UNITED NATIONS NATIONS UNIES

POPULATION DIVISION
Department of Economic and Social Affairs

ASSUMPTIONS UNDERLYING THE *2010 REVISION*

The preparation of each new revision of the official population estimates and projections of the United Nations involves two distinct processes: (a) the incorporation of all new and relevant information regarding the past demographic dynamics of the population of each country or area of the world; and (b) the formulation of detailed assumptions about the future paths of fertility, mortality and international migration. The data sources used and the methods applied in revising past estimates of demographic indicators (i.e., those referring to 1950-2010) are presented online[1] and in an Excel file (WPP2010_F02_METAINFO.XLS).
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The future population of each country is projected starting with an estimated population for 1 July 2010. Because population data are not necessarily available for that date, the 2010 estimate is derived from the most recent population data available for each country, obtained usually from a population census or a population register, projected to 2010 using all available data on fertility, mortality and international migration trends between the reference date of the population data available and 1 July 2010. In cases where data on the components of population change relative to the past 5 or 10 years are not available, estimated demographic trends are projections based on the most recent available data. Population data from all sources are evaluated for completeness, accuracy and consistency, and adjusted as necessary.

To project the population until 2100, the United Nations Population Division uses assumptions regarding future trends in fertility, mortality and international migration. Because future trends cannot be known with certainty, a number of projection variants are produced. The following paragraphs summarize the main assumptions underlying the derivation of demographic indicators for the period starting in 2010 and ending in 2100.

FERTILITY ASSUMPTIONS: CONVERGENCE TOWARD TOTAL FERTILITY AROUND REPLACEMENT LEVEL

The fertility assumptions are described in terms of the following groups of countries:

- *High-fertility countries*: Countries that until 2010 had no fertility reduction or only an incipient decline;

- *Medium-fertility countries*: Countries where fertility has been declining but whose estimated level was still above 2.1 children per woman in 2005-2010;

[1] Data sources and related meta-information for the *2010 Revision* of the *World Population Prospects* are available for each country from the following web page: http://esa.un.org/unpd/wpp/Documentation/data-sources.htm

- *Low-fertility countries*: Countries with total fertility at or below 2.1 children per woman in 2005-2010.

1. Medium-fertility assumption

In the *2010 Revision* of the *World Population Prospects* a new, probabilistic method for projecting total fertility has been used. This new method was developed in collaboration with the Probabilistic Projections Group of the Center for Statistics and the Social Sciences (CSSS) of the University of Washington[2]. The method is based on empirical fertility trends estimated for all countries of the world for the period 1950 to 2010[3].

There has been a general consensus that the evolution of fertility includes three broad phases (see Figure 1): (i) a high-fertility pre-transition phase, (ii) the fertility transition itself and (iii) a low-fertility post-transition phase during which fertility will probably fluctuate around and remain close to replacement level (or converge towards it). These historic trends of fertility decline are re-estimated every second year by the United Nations Population Division, using the most recent empirical evidence from censuses, surveys, registers and other sources and after extensive re-evaluation of past historical trends in the light of all the information available and internal consistency checks with intercensal cohorts.

In past revisions of the World Population Prospects it was assumed that countries in the transition from high to low fertility will ultimately approach a fertility floor of 1.85 children per woman, regardless of their current position in the fertility transition. The transition from the current level of fertility to the fertility floor was expressed by three models of fertility change over time. These fertility projection models have been formalized since the *2004 Revision* using a double-logistic function, defined by six deterministic parameters[4]. For countries that were below replacement level, a much simpler model of fertility change was used. In general, it was assumed that fertility would recover from very low levels of fertility, following a uniform pace that would also converge to the fertility floor of 1.85 children per woman, just as in the high and medium fertility countries.

The new probabilistic method that was used in the *2010 Revision* for projecting total fertility consists of two separate processes:

The first process models the sequence of change from high to low fertility (phase II of the fertility transition). For countries that are going through this fertility transition, the pace of the fertility decline is decomposed into a systematic decline and random distortion terms. The pace of the systematic decline in total fertility is modelled as a function of its level, based on the current UN methodology using a double-logistic decline function. The parameters of the double-logistic function are estimated using a Bayesian Hierarchical Model (BHM), which results in country-specific *distributions* for the parameters of the decline. These distributions are informed by

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[2] Alkema L, Raftery AE, Gerland P, Clark SJ, Pelletier F, Buettner T (2010). "Probabilistic Projections of the Total Fertility Rate for All Countries." *Working Paper of the Center for Statistics and the Social Sciences*, University of Washington, 97. URL http://www.csss.washington.edu/Papers/wp97.pdf

[3] The initial version of this new approach was developed and tested using data from the 2008 revision, and the results were presented to a panel of experts during an Expert Group Meeting on Recent and Future Trends in Fertility: United Nations, Department of Economic and Social Affairs, Population Division (2009). *Expert Group Meeting on Recent and Future Trends in Fertility*. New York, 2-4 December 2009. http://www.un.org/esa/population/meetings/EGM-Fertility2009/egm-fertility2009.html

