Replacement fertility, what has it been and what does it mean?

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Replacement fertility is a term commonly used by demographers when referring to levels of childbearing and yet is rarely explained. It is normally presented as being around 2.1 children per woman. Continued below replacement fertility in developed countries and fertility falling in developing countries has given the concept of replacement fertility a higher profile. This article explains how replacement level is calculated and explores the concept further. Past replacement fertility levels are calculated for England and Wales. A possible alternative definition of replacement is also presented. Simple projection scenarios are used to show the effect on population of below replacement fertility, and also of postponement of fertility. The importance and implications of below replacement fertility are discussed.

Introduction

Replacement fertility is a term that appears to be self-explanatory and has gained a common usage in demographic literature and the media. However, it is more complex than is often assumed. This article aims to provide a clear explanation of replacement fertility, with regards to its components and calculation. Modelling work was undertaken to investigate the effect of different fertility levels and trends on population growth and structure. In particular, there is a focus on below replacement level fertility because the countries of the United Kingdom, like nearly all European countries, are experiencing below replacement fertility. The focus on fertility being below replacement level poses a number of questions such as: What is meant by 'replacement'? Does it matter demographically that fertility is below replacement? This article also shows that replacement fertility is more than a demographic curiosity. Below replacement fertility can have important demographic and social implications. However, these consequences are only likely to arise with persistent long-term below replacement fertility. The article is intended to be of interest to a wide audience and the technical sections can be omitted by the reader with a more general interest.

The concept of replacement fertility may seem relatively simple, the level of fertility required to ensure a population replaces itself in size. To replace themselves women, on average, need to have one female child, who survives long enough for a female grandchild to be born, and so on for succeeding generations.[1] An average of two children will 'replace' all mothers and fathers, but only if the same number of boys as girls are born and all female children survive to the end of reproductive age. However, as explained later, mortality and the unbalanced sex ratio at birth mean that replacement level fertility is actually a little higher than 2.0. Although migration can be a significant driver of population change for the purposes of calculating replacement fertility migration is normally ignored. The calculations are based on rates so it is only the extent to which mortality and fertility rates are changed by migrants that migration has any effect on the calculations. Note that while men are clearly important in terms of reproduction, analysis of fertility levels tend to be exclusively female-based and the effect of men on replacement fertility in this analysis is restricted to the sex ratio at birth.

The understanding of replacement fertility is made more complex by the need to consider both the period and cohort dimensions. On a period basis, replacement fertility is the level of fertility needed to exactly replace all the women in a population constructed using mortality and fertility at a particular point in time. It is a measure that represents the demographic situation of a point in time, and thus, like the TFR, is synthetic as no individual experiences the rates from which it is composed. Replacement on a cohort basis, is the level of fertility needed to ensure that a generation born at a particular point in time is replaced. We discuss both these concepts in the context of England and Wales later.

In England and Wales, as in all developed countries, a total fertility rate (TFR) or completed family size (CFS) of 2.1 is usually taken as roughly approximate to the level of replacement fertility. However, it is important to remember that this level of 2.1 children is an average across all women. Therefore, to ensure replacement fertility a substantial proportion of women have to have three or more children in order to compensate for those remain childless or have only one child.[2]

Demographic factors that affect replacement fertility

Two components interact with fertility to determine the level of replacement fertility; they are mortality and the sex ratio at birth. High infant, child and young adult mortality rates were the key determinants of replacement fertility levels in the past in developed countries. Mortality up to the end of a woman's fertile life is now very low in developed countries, and therefore its effect on the replacement fertility level has substantially decreased, and is now similar to or smaller than that of the sex ratio. However, mortality is still the key component in the calculation of replacement fertility levels in developing countries, especially in the context of the HIV/AIDS epidemic.

The sex ratio at birth for a population is usually around 105 males born for every 100 females. However, there are some countries where it differs, for example in China the sex ratio at birth is given in official statistics as 109 males to 100 females.[3] If male births increase relative to female births, an overall rise in the number of births is needed to compensate and replace the population.[4] The sex ratio is perhaps a secondary factor, in that mortality had the greater effect on calculating replacement in the past, but with low mortality it does have an effect and can change over space and time, and therefore should be considered when looking at replacement fertility levels. However, in England and Wales the sex ratio has varied between 104 and 106 over the twentieth century[5] so it has not greatly affected levels of replacement fertility.

If mortality did not exist until after childbearing ages (and ignoring migration) the replacement level fertility is wholly dependent on the sex ratio. Given the stability of the sex ratio, replacement fertility will tend towards a figure of around 2.05 and would not realistically fall much below that level.

Migration further complicates the concept of replacement fertility. Calculations are based on rates derived from the vital events (births and deaths) and the population within a country in each year. These rates may vary either upwards or downwards because of the effect of migrants. These effects are, however, likely to be marginal as, in the UK for example, the overseas-born form only one twelfth of the total population.[6]

However, migration is an important component of population size and composition by ethnic group. Continued net inward migration is projected for the United Kingdom.[7] Therefore, population and individual cohorts are likely to be larger than they would have been in the absence of migration. It would be possible to calculate replacement level for a period or cohort given a level of actual or assumed migration, as Calot and Sardon have done for France.[8] We do not do so in this article, although some of the projections presented later do include the effect of migration on the population.

The calculation of replacement fertility in England and Wales

In the next section of the article we present calculations of replacement fertility and also some illustrative population projections. The projections are based mainly on data for England and Wales. Note that the projections show population in terms of an index with the base year equal to 100 and natural change as a proportion of the population. This is in order to avoid any confusion with population numbers in either official estimates or projections.

Replacement fertility – the period perspective

Most demographic measurement is done in terms of a particular period of time, normally a calendar year or group of years, hence the term 'period'. Period replacement fertility uses the fertility and mortality rates in a particular year to calculate a level of fertility that would produce sufficient births that a population age distribution constructed using current mortality would remain unchanged. Although period measures are by their nature synthetic (as no group of individuals experience the fertility and mortality rates of a particular period through their life time) they are still useful in assessing the demographic situation. The level of actual fertility in a particular year is directly related to the total number of births, which in turn largely determines the size of that birth generation relative to others. Thus, as we shall see below, below replacement fertility on a period basis has a direct effect on future population size.

The detailed calculation of period replacement fertility is described in Box one. Briefly it involves the construction of a female population by assuming a set number of births (a radix) and then applying age-specific mortality rates for the period concerned. Age-specific fertility rates for the period are then applied to the population and scaled so as to produce the number of female births that match the size of the original radix. The sum of the scaled fertility rates gives a measure of the level fertility required to replace the population. This can then be compared with the actual TFR.

Figure 1 shows period replacement fertility for England and Wales, as well as calculations by the authors the chart includes an approximated calculation carried out by Sardon[9] (see Box one). Our calculations have only been carried out from 1938, when age of mother became available on birth registration data. The advantage of Sardon's approximation is that he was able to calculate a longer historical series. Where the series overlap the results of both calculations are very similar.

