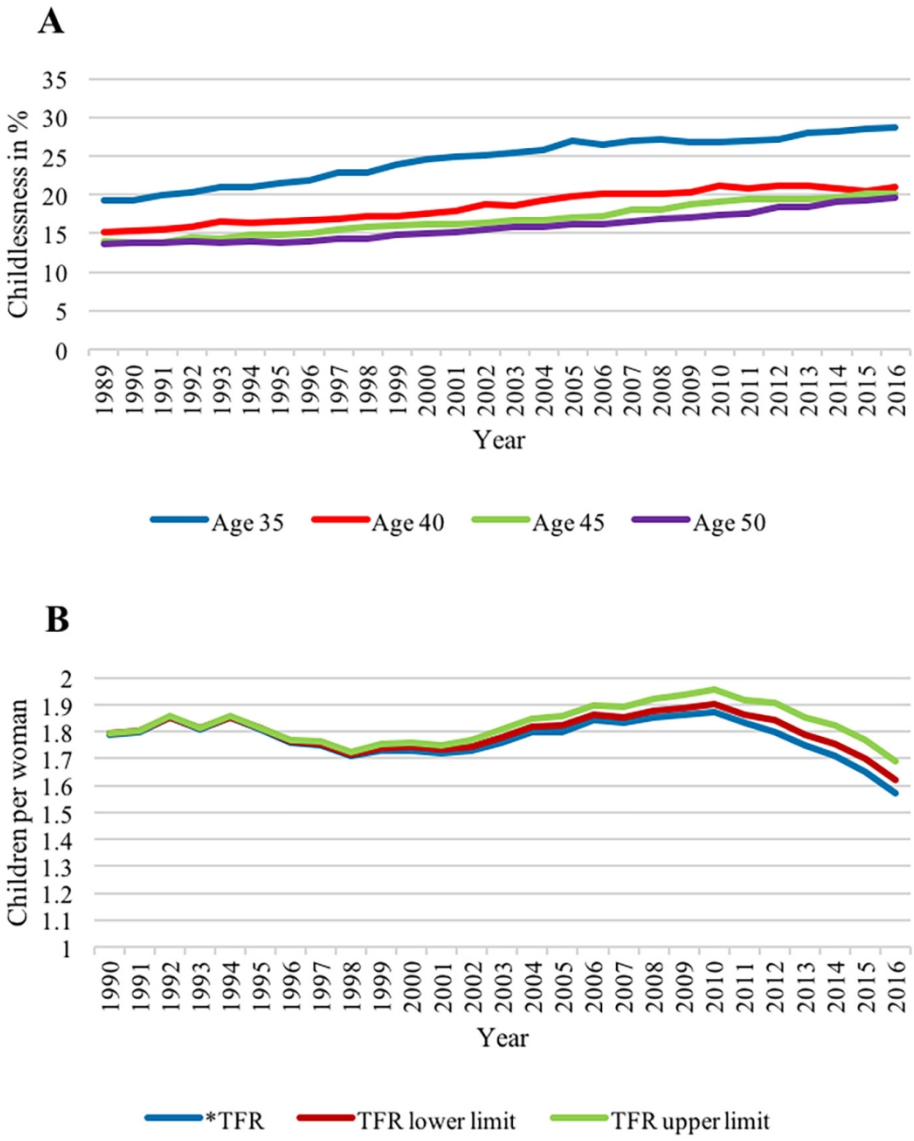
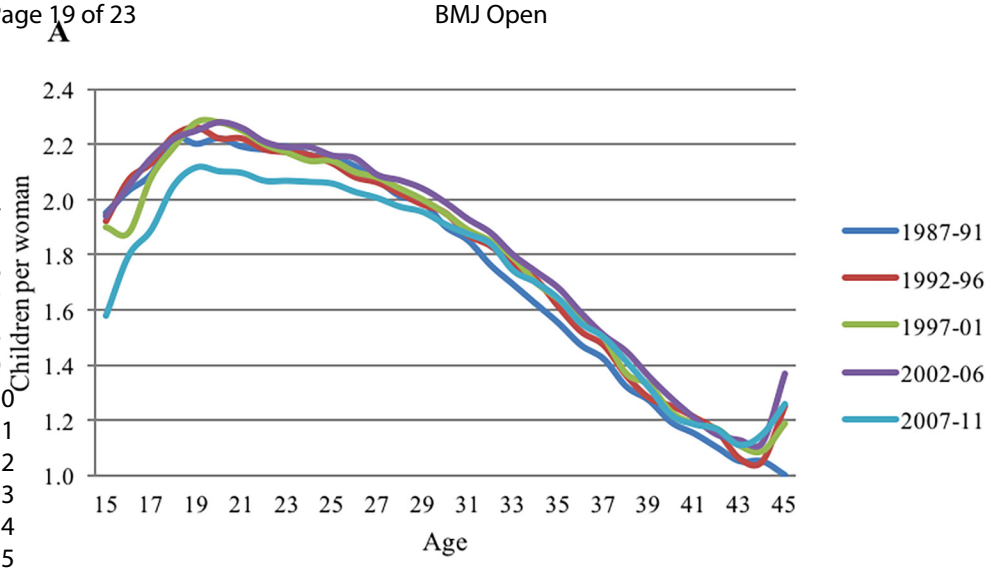