[4] United Nations, Department of Economic and Social Affairs, Population Division (2006). World Population Prospects. The 2004 Revision, Vol. III, Chapter VI. Methodology of the United Nations population estimates and projections, pp. 100-104. http://www.un.org/esa/population/publications/WPP2004/WPP2004 Volume3.htm

historical trends within the country, as well as the variability in historical fertility trends of all countries that have already experienced a fertility decline. This approach not only allows to better take into account the historical experience of each country, but also to reflect the uncertainty about future fertility decline based the past experience of all other countries at similar level of fertility. Under these conditions, the pace of decline and the limit up to which fertility will decline vary for each projected trajectory. The model is hierarchical because in addition to the information available at the country level, a second-level (i.e., the world's experience through the information of all the countries) is used to inform the statistical distributions of the parameters of the double-logistic. Especially for countries at the beginning of their fertility transition, limited information exists as to their speed of decline and future trajectories, so the future potential trajectories (and speed of decline) are mostly informed by the world's experience and the variability in trends experienced in other countries at similar fertility levels in the past. The Bayesian statistical approach itself is particularly adapted to estimate the parameters of the double-logistic model even when the number of empirical observations for each country is very limited (i.e., about 100 countries started their fertility transition since the 1960s and have nine or fewer observations).

The second component of the projection model deals with countries once they have completed the demographic transition, and reached Phase III and potentially sub-replacement fertility. A time series model is used for projecting fertility, assuming that in the long term the total fertility will approach and fluctuate around the replacement-level of 2.1. The time series model uses the empirical information from countries that have had documented fertility increases from a sub-replacement level after a completed fertility transition. The assumption that fertility will converge toward and fluctuate around replacement-level fertility in the long run is driven by the extension of the projection horizon from 2050 to 2100 between the *2008 and 2010 Revisions*, and the underlying assumption of a population stabilization within 3-4 generations. The long term assumption of a fertility recovery is supported by the experience of many below-replacement fertility countries in Europe and East Asia[5].

The two processes are schematically explained in Figure 1. During the observation period, the start of Phase II is determined by examining the maximum total fertility (or more precisely, the most recent local maximum within half a child of the global maximum to exclude random fluctuations in Phase I): the start of Phase II is deemed to be before 1950 for countries where this maximum is less than 5.5, and at the period of the local maximum for all other countries. The end of Phase II during the observation period is defined as the midpoint of the first two increases below 2 (if observed, else a country is still in Phase II).

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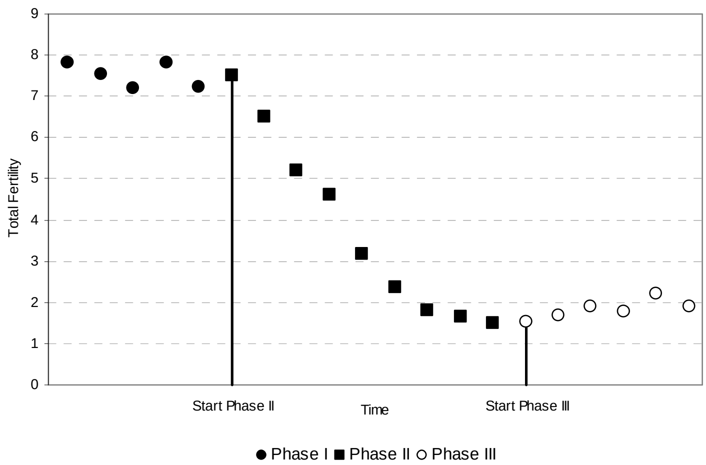
[5] Goldstein, J.R., T. Sobotka, and A. Jasilioniene. 2009. The End of "Lowest-Low" Fertility ? *Population and Development Review* 35(4):663-699. DOI: 10.1111/j.1728-4457.2009.00304.x
Caltabiano, M., M. Castiglioni, and A. Rossina. (2009). Lowest-low fertility: Signs of a recovery in Italy? *Demographic Research*. 21, 681–718. DOI: 10.4054/DemRes.2009.21.23
Myrskyla, M., H.- P. Kohler, and F. C. Billari. (2009). Advances in development reverse fertility declines. *Nature* 460, 741–743. DOI: 10.1038/nature08230
Sobotka, T. 2011. Fertility in Central and Eastern Europe after 1989: Collapse and Gradual Recovery. *Historical Social Research-Historische Sozialforschung* 36(2):246-296.

Figure 1: **Schematic phases of the fertility transition**



Phase I: Fertility is high and the fertility transition has not yet started. **Not modeled.**

Phase II. Fertility transition, **modelled by double-logistic function using a Bayesian Hierarchical Model (BHM)**.