For the latest year, 2003, period replacement fertility for England and Wales was 2.07. This compares with a figure of 2.30 for 1938, the first year that data are available for a detailed calculation of the figure. The fall occurs because of improvements in mortality. Sardon's estimates suggest that period fertility was below replacement level between the

Box one

CALCULATION OF PERIOD REPLACEMENT LEVEL FERTILITY

Period replacement

The first step is to calculate a life table using mortality data for the period. This is done by using age-specific mortality rates converted to probabilities of dying between exact ages applied to a notional group of women born at the same time. This group is known as the life table radix (often assumed to be 10,000 or 100,000). This produces a 'synthetic' population (*l*) at each exact age (*x*) that would exist if the radix group experienced the mortality of the period.

The *lx* population is then converted at fertile ages in to a population at age last birthday (Lx) by interpolating the lx values.

The period age-specific fertility rates (ASFR) can then be applied to the Lx population to give the number of births produced at each age given current fertility rates.

In order to produce the number of female births to replace the population radix the fertility rates are multiplied by a factor, calculated by dividing the radix by the total number of female births. To determine the number of female births the actual sex ratio was used to split the births into male and female.

The sum of the adjusted fertility rates equals the replacement fertility level. The calculation for 2001 is illustrated in the table in this box.

Cohort replacement

The calculation of cohort replacement is identical in method to the calculation of period replacement; except that instead of using age-specific mortality rates and age-specific fertility rates from a particular period, rates that apply to a particular cohort are used.

Cohort 'reproductive capacity' replacement

In this calculation the female births are subjected to the actual and projected mortality rates that apply to them, up to the end of their fertile life. The resulting population is totalled at fertile ages (here assumed to be 14–46). The fertility rates are adjusted so that this total population equals the numbers in the original female cohort life table population aged 14–46.

Sardon approximation for calculating replacement

Sardon calculated replacement fertility as the inverse of two factors: the product of the probability of survival to the mean age of motherhood; and, the assumed proportion of female births. For example, if the probability of survival to the mean age of motherhood was 0.8 and the proportion of female births was 0.488 replacement level would be 1 /(0.80 x 488) = 2.56.

Calculation of period replacement fertility for 2001

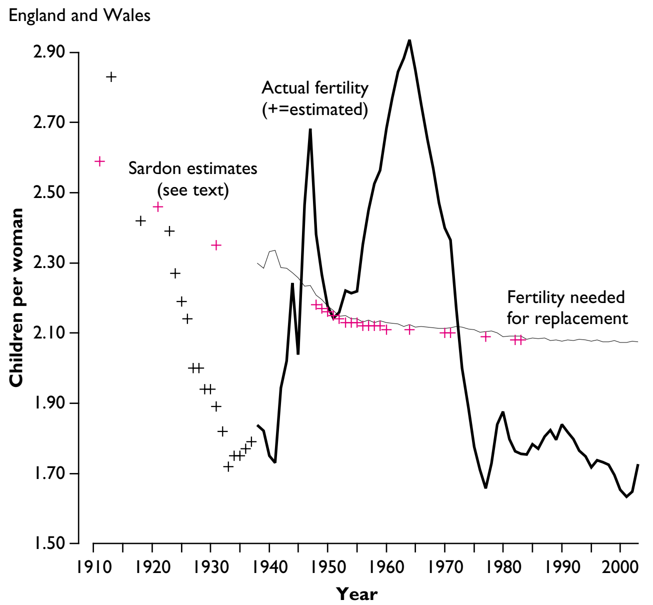
England and Wales

Age x	Female q_x [1]	l_x $l_x=l_{x-1}-(l_{x-1} \times q_{x-1})$	L_x $L_x=(l_x+l_{x+1})/2$	ASFR per 1,000	Scaled ASFR Scaling factor= 1.2653	Number of births produced by scaled ASFRs
0	0.00492	100,000.0				
1	0.00036	99,507.8				
2	0.00020	99,472.3				
3	0.00020	99,452.2				
4	0.00014	99,432.5				
5	0.00013	99,418.9				
6	0.00011	99,405.9				
7	0.00010	99,394.6				
8	0.00013	99,384.4				
9	0.00010	99,371.0				
10	0.00007	99,360.9				
11	0.00012	99,354.2				
12	0.00009	99,342.7				
13	0.00011	99,333.5				
14	0.00015	99,322.5	99,315.2	0.9	1.1	113
15	0.00018	99,308.0	99,299.3	3.5	4.5	443
16	0.00022	99,290.5	99,279.5	11.4	14.5	1,437
17	0.00025	99,268.4	99,255.9	27.4	34.8	3,453
18	0.00028	99,243.4	99,229.4	42.7	54.2	5,380
19	0.00027	99,215.5	99,202.2	55.9	71.0	7,040
20	0.00027	99,189.0	99,175.8	62.6	79.4	7,875
21	0.00031	99,162.5	99,147.0	66.3	84.1	8,335
22	0.00030	99,131.4	99,116.3	69.4	88.1	8,732
23	0.00034	99,101.3	99,084.6	72.1	91.5	9,063
24	0.00026	99,067.9	99,055.1	75.1	95.3	9,441
25	0.00027	99,042.2	99,028.8	81.4	103.3	10,233
26	0.00038	99,015.3	98,996.6	87.3	110.8	10,966
27	0.00036	98,977.9	98,960.2	92.9	117.9	11,663
28	0.00033	98,942.6	98,926.5	95.5	121.1	11,983
29	0.00037	98,910.4	98,892.0	99.1	125.7	12,429
30	0.00037	98,873.6	98,855.4	101.1	128.3	12,678
31	0.00048	98,837.3	98,813.6	98.2	124.5	12,307
32	0.00051	98,789.8	98,764.4	90.8	115.2	11,375
33	0.00049	98,739.0	98,714.7	80.6	102.2	10,090
34	0.00058	98,690.3	98,661.5	70.5	89.5	8,826
35	0.00072	98,632.7	98,597.2	61.7	78.3	7,720
36	0.00068	98,561.8	98,528.5	50.9	64.5	6,357
37	0.00070	98,495.2	98,460.8	40.6	51.6	5,076
38	0.00079	98,426.3	98,387.2	30.6	38.8	3,815
39	0.00085	98,348.1	98,306.1	22.9	29.0	2,851
40	0.00093	98,264.1	98,218.6	16.9	21.4	2,101
41	0.00107	98,173.0	98,120.4	11.0	13.9	1,368
42	0.00117	98,067.7	98,010.2	7.0	8.9	872
43	0.00143	97,952.7	97,882.6	3.9	5.0	490
44	0.00139	97,812.5	97,744.3	2.1	2.6	259
45	0.00160	97,676.1	97,598.2	2.2	2.8	276
46	0.00179	97,520.3				
TFR				1.63		
Replacement TFR					2.07	
Total births						**205,047**

Actual sex ratio, 2001		
Births	Males	304,635
	Females	289,999
Ratio		1.0505
Therefore target births = 205,047		

1 *Source: GAD mortality database - available from Government Actuary's Department on request.*

Figure 1 **Period actual and replacement level fertility 1910–2003**



mid-1920s and the mid-1940s. There then followed the post World War II (WWII) baby boom and the more sustained 1960s baby boom where the TFR was up to 0.8 children higher than the replacement level at 2.9 children per woman. Since the early 1970s the TFR has been below replacement level, and from the mid-1970s it has been around 1.7 to 1.8, 0.3 to 0.4 children per woman lower than replacement.