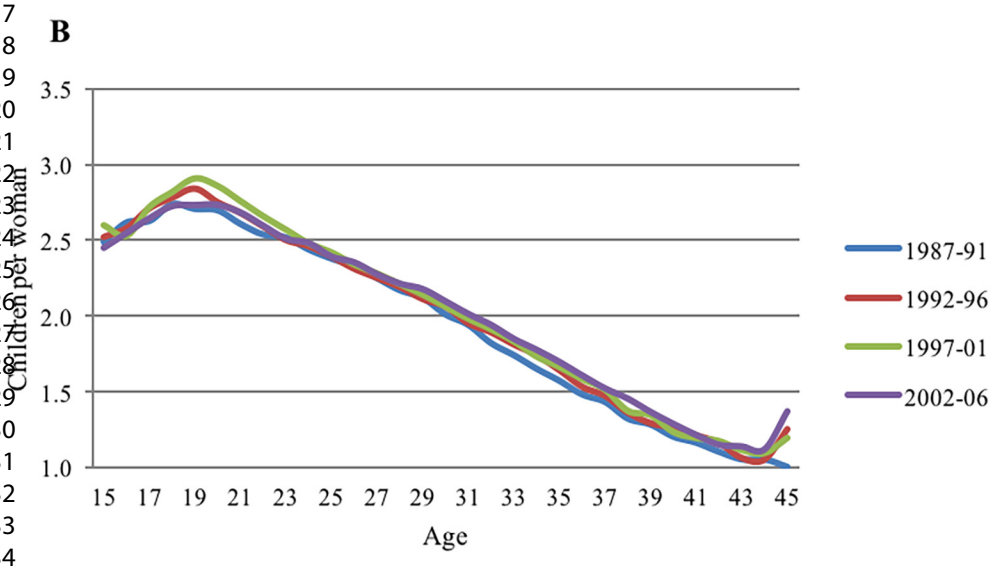
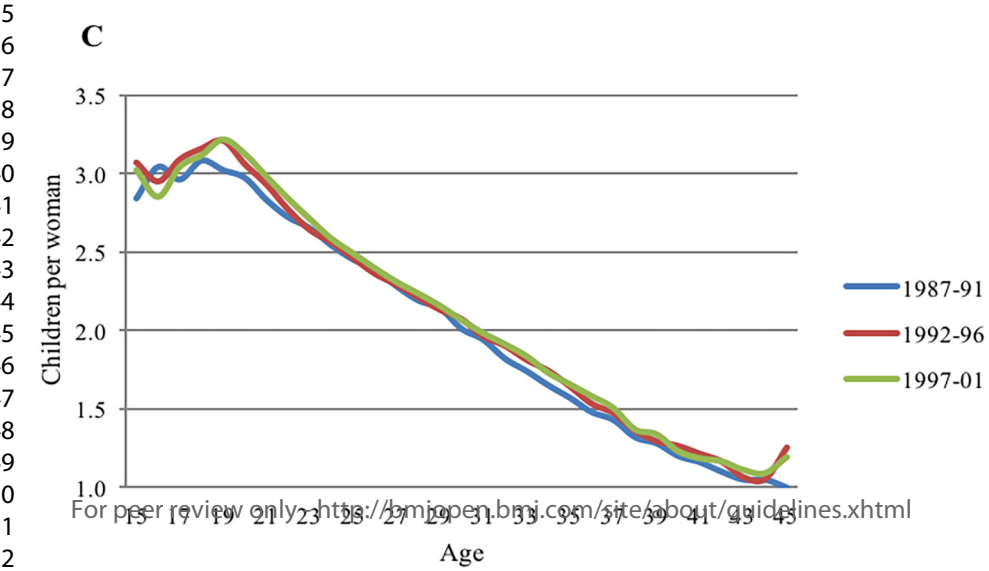