Phase III. Sub-replacement recovery, **modelled with a first order auto-regressive time series model (AR(1)).**

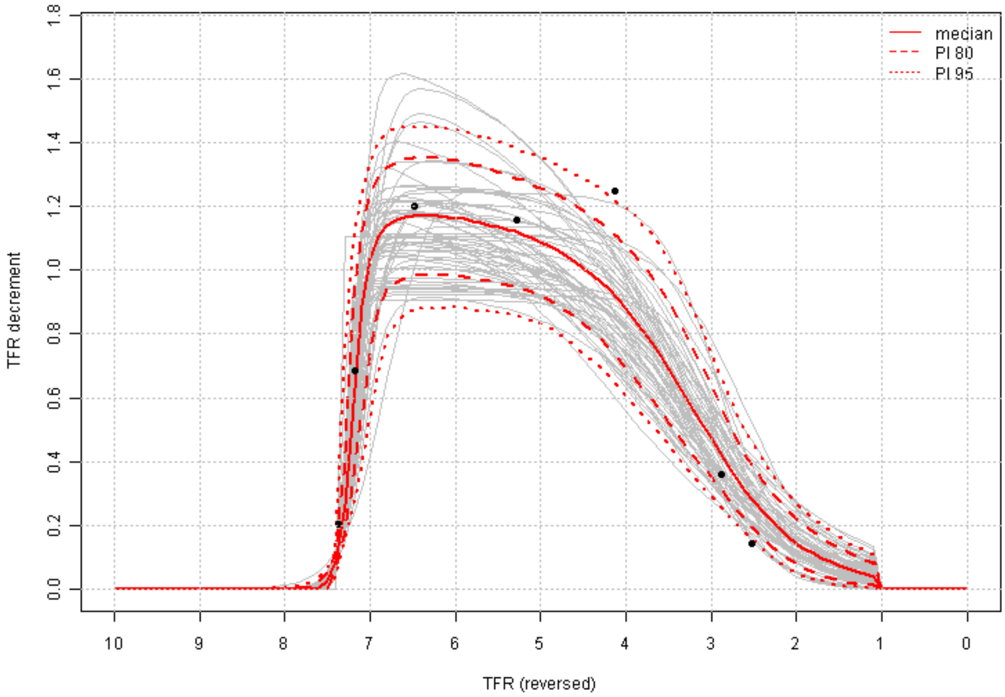
Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2011). World Population Prospects: *The 2010 Revision*. New York: United Nations

To construct projections for all countries still in Phase II, the BHM model is used to generate 100,000 double-logistic curves for all countries that have experienced a fertility decline (see example in figure 2), representing the uncertainty in the double-logistic decline function of those countries (graphs of this double-logistic curve are available online[6]). The sample of double-logistic curves is then used to calculate 100,000 total fertility projections for all countries which have not reached Phase III in 2005-2010. For each trajectory, at any given time, the double-logistic function gives the expected decrement in total fertility based on its current level. A distortion term is added to the expected decrement to calculate the projected change in total fertility. (This distortion term represents the deviations of fertility decrements from the double-logistic curve, as observed in past declines.)

Once a trajectory has decreased to a level that is around or below replacement-level fertility, and after the pace of the fertility decline has decreased to zero reached, future changes of fertility are calculated using a time series model of fertility recovery that is informed by the countries that have experienced fertility increases.

[6] United Nations, Department of Economic and Social Affairs, Population Division (2011): *World Population Prospects: The 2010 Revision*. New York. Online plots of total fertility decline curves (based on Double-Logistic function) from the Bayesian Hierarchical Model (BHM): median, 80% and 95% projection intervals: http://esa.un.org/unpd/wpp/fertility_figures/interactive-figures_DL-functions.htm

Figure 2: Total fertility decrements and projection intervals of double-logistic curves for Algeria (systematic decline part)