Just because period fertility is below replacement level does not mean that a population will immediately see natural decline (more deaths occurring than births). The age structure of the population and changes in mortality will determine when natural decline occurs. In England and Wales, even though fertility has been below replacement level since the 1973, births have exceeded deaths (except in the exceptionally low fertility year of 1976), normally by around 10 to 20 per cent each year. This is almost certain to continue in the very near future, as can be illustrated by running a simple population projection using the current population structure, current fertility rates and current mortality rates and assuming no migration. Box two further describes the data and assumptions used in all of our modelling scenarios. Figure 2 shows that, under these assumptions, the population of England and Wales would increase for the next few years and would start to decrease very gradually within a decade. Scenarios 2 and 3 show that, even without increased fertility, with net inward migration or improving mortality population increase will continue further into the future. Both improving mortality and net inward migration are assumed in official population projections.[7] However, if below replacement fertility continues for many generations then a 'reverse compound interest' effect operates as successively smaller generations fail to replace themselves. Although it must be noted that is is difficult to project the childbearing behaviour of women who are themselves not yet born. If we run our first projection scenario (constant fertility, no mortality improvement and nil migration) forward 70 years the population is only around 77 per cent of the starting population and by 100 years 63 per cent. Figure 3 shows the age distributions resulting from the three population projection scenarios. In all three the populations age, with fewer aged under 16 and more aged 65 and over.

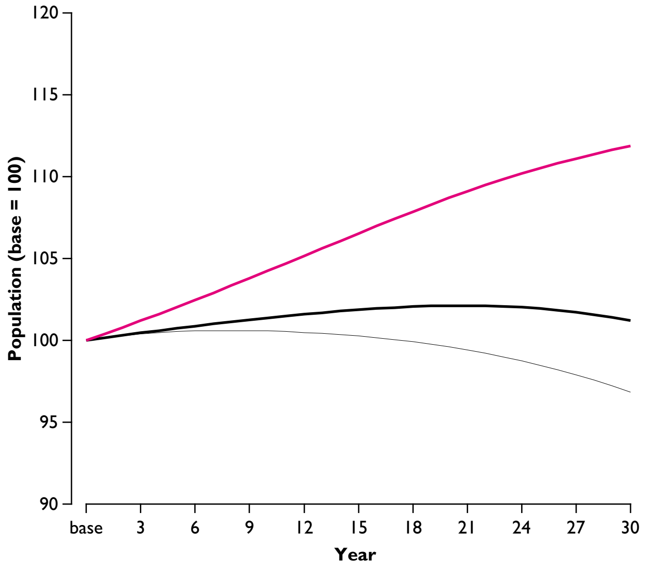
Box two

Data and assumptions used in projection scenarios

All data from England and Wales

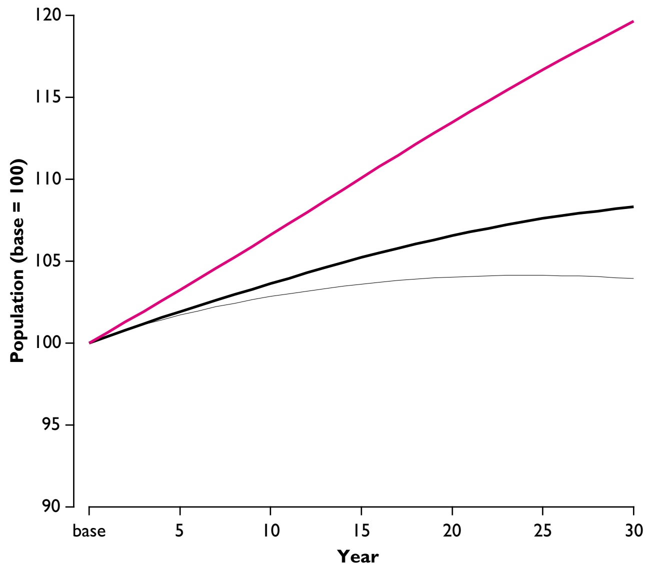
Scenario	Base population	Fertility	Mortality	Migration
1. Constant fertility, constant, mortality no migration	Mid-2003 population	Actual fertility Calendar year 2003	Mid-2003 to mid-2004 rates from 2003-based principal projection	None
2. Constant fertility, improving mortality, no migration	Mid-2003 population	Actual fertility Calendar year 2003	2003-based principal projection	None
3. Constant fertility, improving mortality, net inward migration	Mid-2003 population	Actual fertility Calendar year 2003	2003-based principal projection	2003-based principal projection
4. Replacement fertility, constant mortality, no migration	Mid-2003 population	Replacement fertility Calendar year 2003	Mid-2003 to mid-2004 rates from 2003-based principal projection	None
5. Replacement fertility, improving mortality, no migration	Mid-2003 population	Replacement fertility Calendar year 2003	2003-based principal projection	None
6. Replacement fertility, improving mortality, net inward migration	Mid-2003 population	Replacement fertility Calendar year 2003	2003-based principal projection	2003-based principal projection
7. Cohort postponement projection	Stationary population constructed using 2002 mortality and replacement level fertility	Assumption constructed by postponing fertility by cohort (see text and Figure 7)	Calendar year 2002	None

Figure 2 **Constant current fertility projections, change in population size under three scenarios**



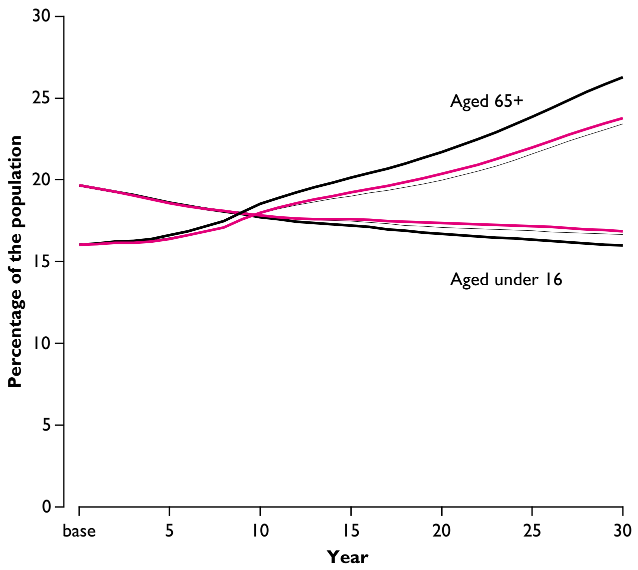
Constant fertility (TFR=1.73) Constant mortality Nil Migration (Scenario 1)
Constant fertility (TFR=1.73) Improving mortality Nil Migration (Scenario 2)
Constant fertility (TFR=1.73) Improving mortality Migration (Scenario 3)