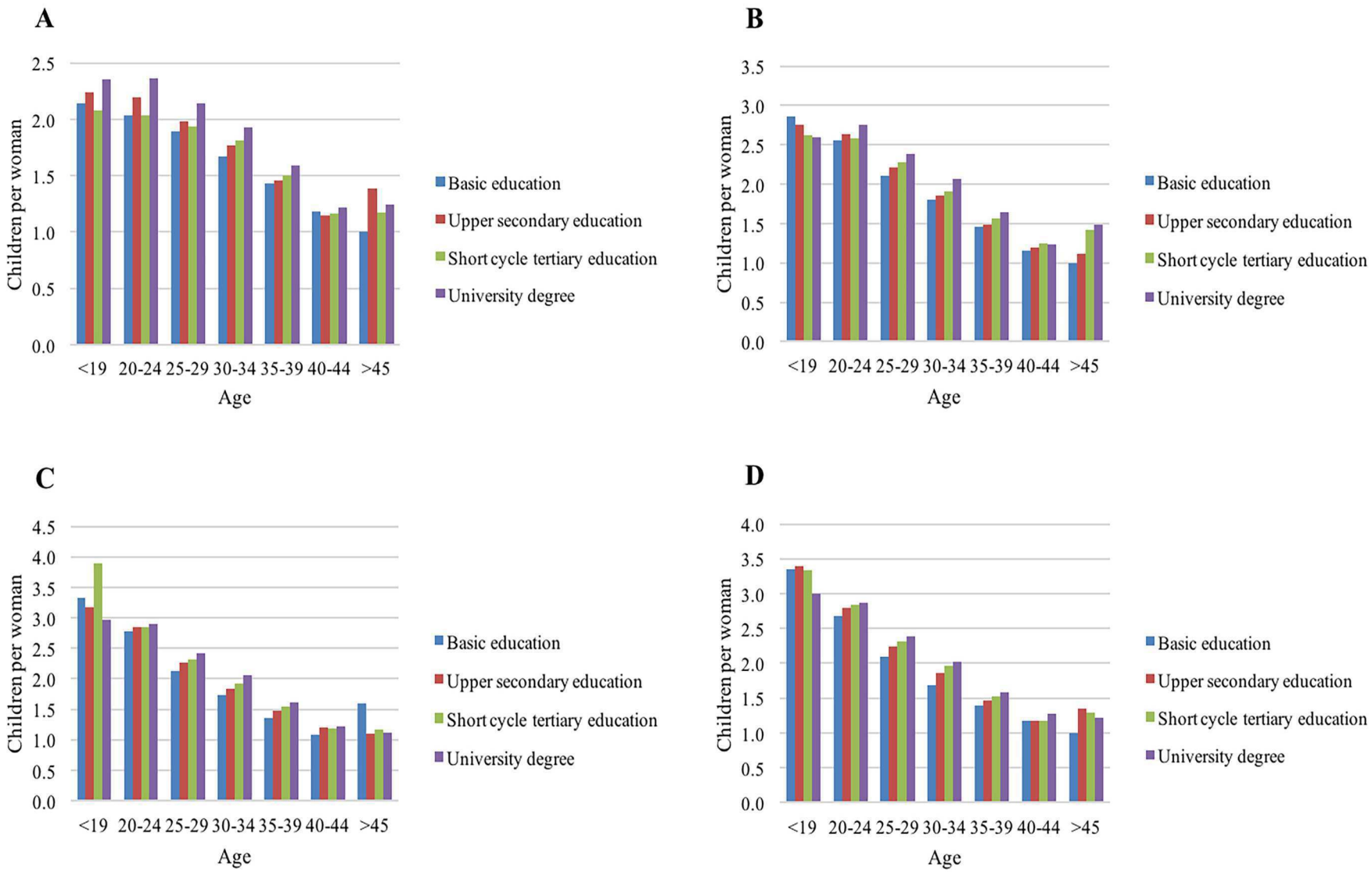
Figure 3. A: The proportion of childless women at the age of 35, 40, 45 and 50 years, from 1989 to 2016 in Finland. B: The estimated effect of postponing pregnancy on total fertility rate without delay since 1989 in Finland. *Total Fertility Rate (TFR). Note: below-replacement fertility: The total fertility rate lower than 2.1 children per women.