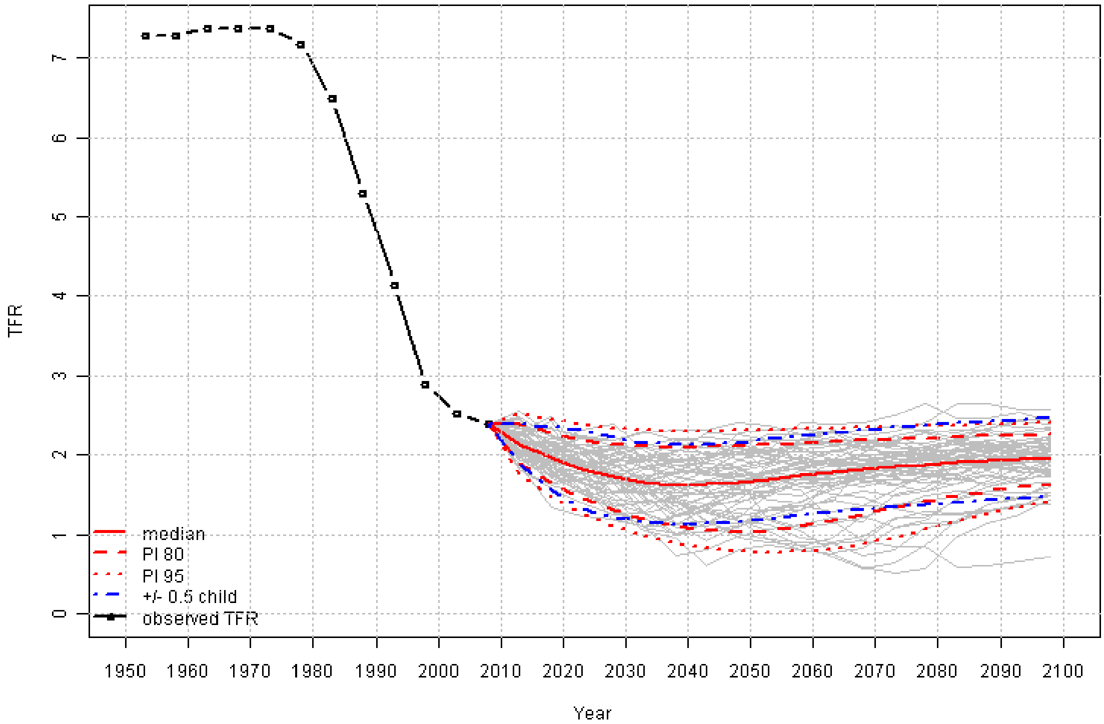
NOTE: The observed five-year decrements by level of total fertility are shown by black dots. For clarity, only 80 trajectories from 100,000 are displayed. The median projection is the solid bold red line, and the 80% and 95% projection intervals are displayed as dashed and dotted red lines respectively.

An additional innovation in the *2010 revision* of the *World Population Prospects* is the removal of the 1.85 floor used in previous revisions as stabilization level after the fertility transition; the total fertility is now allowed to decrease *below* replacement level (i.e., 2.1 children per woman) in the projections because of the uncertainty up to which level fertility will decline (end of Phase II) before it starts to recover toward replacement level (start of Phase III). The pace of the fertility change, the level and timing when Phase II stops and Phase III starts vary for each of the 100,000 projected trajectories for a country that has not reached Phase III in 2005-2010: Its future trajectories are a combination of total fertility in Phase II and Phase III until Phase III has started in all trajectories. For countries that are already in Phase III, the time series model for that phase is used directly.

For each country, the end result is 100,000 projected country trajectories. The median of these 100,000 trajectories is used as the medium fertility variant projection in the World Population Prospects. To evaluate future trends in fertility, 80% and 95% projection intervals are also calculated (see figure 3 for Algeria, additional graphs are available online for all countries[7]). For countries which have not reached Phase III in 2005-2010, the projected median trajectory reflects the uncertainty as to when the fertility transition will end and at which level.

[7] United Nations, Department of Economic and Social Affairs, Population Division (2011): *World Population Prospects: The 2010 Revision*. New York. Online plots of projections of total fertility: median, 80% and 95% projection intervals, high and low WPP fertility variants: http://esa.un.org/unpd/wpp/fertility_figures/interactive-figures_TF-trajectories.htm

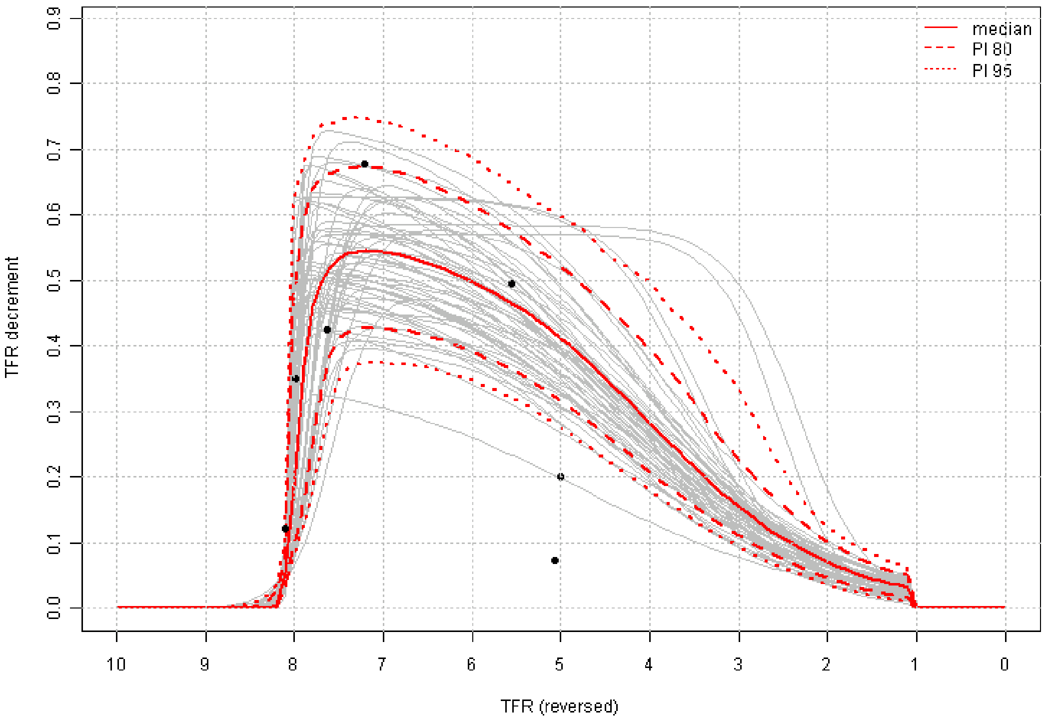
Figure 3: Probabilistic trajectories of projected total fertility (2010-2100) for Algeria