Figure 4 **Replacement fertility projections, change in population size under three scenarios**



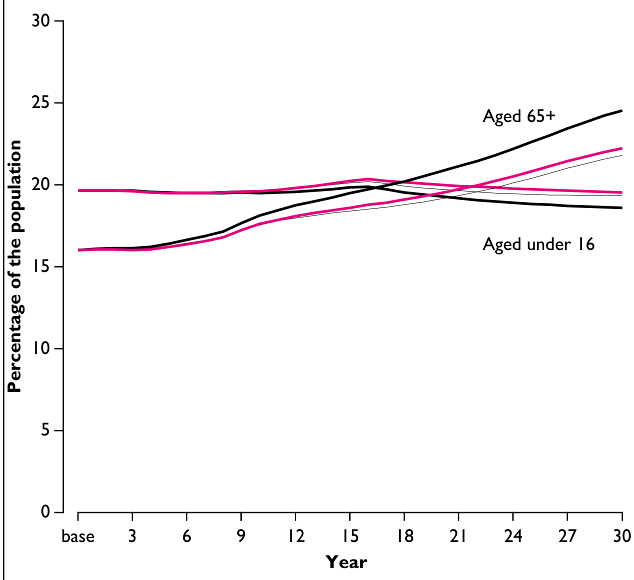
Replacement fertility Constant mortality Nil Migration (Scenario 4)
Replacement fertility Improving mortality Nil Migration (Scenario 5)
Replacement fertility Improving Migration (Scenario 6)

Figure 3 **Constant current fertility projections, percentage under 16 and 65 and over under three scenarios**



Constant fertility Constant mortality Nil Migration (Scenario 1)
Constant fertility Improving mortality nil Migration (Scenario 2)
Constant fertility Improving mortality Migration (Scenario 3)

Figure 5 **Replacement fertility projections, percentage under 16 and 65 and over under three scenarios**



Replacement fertility Constant mortality Nil Migration (Scenario 4)
Replacement fertility Improving mortality Nil Migration (Scenario 5)
Replacement fertility Improving mortality Migration (Scenario 6)

Let us now take our first three scenarios and instead of assuming constant fertility at current rates, assume an immediate increase to replacement level. Figure 4 shows that a rise to replacement level fertility would result in population increase in all of our three scenarios, the population being around four per cent higher than the base year after thirty years, assuming no migration or mortality improvement. This rise may seem smaller than might be expected, however without such a rise in fertility the population falls by around four per cent (Figure 2). Assuming improving mortality and then the addition of net inward migration produces a larger rise in the population.

An immediate increase to replacement fertility produces a clear effect on the age distribution of the population (Figure 5). All three replacement scenarios show that the proportion under 16 remains fairly constant rather than falling, as in the previous scenarios, and under all three scenarios the proportion over 65 still continues to increase. However, compared with scenarios 1 to 3, the point at which the under 16 lines and the 65 and over lines cross over is delayed for around a decade and the proportion of the population aged 65 and over is lower.

Thus from a period perspective it is clear that future population size is affected by whether fertility is below replacement level, however the direction and amount of population change is dependent on the current age distribution of the population, as well as migration and mortality. Even an immediate return to replacement level fertility would not halt population ageing, although it would attenuate it. In the short-term it would actually increase the overall dependency ratio as there would be a greater proportion of the population aged under 16 or over 65. The scenarios here have only been shown for a relatively short projection period of 30 years. Previous work by Shaw has shown that fertility would have to rise substantially above replacement level for pension age dependency ratios at the end of this century to be near those at the start of this century.[10]

Replacement fertility – the cohort perspective

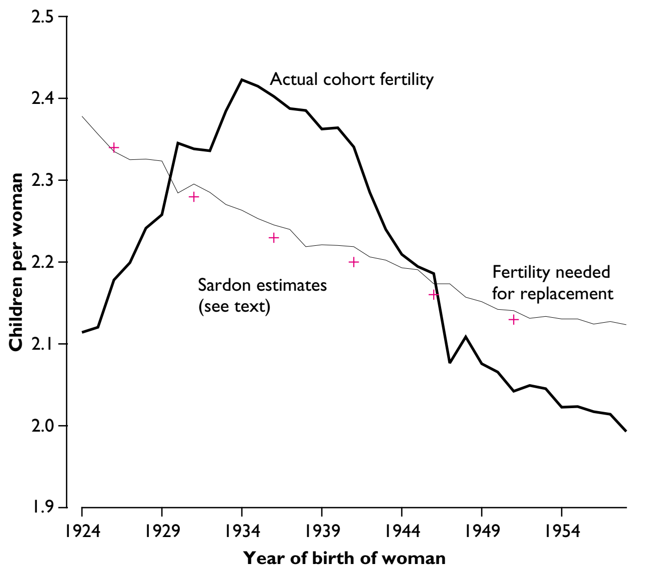
As mentioned previously, period measures of fertility are synthetic, as they are derived from a series of rates that no individual woman will experience. However, by looking at age-specific rates that would apply to a group of women born at a particular time (a cohort) we can produce a measure that is much less synthetic, since these are the rates that women born in a particular year would experience through their childbearing life.

Thus, using the appropriate fertility and mortality rates, a cohort replacement level of fertility can be calculated. Box one describes the calculations involved and Figure 6 shows the result for cohorts born, in England and Wales, between 1924 and 1960. Again, we see a gradual fall in the replacement fertility level because of improving mortality, that is, for successive cohorts more women have survived to childbearing ages. Again the chart shows some approximate calculations by Sardon[9] which match our more detailed estimates. The chart shows that for cohorts of women born in the mid to late 1920s their fertility was below replacement level. Women born from around 1930 to the end of WWII experienced above replacement level fertility whilst women born since then who have completed, or are close to completing, their childbearing being only around 0.1 of a child below replacement level.