128x153mm (300 x 300 DPI)








A
Children per woman
2.5
2.0
1.5
1.0
0.5
0.0
<19 20-24 25-29 30-34 35-39 40-44 >45
Age
Basic education
Upper secondary education
Short cycle tertiary education
University degree
B
Children per woman
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
<19 20-24 25-29 30-34 35-39 40-44 >45
Age
Basic education
Upper secondary education
Short cycle tertiary education
University degree
C
Children per woman
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
<19 20-24 25-29 30-34 35-39 40-44 >45
Age
Basic education
Upper secondary education
Short cycle tertiary education
University degree
D
Children per woman
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
<19 20-24 25-29 30-34 35-39 40-44 >45
Age
Basic education
Upper secondary education
Short cycle tertiary education
University degree

Supplementary table 1 The estimated effect of postponing pregnancy on total fertility rates without delay since 1989 in Finland.

Year	Childlessness rate in each year in %	The rise in childlessness rate at the age 50 since 1989 in %	TFR*	Estimated TFR Without delay since 1989	The increase in TFR without delay since 1989
1989	36.6	-	1.71	-	-
1990	36.1	0.1	1.79	1.79-1.79	0.00-0.00
1991	35.7	0.2	1.80	1.80-1.80	0.00-0.00
1992	35.2	0.4	1.85	1.85-1.86	0.00-0.01
1993	34.8	0.1	1.81	1.81-1.81	0.00-0.00
1994	34.4	0.4	1.85	1.85-1.86	0.00-0.01
1995	34.1	0.2	1.81	1.81-1.81	0.00-0.00
1996	33.8	0.3	1.76	1.76-1.77	0.00-0.01
1997	33.6	0.7	1.75	1.76-1.76	0.01-0.01
1998	33.4	0.7	1.71	1.72-1.72	0.01-0.01
1999	33.3	1.2	1.73	1.74-1.75	0.01-0.02
2000	33.2	1.4	1.73	1.74-1.76	0.01-0.03
2001	33.1	1.5	1.72	1.73-1.75	0.01-0.03
2002	32.9	1.9	1.73	1.75-1.77	0.02-0.04
2003	32.8	2.3	1.76	1.78-1.81	0.02-0.05
2004	32.7	2.3	1.80	1.82-1.85	0.02-0.05
2005	32.6	2.6	1.80	1.82-1.86	0.02-0.06
2006	32.5	2.6	1.84	1.86-1.90	0.02-0.06
2007	32.5	2.9	1.83	1.85-189	0.02-0.06
2008	32.5	3.3	1.85	1.88-1.90	0.03-0.07
2009	32.5	3.4	1.86	1.89-1.94	0.03-0.08
2010	32.5	3.7	1.87	1.90-1.95	0.03-0.08
2011	32.4	3.9	1.83	1.86-1.92	0.03-0.09
2012	32.4	4.8	1.80	1.84-1.91	0.04-0.11
2013	32.4	4.8	1.75	1.79-1.85	0.04-0.10
2014	32.4	5.4	1.71	1.76-1.82	0.05-0.11
2015	32.4	5.7	1.65	1.70-1.77	0.05-0.12
2016	32.5	6.0	1.57	1.62-1.69	0.05-0.12

*TFR: Total Fertility Rate

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Report on page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 3
Methods			
Study design	4	Present key elements of study design early in the paper	Page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	
Participants	6	Give the eligibility criteria, and the sources and methods of selection of participants	Page 4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 4
Bias	9	Describe any efforts to address potential sources of bias	Page 4
Study size	10	Explain how the study size was arrived at	Page 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 4
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 4,5
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	NA
		(*d*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 5,6
		(b) Indicate number of participants with missing data for each variable of interest	NA
		Report numbers of outcome events or summary measures	Page 5, 6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 6
		(*b*) Report category boundaries when continuous variables were categorized	Page 4
Other analyses	17	Report other analyses done—eg analyses of subgroups and	NA

		interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarize key results with reference to study objectives	Page 7
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 7, 8
Generalisability	21	Discuss the generalizability (external validity) of the study results	Page 8
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 9

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.