NOTE: For clarity, only 80 trajectories from 100,000 are displayed. The median projection is the solid bold red line, and the 80% and 95% projection intervals are displayed as dashed and dotted red lines respectively. The high-low fertility variants in the *2010 Revision* correspond to +/- 0.5 child around the median trajectory displayed as blue dashed lines.

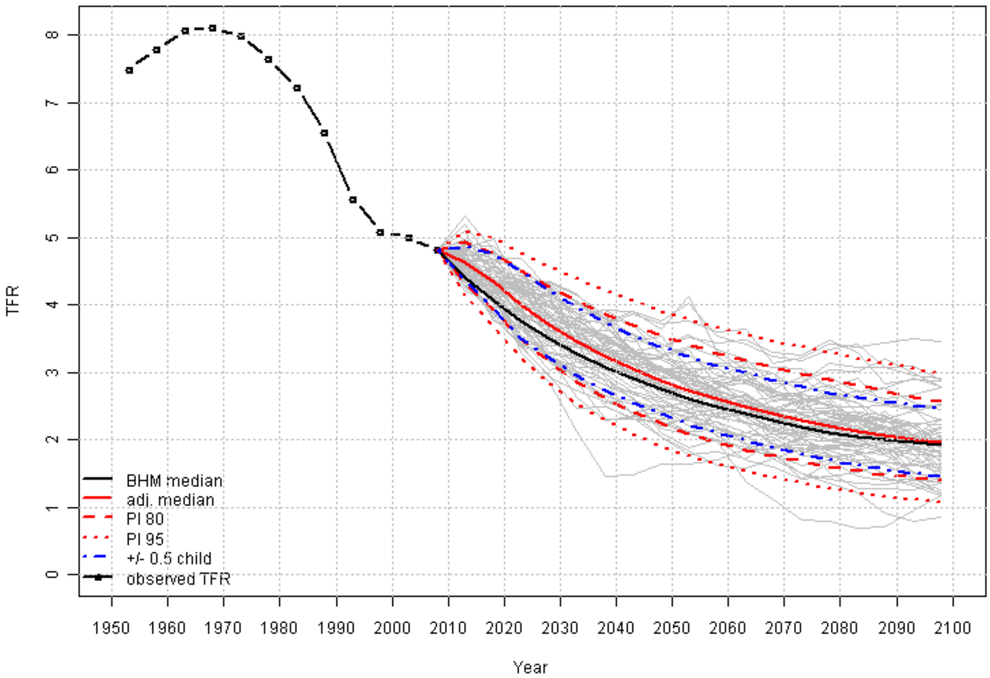
For a small set of countries which are still at the very early stage of their fertility transition (e.g., Burkina Faso, Congo, Equatorial Guinea, Guinea-Bissau, Mali, Mayotte, Niger, Nigeria, Rwanda, United Republic of Tanzania, Yemen) or have experienced recent fertility stalling (e.g., Israel, Kenya, Malawi, Somalia, Zambia), some post-adjustment was performed to preserve a smoother continuity with the recent trend in the past decade. In these countries, fertility decline has been much slower than typically experienced in the past decades by other countries at similar levels of fertility. As seen in Figure 4 for Kenya, fertility decline has been stalling at around 5 children per woman for the past decade: the observed decline between 2000-2010 was much smaller than in previous periods ($\leq$ 0.2 child per woman by 5-year period), especially compared to other countries at similar level of fertility in the past. In such cases, the double-logistic model does not fit well the recent observations, and the projections are adjusted using the difference between the observed and expected decrement in the last period. Specifically, in the first and second projection periods, a decreasing proportion of this difference is added to the expected decrement, such that the adjusted expected decrement in those periods takes into account the difference between the double-logistic and observed decrement in the last observation period. Figure 5 shows the unadjusted and adjusted projection of total fertility for Kenya.

Figure 4: Total fertility decrements and projection intervals of double-logistic curves for Kenya



NOTE: The black dots represent the observed decrements, which are much smaller than the double-logistic-decrements in the last two observation periods because of a stall in the fertility decline. For clarity, only 80 trajectories from 100,000 are displayed.