The last two decades have seen a rise in the average age at which women bear children. It is likely that in part the rise in mean age reflects a postponement of childbearing. The effect of postponement is to make period measures of fertility, like the TFR, unrepresentative of the final fertility of particular cohorts of women.[11]

Figure 6 **Cohort actual and replacement level fertility 1924–1960**

England and Wales

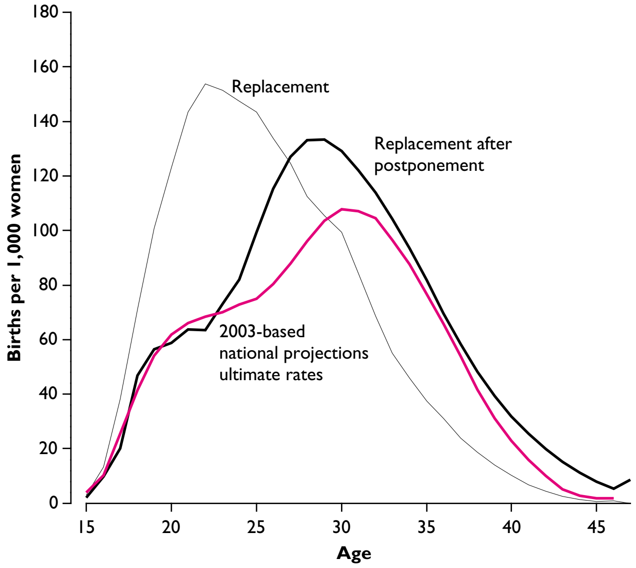


The effect of postponing births in a population is also to reduce population size. Thus even a population in which each cohort is replacing itself will, other things being equal, decline in size if postponement is occurring. Although in such a population each person is replaced, the population gets 'stretched' into the future meaning fewer people alive at any one time. A simple demographic model demonstrates this effect. We start with a 'stationary population', where mortality is unchanging and there are sufficient births for the population to be replaced. To make the model of fertility change as realistic as possible we used an age distribution for replacement close to that of the 1949 cohort, the last cohort to replace itself in England and Wales. We then assumed that women begin to postpone births, but that they still have sufficient births to replace their generation. The postponement was constructed to produce the current assumed age pattern of fertility in the national population projections[12] and takes place over 30 cohorts. Within the model the effect will be a rise in mean age of childbearing as well as the total fertility rate being below replacement level for around 60 years (see Figure 7).

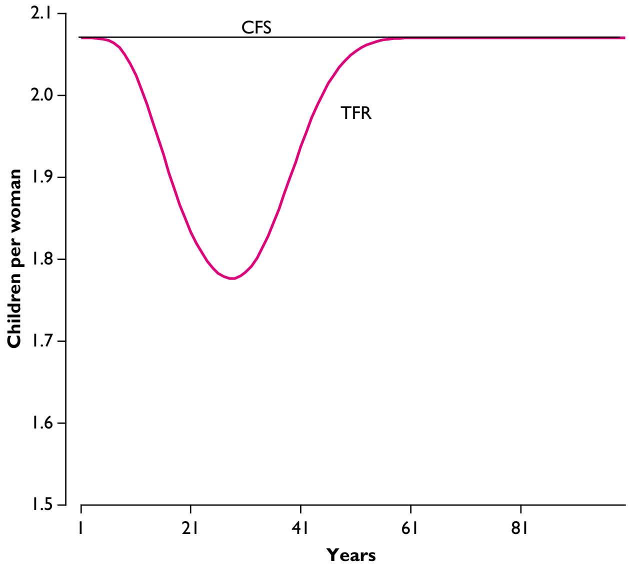
The results of this model in term of population size and population ageing are shown in Figures 8 and 9. Figure 8 shows that the population is still declining slightly even 100 years on from the start of the postponement, as the successively smaller cohorts replace themselves, and is around 12 per cent lower than the base. In fact a recent short paper by Schoen,[13] pointed out that it is theoretically possible for a population to decrease, even if each cohort has above replacement level fertility, if the level of postponement is sufficient. The effect on the age distribution, shown in Figure 9, might initially seem unexpected in that by the time 100 years has passed the proportions of the population aged under 16 and 65 or over are almost the same as in the base stationary population. In fact what eventually develops is a new stationary population, which, because mortality is constant in this model, will be similar to the original stationary population at the start of the projection.

Figure 7 **Assumptions for cohort replacement fertility with childbearing postponement scenario**

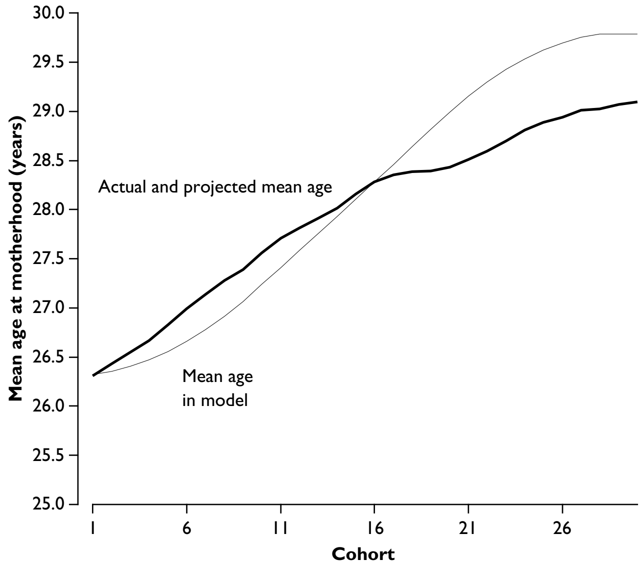
(a) Age specific fertility rates



(b) Total fertility rate and completed family size in the model



(c) Mean age at childbearing for cohorts in model, and actual/projected[1] mean age of cohorts born from 1949 to 1978 in England and Wales



1 Using the 2002-based projections

Figure 8 **Cohort replacement with postponement, change in population size**

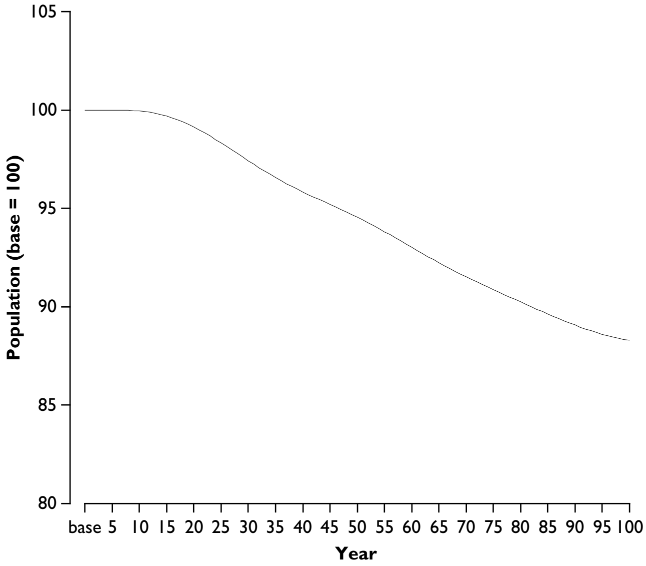
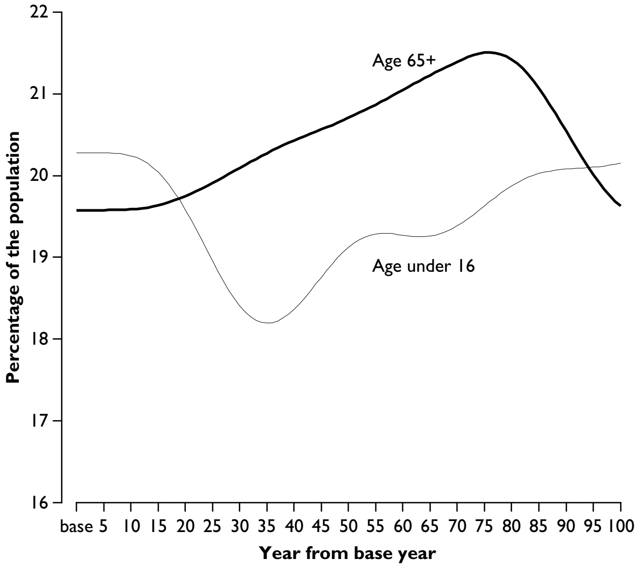