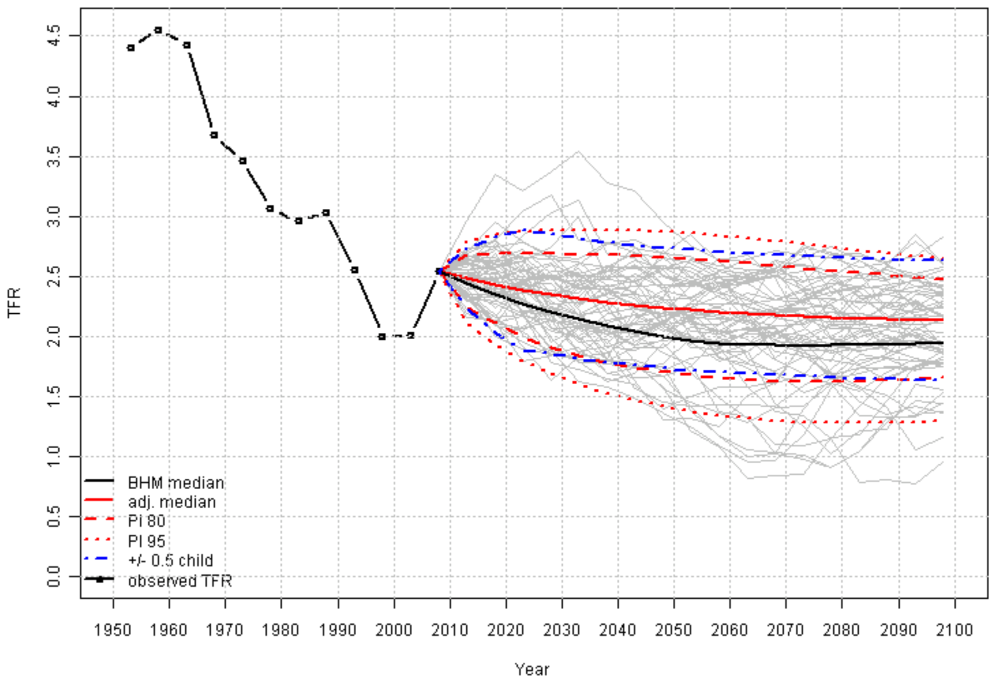
Figure 5: Probabilistic trajectories of projected total fertility (2010-2100) for Kenya (adjusted)



NOTE: For clarity, only 80 trajectories from 100,000 are displayed.

In addition, for seven countries with fertility already around replacement levels (i.e., 2.1 children per woman) which have experienced recent up-surge of fertility since mid-2000 (e.g., Australia, Azerbaijan, Kazakhstan, Kyrgyzstan, Iceland, Mongolia, New Zealand), only the phase III model was applied to insure consistency with the historical and regional context, and demographic trends of these countries. Figure 6 shows for Kazakhstan the adjusted median projection compared to the unadjusted one which is a combination of trajectories based on Phases II and III (and assume greater uncertainty as to the completion of the fertility transition).

Figure 6: Probabilistic trajectories of projected total fertility (2010-2100) for Kazakhstan (adjusted)



NOTE: For clarity, only 80 trajectories from 100,000 are displayed.

The results of this new modelling approach are country-specific projections of total fertility that are fully reproducible and take into account past empirical trends. Extensive documentation for all countries and areas has been posted online[8], and further details about the methodology are available from Alkema et al. (2010, 2011)[9]. In addition, an open-source and portable software implementation of the new UN approach to project total fertility, based on the R statistical language, developed by Sevcikova et al.[10] is available as a fully documented R package (bayesTFR[11]) through the public R CRAN archive together with a user-friendly Graphical User

[8] United Nations, Department of Economic and Social Affairs, Population Division (2011): *World Population Prospects: The 2010 Revision*. New York. Online plots of projections of total fertility: median, 80% and 95% projection intervals, high and low WPP fertility variants: http://esa.un.org/unpd/wpp/fertility_figures/interactive-figures_TF-trajectories.htm

[9] Alkema L, Raftery AE, Gerland P, Clark SJ, Pelletier F, Buettner T , Heilig G (2011). "Probabilistic Projections of the Total Fertility Rate for All Countries." To appear in *Demography* in August 2011. DOI: 10.1007/s13524-011-0040-5

[10] Sevckova H, Alkema L, Raftery AE (2011). "bayesTFR: An R package for Probabilistic Projections of the Total Fertility Rate". *Working Paper of the Center for Statistics and the Social Sciences, University of Washington, 111. April 2011. URL http://www.csss.washington.edu/Papers/wp111.pdf*

[11] Sevcikova H., Alkema L, Raftery AE (2011). “bayesTFR: Bayesian Fertility Projection”. R Package and documentation: http://cran.r-project.org/web/packages/bayesTFR/index.html

Interface (bayesDem[12]). Version 1.3-0 of the package was used to compute the final set of projections used for the *2010 Revision* of the *World Population Prospects*[13].

2. High-fertility assumption

Under the high variant, fertility is projected to remain 0.5 children above the fertility in the medium variant over most of the projection period. By 2020-2025, fertility in the high variant is therefore half a child higher than that of the medium variant. That is, countries reaching a total fertility of 2.1 children per woman in the medium variant have a total fertility of 2.6 children per woman in the high variant.

3. Low-fertility assumption

Under the low variant, fertility is projected to remain 0.5 children below the fertility in the medium variant over most of the projection period. By 2020-2025, fertility in the low variant is therefore half a child lower than that of the medium variant. That is, countries reaching a total fertility of 2.1 children per woman in the medium variant have a total fertility of 1.6 children per woman in the low variant.

4. Constant-fertility assumption

For each country, fertility remains constant at the level estimated for 2005-2010.

5. Instant-replacement assumption

For each country, fertility is set to the level necessary to ensure a net reproduction rate of 1 starting in 2010-2015. Fertility varies over the rest of the projection period in such a way that the net reproduction rate always remains equal to unity thus ensuring, over the long-run, the replacement of the population.

B. MORTALITY ASSUMPTIONS: INCREASING LIFE EXPECTANCY EXCEPT WHEN AFFECTED BY HIV/AIDS

1. Normal-mortality assumption

Mortality is projected on the basis of models of change of life expectancy produced by the United Nations Population Division. These models produce smaller gains the higher the life expectancy already reached. The selection of a model for each country is based on recent trends in life expectancy by sex. For countries highly affected by the HIV/AIDS epidemic, the model

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[12] Sevcikova H. (2011). "bayesDem: Graphical User Interface for bayesTFR and bayesLife". R Package and documentation: http://cran.r-project.org/web/packages/bayesDem/index.html

[13] The estimates of the double logistic parameters are based on three parallel chains of 62,000 iterations discarding the first 2,000 of each chain to yield a total of 180,000 samples of all model parameters. For each country, 100,000 trajectories were projected, and used to derive the median and other projection intervals. The AR(1) parameters used for the Phase III were estimated using maximum-likelihood estimation based on 55 empirical observations of countries having already experienced Phase III. Total computation time was about 7 days on a 32-bit Windows server. The seed of the random number generator for the Markov Chain Monte Carlo estimation used was: 20110206.

incorporating a slow pace of mortality decline has generally been used to project a certain slowdown in the reduction of general mortality risks not related to HIV/AIDS.

2. The impact of HIV/AIDS on mortality

In the *2010 Revision*, countries where HIV prevalence among persons aged 15–49 was ever equal to or greater than two percent during 1980–2009, and/or the maximum effect of HIV/AIDS on life expectancy at birth was estimated to be greater or equal to two years are considered as affected by the HIV/AIDS epidemic and their mortality is projected by modelling explicitly the course of the epidemic and projecting the yearly incidence of HIV infection. Also considered among the affected countries are those where HIV prevalence is lower than one per cent but whose population is so large that the number of people living with HIV in 2009 is more than 700,000 (i.e., China, India, Russian Federation, United States). In total, 48 countries are considered to be most affected by the HIV/AIDS epidemic in the *2010 Revision*.

The model developed by the UNAIDS Reference Group on Estimates, Modelling and Projections[14,15,16] is used to fit past estimates of HIV prevalence provided by UNAIDS for each of the affected countries so as to derive the parameters determining the past dynamics of the epidemic in each of them. For most countries, the model is fitted assuming that the relevant parameters have remained constant in the past. Beginning in 2009, the parameter PHI, which reflects the rate of recruitment of new individuals into the high-risk or susceptible group, is projected to decline by half every twenty years. The parameter R, which represents the force of infection, is projected to decline by half every thirty years. The reduction in R reflects the assumption that changes in behaviour among those subject to the risk of infection, along with increases in access to treatment for those infected, will reduce the chances of HIV transmission.

In the *2010 Revision,* interventions to prevent the mother-to-child transmission of HIV are modelled on the basis of estimated country-specific coverage levels that, in 2009, averaged 51 per cent among the 48 affected countries, but varied from 6 to 100 per cent among them (with 10 countries having less than 20 per cent coverage of pregnant women in 2009, and 14 countries with more than 75 per cent coverage). These coverage levels are projected to reach 74 per cent on average by 2015, varying between 40 per cent and 95 per cent among the affected countries.[17] After 2015, the coverage of interventions to prevent mother-to-child transmission of HIV is assumed to remain constant until 2100 at the level reached in each of the affected countries in 2015. Among women receiving treatment, the probability of transmission from mother to child is assumed to vary between 2 per cent and 20 per cent depending on the particular combination of breastfeeding practices (mixed breastfeeding, replacement feeding, exclusive breastfeeding), its duration in the population and the type of treatment available (single-dose nevirapine, dual ARV