Figure 9 **Cohort replacement with postponement, percentage under 16 and 65 and over**

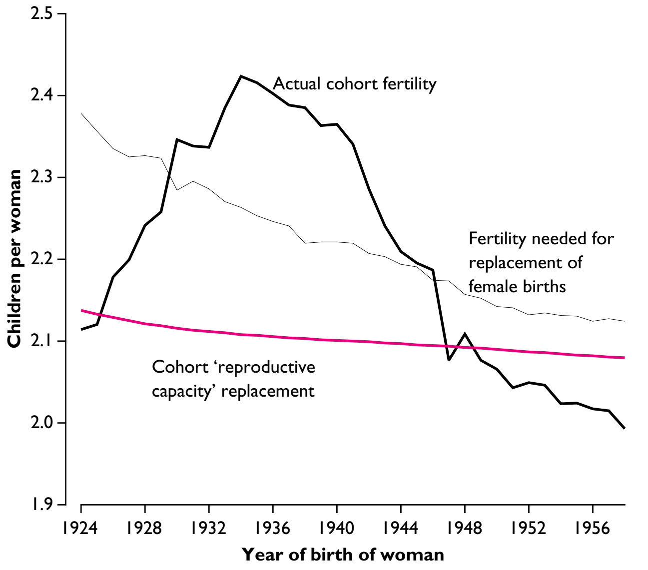


Further thoughts on the concept of cohort replacement

Traditionally replacement fertility is thought of in terms of replacing the numbers of the cohort born. Thus if we return to the actual cohort replacement shown in Figure 6 the level of fertility shown is that which would produce a sufficient number of births to replace each cohort, given the mortality that each cohort experienced. However, mortality has been improving for many years (hence the declining replacement level trend in Figure 6) and is projected to continue to improve. Therefore the calculation of replacement of births gives an inflated measure of a cohort replacing itself, as a greater proportion of children are likely survive through to adulthood and old age than in the cohort bearing the children.

Sardon made this point in his paper in 1993,[9] and in a paper with Calot[8] presented some calculations for French fertility to take account of mortality improvement. We have carried out a calculation to consider this

Figure 10 **Cohort actual and replacement level fertility under different definitions of replacement**



aspect for England and Wales cohort replacement fertility. We call this calculation 'reproductive capacity', and we calculate replacement, not of the numbers of the cohort at birth, but the fertility required to replace the number of person years of women of fertile age, given actual and projected future mortality improvement (projected mortality from the 2002-based national population projections). This seems an intuitively more plausible form of replacement, as it results in the same number of women at ages exposed to having children as there are in the cohort being considered. The results are shown in Figure 10.

For England and Wales the interpretation that 1920s born cohorts had below replacement fertility changes when the definition of replacement changes. The improved mortality of this cohort's female children, from birth to the completion of childbearing age, removes the higher fertility needed to counteract the cohort's own higher mortality. However, mortality at ages below the end of childbearing ages is now very low therefore the redefinition of replacement tends towards the current period level of replacement, because even large improvements in mortality will have little further effect.

Of course mortality continues to improve at ages beyond the cessation of childbearing. To take this into account one could calculate a level of fertility that would produce an equivalent number of years lived in total to the number of years lived by the cohort producing the children, i.e. replacing the person years lived for the cohort. If large improvements in mortality were to continue to occur[14] such a measure would have 'replacement' fertility levels of below 2.0.

Global variation in replacement fertility level

World fertility

Espenshade *et al* recently criticised the tendency for the level of replacement fertility to be presented to the public by the media, and even some demographers, as 2.1 children per woman, 'frozen' once and for all, valid for all times and places[15], including developing countries. For example, from the *2002 Revision* of the official United Nations population estimates and projections, 'the United Nations Population Division projects that future fertility levels in the majority of developing countries will likely fall below 2.1 children per woman, the level needed to ensure the long-term replacement of the population, at some point in the twenty-first century'.[16] If the improved mortality assumed in the UN projections comes to pass then replacement level will approach 2.1 in developing countries. The statement could be seen, however, as implying that 2.1 is always the level of replacement fertility.

Replacement fertility values are highly country and region specific, primarily due to differing mortality levels. Work by Espenshade *et al*[15] shows that recent period replacement level fertility, across the world, ranges from a low of 2.05 in Réunion to a high of 3.43 in Sierra Leone. Table 1 shows the TFRs and the TFR value for replacement fertility for different regions of the world. Box three demonstrates how misleading using 2.1 as replacement can be.

Table 1 **TFR and replacement level TFR (TFRr) for the world and major regions, 1995–2000**

	TFR	TFRr
World	2.82	2.34
More developed regions	1.57	2.09
Less developed regions	3.10	2.37
Least developed regions	5.47	2.75
Northern America	2.00	2.09
Europe	1.41	2.10
Oceania	2.41	2.18
Latin America/Caribbean	2.69	2.17
Africa	5.27	2.70
Asia	2.70	2.32

Source: Espenshade et al[15]

Wilson and Pison recently estimated that in 2003 the world population crossed the threshold of 50 per cent of the world's people living in a country or region in which fertility is below replacement level (using 2.1 as the measure of replacement).[17] They recognised, however, that in some areas of the world replacement will be higher than 2.1, therefore, it is likely that even more than half of the world's population are in areas with below replacement fertility.

European Fertility

For developed countries assuming a replacement level of around 2.1 is less contentious. Table 2 shows for 33 European countries the year in which their TFR was last at 2.1 children per woman or above, in order of the year of occurrence. All of the European Union (EU25) countries have below replacement fertility on a period basis, with some, such as Germany having had fertility well below replacement for several decades.[18] In some countries, such as Spain and Italy, fertility has now even fallen to what are classed as 'lowest low' fertility levels (a TFR of below 1.3[19]). A table showing the EU25 total fertility rates for selected years can be found in the article by Pearce and Bovagnet (Table 6) in this issue of *Population Trends*.[20] England and Wales has experienced below replacement fertility on a period basis since 1973. However, as we have seen, this is not a new phenomenon; fertility was also below replacement in England and Wales for most of the period between the two World Wars.

Turning to cohort fertility, Table 2 also shows the year of birth of the last generation to achieve fertility of an average of 2.1 children, or more, per woman. By the 1960 cohort only four of the 23 countries of the EU25, for which data are available, had above replacement fertility (France, Ireland, Poland and the Slovak Republic), as well as Norway, Serbia Montenegro and Romania. However, many other countries had cohort fertility only a little below 2.1 children per woman. Two graphs showing the EU25 completed family size for cohorts born in 1930 and 1963 can be found in the article by Pearce and Bovagnet (Figure 10) in this issue of *Population Trends*.[20] For the 1963 cohort the lowest cohort fertility was in Italy and Germany, with 1.57 and 1.58 children per woman respectively.

Box three

ACTUAL REPLACEMENT VERSUS 2.1

The values in Table 1 for replacement fertility in North America, Europe and more developed regions equate, as expected, to a TFR of 2.1. The TFR required for replacement fertility in Oceania and Latin America/Caribbean is also very close to 2.1. However, in Africa, Asia, the less developed regions and least developed regions replacement fertility levels are higher than 2.1. Therefore, globally the fertility needed for replacement is higher than the often assumed TFR of 2.1.

The table below shows the percentage differences between actual TFR, replacement level TFR and 2.1 for different regions of the world. The first column shows the difference between the actual TFR in 1995–2000 and a TFR of 2.1, and the second column shows the difference between the actual TFR and the region specific replacement level TFR in 1995–2000. They show that if a TFR of 2.1 was assumed to be replacement level then fertility in the least developed regions was 160 per cent above replacement level, but when the correct replacement level fertility is shown to actually have been 99 per cent above replacement level. The problems associated with assuming replacement level fertility is always 2.1 are further highlighted in the third column, which shows the gap between a TFR of 2.1 and the actual TFR required for replacement. This shows on a global scale a TFR of 2.1 would actually result in fertility 10 per cent below replacement level. Furthermore, if fertility in the least developed regions fell to 2.1 then fertility would actually be 24 per cent below replacement, since the replacement fertility level for the least developed regions is actually a TFR of 2.75. Where demographic literature talks about fertility in developing countries falling to a replacement level of 2.1 there is an implicit assumption that mortality is at least around developed country levels of the 1960s and 1970s. In particular, with the threat of the HIV/AIDS maintaining or even raising mortality rates, there is the possibility that the level of world replacement fertility will remain well above 2.1. The problem of increased mortality from HIV/AIDS is also compounded by the fact that HIV-positive women have reduced fertility. Studies have shown their fertility rate to be 20 to 30 per cent below those of their uninfected counterparts.[15]

Percentage gap between actual fertility, replacement fertility and a TFR of 2.1, for the world and major regions, 1995–2000

	TFR/2.1	TFR/TFRr	2.1/TFRr
World	34	21	–10
More developed regions	–25	–25	0
Less developed regions	48	31	–11
Least developed regions	161	99	–24
Northern America	–5	–4	1
Europe	–33	–33	0
Oceania	15	11	–4
Latin America/Caribbean	28	24	–3
Africa	25	95	–22
Asia	13	16	–10

Source: Espenshade et al[15]

Table 2 must be interpreted with caution as it does not show how far below replacement level fertility has fallen. However, it demonstrates that cohort fertility falls below replacement fertility for cohorts born around 20-30 years before the point when period fertility falls below replacement level. Of the five EU countries where fertility was last at replacement level in the 1960s, only Germany experienced natural population decline (more deaths occurring than births) in 2003.[20]

Table 2 Last year TFR was 2.1 or above and last birth year cohort fertility was 2.1 or above, 33 European countries

Countries	Year TFR last at 2.1 or more	Last birth cohort year completed fertility was 2.1 or more
(Bold = in European Union)		
Croatia	1966	pre 1944
Sweden	1967	1937
Luxembourg (Grand-Duché)	1968	pre 1935
Finland	1968	1939
Denmark	1968	1944
Germany (including ex-GDR from 1991)	1969	1937
Switzerland	1970	1939
Austria	1971	1940
Belgium	1971	1941
Netherlands	1972	1942
United Kingdom[1]	1972	1949
Norway	1974	1961
Italy	1976	1943
Hungary	1977	pre 1944
Bosnia and Herzegovina	pre 1979	1951
Bulgaria	1979*	1952
Slovenia	1980	pre 1945
Greece	1980	pre 1935
Czech Republic	1980	1951
Spain	1980	1952
Portugal	1981	1951
France	1984	1961
Lithuania	1987	pre 1960
Latvia	1988	pre 1960
Poland	1988	1962
Slovak Republic	1988	1963
Serbia and Montenegro	1988	1966
Estonia	1989	pre 1945
Romania	1989	1961
Ireland	1990	yet to be <2.1
Macedonia, the former Yugoslav Republic of	1993	yet to be <2.1
Cyprus	1995	n/a
Malta	1996	pre 1945
Iceland	1996	yet to be <2.1
Albania	currently 2.1†	n/a

Notes:
* Data for 1980 not available, below 2.1 in 1981
† data to 1999 only
Source Eurostat[18]

THE IMPACT OF BELOW REPLACEMENT FERTILITY

Population ageing

Sustained below replacement fertility has two important demographic effects, population ageing and population decline. Fertility is the principal determinant of age composition; continued low fertility produces a population with relatively few young people and relatively many old people. Improvements in mortality at older ages also lead to population ageing. The potential consequences of population ageing and decline have been widely discussed in demographic literature and population ageing has even been labelled a 'demographic timebomb'. There have been many fears expressed about the consequences of an ageing population. In particular, concerns have been expressed about providing pensions and the shortage of new entrants into the labour force. As a population ages, each person of working age will have to support more aged dependants. Not only could this put a strain on the pension and health systems, but it has also been hypothesised to potentially have many other negative effects on the economy and productivity. Other concerns regarding an ageing population include housing and care. At least some of these concerns may be met by changes in life course patterns, topics which are outside the remit of this article.

Population decline

Below replacement fertility will eventually lead to natural decline (more deaths occurring than births), and therefore in the absence of net in-migration, the population will decline. Of 191 UN countries 43 are projected to have population decrease between 2000 and 2050.[21] However, the effects of migration and mortality are difficult to disentangle. For example, in Western and Northern Europe some of the countries with the lowest fertility in the world are also those that are in the majority attracting international migrants.

The effect of below replacement fertility on the size of the population is quite long term as 'population momentum' can delay the effect. If there are large cohorts in their childbearing years, even if fertility declines, the number of births may still remain high or even increase. In many parts of the world, age structures are still adjusting to the relatively new low fertility levels and in most cases will not fully adjust for decades.[22] So fertility that is only a little below replacement has a small effect on the population size or age structure in the short run, but in the long run has a cumulative, multiplicative effect.[23] The Government Actuary's Department (GAD) has projected that the UK population will only start to decline from around 2050, despite fertility being assumed to continue being below replacment.[7] Population decline is associated with many of the same economic, productivity and social concerns as population ageing.

Concerns about below replacement fertility and consequent population decline were experienced in the 1930s, when Western societies were experiencing unprecedented low fertility.[24] However, nowadays there are some who are not convinced that low or negative levels of population growth are harmful.[22] Some argue that low or negative population growth is beneficial as it would help protect the environment and ensure long-term environment and resource sustainability. Others would argue that while the world population as a whole continues to grow it would be inappropriate to argue for higher fertility.[22]

Will below replacement fertility continue?

When fertility started to decline in European countries it was initially assumed that below replacement fertility would be transitory and limited, and that there would be a return to replacement level fertility (or above). This was reflected in population projections, which Westhoff[25] said showed a 'a magnetic force' toward replacement level fertility. This was in part recognition of the unavoidable necessity of two children per women, on average, in very long-term projections to avoid eventual population extinction. It was only as recently as their 1998-based projections that UN population projections no longer assume a return to replacement level fertility in the long-term in Europe.[26] It is now believed by many demographers that below replacement fertility is likely to be a sustained and widespread experience. Cliquet stated in 1991 that 'given present cultural and economic conditions, fertility will remain considerably below replacement level, and that, granted, that cultural and economic conditions don't change fundamentally, a spontaneous reversal is very improbable.'[2] . Although low fertility on a period basis may be partly a transient phenomenon as it may not be a true indication of fertility on a cohort basis, where women are postponing births to later ages.[27] In England and Wales the trend in cohort fertility has been gradually downward, with the 1958 cohort being the first to have a completed family size of less than two children per woman (1.99).

However, Vishnevsky has proposed an alternative scenario, in which below replacement fertility is an aberration. He hypothesises that fertility levels are the result of 'homeostatic demographic systems' that aim at their own inherent goals of self-maintenance and survival. Therefore, below replacement level fertility in his theory is an 'overshoot' of demographic systems readjusting themselves to lower mortality, and inevitably will be reversed in the future.[28] Although this hypothesis is not specific enough to be tested empirically, it remains very influential partly because fertility intention surveys consistently show the two-child family is still a strong normative goal.[23] However, recently there was a Eurobarometer survey which suggested that the average ideal family size in Germany had fallen to well below two.[29] Easterlin also proposed, in his cyclical theory of fertility rates, that below replacement fertility is a temporary experience.[30]

How low can fertility go?

Most research regarding fertility assumes that a certain level of fertility will occur, however, sustained very low fertility has caused demographers to look at this assumption. Researchers have started to look at: why people have children; if the reasons for having children can be fulfilled with just one child; and, if there are biosocial mechanisms that underlie fertility and mean that there is a level below which fertility will not fall.[31] These concerns led Coleman to state that 'the really fundamental problem is not the level of fertility and trends over time but the basic question of whether we will have any children at all, and if we do whether there is any imaginable reason why the average should be two.'[32]

As mentioned previously, studies have shown that men and women desire two children,[33] however this is not reflected in actual fertility levels. This gap between fertility desires and achieved fertility shows there may be the possibility of increases in fertility or at least lend support to some of the recent reductions in fertility being the result of postponement. There is also discussion across Europe about whether governments should introduce policies to try and increase fertility, and, if so, what, if anything would work. The approach of the UK is summed up in part of the statement on population policy presented to the UN Conference on Population in Mexico in 1984 and Population and Development in Cairo in 1994.[34]

'… The prevailing view is that decisions about fertility and childbearing are for people themselves to make, but that it is proper for government to provide individuals with the information and the means necessary to make their decisions effective…'

Below replacement fertility is also linked to postponement of fertility. Postponement has become one of the most prominent features of fertility patterns in developed countries. Most countries in Europe have experienced significant increases in the mean age at first birth.[35] Mean age may also rise as childlessness increases, which has been happening in England and Wales. It is hard to distinguish between voluntary and involuntary childlessness, but it is likely that a proportion of the increase in childless, and smaller completed family size, is due to postponement of births to such an age where women find it more difficult to achieve their fertility desires.[36] Many factors have been posited as to why postponement of fertility is occurring. Sobotka sums these up by saying 'the shift towards late timing of parenthood is an outcome of fundamental social, economic and cultural transformation, which altered the norms related to parenthood as well as the nature of decision-making of the timing of childbearing'.[37]

Conclusion

The common number used by demographers to define replacement fertility level is 2.1 children per woman. The analyses in this article demonstrate that while the traditional concept of replacement fertility is useful we need to be careful in taking replacement fertility of 2.1 as a constant figure in all places and for all time. Replacement fertility provides a useful concept for thinking about population dynamics since, eventually, below replacement fertility is likely to lead to a decline in population size. However, this decline may be delayed long into the future by: the current population structure; improvements in mortality; and, inward migration. Furthermore below replacement fertility contributes to the ageing of the population.

In the developed world the concern is about fertility rates being below replacement level. Lutz[38] recently described Europe's population as being at a turning point in history, as below replacement fertility had operated for such a time that natural decrease in the population was about to occur. He also concluded that postponement of births may contribute to population decline, a finding confirmed in this article.

However, the interaction of fertility, mortality and migration means that replacement fertility does not necessarily maintain a constant population size. Thus taking replacement fertility as some kind of target or ideal level of fertility in the short term is misplaced. Nevertheless it is clear that the further fertility falls below replacement the greater likelihood of more rapid population decline and population ageing. Countries with severe and sustained reductions of fertility to 'lowest low' levels, such as the Mediterranean and former Eastern Bloc countries may have cause for concern, even if their current low period fertility rates may in part be the result of postponement of fertility. Even then, whether the population declines will depend on whether population momentum, mortality improvements and migration outweigh the effect of below replacement fertility.

Fertility levels in England and Wales are such that, even in the absence of future inward migration and having already experienced below replacement fertility for 30 years, the population will not dramatically rise or fall over the next 30 years. Very long-term below replacement fertility affecting many generations would however lead to a more rapid population decline later in the century. Population ageing is inevitable unless fertility rises substantially, with consequential increases in population size. Increases in fertility would have some effect on the pace and overall level of ageing, but the population will still age. Therefore we should not be overly obsessed in this country, in terms of population size, by fertility being below replacement level and births being delayed. Higher fertility would delay population ageing and increase population growth.

Key findings

- Replacement fertility is not a fixed level. It has varied through time and differs between countries. In particular, as traditionally defined, it has declined in developed countries, and is continuing to decline in developing countries, because of improving mortality.
- Based on 2003 fertility and mortality rates the replacement fertility rate in England and Wales is 2.07 children per woman.
- Using period fertility rates, fertility in England and Wales has been below replacement level since 1973.
- Using the 'traditional' definition of cohort replacement, the 1950 cohort was the first cohort in England and Wales not to replace itself since the major reductions in infant and child mortality. Cohort born in the 1920s also had fertility below replacement level.
- Cohort replacement fertility in the 20th century was higher than 2.1 until the 1950 cohort, but if mortality improvements for the children born are taken into account then replacement level has been around 2.1 for all cohorts born since 1920.

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