[14] Ghys P.D., Garnett G.P. (2010). The 2009 HIV and AIDS estimates and projections: methods, tools and analyses. *Sexually Transmitted Infections.* October 2010, Volume 86, Supplement 2, pp. ii1-ii2; doi: 10.1136/sti.2010.047852 - http://sti.bmj.com/content/86/Suppl_2.
[15] Brown T., Bao L., Raftery A. E., Salomon J. A., Baggaley R. F., Stover J., Gerland P. (2010). Modelling HIV epidemics in the antiretroviral era: the UNAIDS Estimation and Projection package 2009. *Sexually Transmitted Infections.* October 2010, Volume 86, Supplement 2, pp. ii3-ii10; doi: 10.1136/sti.2010.044784 - http://sti.bmj.com/content/86/Suppl_2.
[16] Stover J., Johnson P., Hallett T., Marston M., Becquet R., Timaeus I. M. (2010). The Spectrum projection package: improvements in estimating incidence by age and sex, mother-to-child transmission, HIV progression in children and double orphans. *Sexually Transmitted Infections.* October 2010, Volume 86, Supplement 2, pp. ii16-ii21; doi: 10.1136/sti.2010.044222 - http://sti.bmj.com/content/86/Suppl_2
[17] UNAIDS (2010). *Children and AIDS - Fifth Stocktaking Report, 2010.* Nov. 2010. http://www.unicef.org/publications/index_57005.html.

prophylaxis, triple ARV prophylaxis or treatment). These assumptions produce a reduction in the incidence of HIV infection among children born to HIV-positive women, but the size of the reductions varies from country to country depending on the level of coverage that treatment reaches in each country.

The survivorship of infected children[16] takes account of varying access to paediatric treatment.[11] In the *2010 Revision*, HIV-infected children are divided into two groups: (*i*) those infected in-utero, among whom the disease progresses rapidly and whose median survival is set at 1.1 years, and (*ii*) those infected through breastfeeding after birth, among whom the disease progresses slowly and whose average survival is set at 9.4 years without treatment[16]. Explicit inclusion of paediatric treatment is done via country-specific coverage levels which average 33 per cent in 2009 but vary between 0 and 99 per cent among the 48 affected countries (with 8 countries having less than 10 per cent coverage in 2009 and only 7 countries having a coverage level above 75 per cent)[17]. By 2015, the projected coverage is expected to reach 58 per cent on average in the 48 affected countries, varying from 40 per cent to 99 per cent. Coverage levels are assumed to remain constant from 2015 to 2100 at the level reached in each country by 2015. The annual survival of children receiving treatment is 85 per cent during the first year and 93 per cent for subsequent years.[18]

The *2010 Revision* incorporates a revised survival for persons receiving treatment with highly active antiretroviral therapy (ART).[16,18] The proportion of the HIV-positive population receiving treatment in each country is consistent with estimates prepared by the World Health Organization[19] and UNAIDS which averaged 64 per cent in 2009 among the 48 affected countries, but varied between 24 per cent and 100 per cent. Coverage is projected to reach between 40 per cent and 99 per cent by 2015, averaging 84 per cent for the affected countries. Between 2015 and 2050, coverage levels are assumed to remain constant at the level reached in each country by 2015. It is assumed that adults receiving treatment have, on average, an 86 per cent chance of surviving on the first year of treatment, and a 90 per cent chance of surviving each year thereafter in the absence of other causes of death. Under this assumption, mean survival time after the initiation of therapy is 9.1 years and the median survival time is 5.6 years, in the absence of other causes of death. Therapy is assumed to start at the time full-blown AIDS develops. Without treatment, infected adults have a mean survival time of 2.6 years (and a median survival time of 2.1 years) after the onset of full-blown AIDS. [16,18]

3. Constant-mortality assumption

Under this assumption, mortality over the projection period is maintained constant for each country at the level estimated for 2005-2010.

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[18] Mahy M., Lewden C., Brinkhof, M. W. G, Dabis F., Tassie J.-M., Souteyrand Y., (2010). Derivation of parameters used in Spectrum for eligibility for antiretroviral therapy and survival on antiretroviral therapy. *Sexually Transmitted Infections.* October 2010, Volume 86, Supplement 2, pp. ii28-ii34; doi:10.1136/sti.2010.044255 - http://sti.bmj.com/content/86/Suppl_2.

[19] WHO/UNAIDS/UNICEF. *Towards universal access: scaling up priority HIV/AIDS interventions in the health sector, progress report 2010*. Geneva, WHO, 2010. http://www.who.int/hiv/en/.

C. INTERNATIONAL MIGRATION ASSUMPTIONS

1. Normal migration assumption

Under the normal migration assumption, the future path of international migration is set on the basis of past international migration estimates and consideration of the policy stance of each country with regard to future international migration flows. Projected levels of net migration are generally kept constant over the next decades. After 2050, it is assumed that net migration will gradually decline.

2. Zero-migration assumption

Under this assumption, for each country, international migration is set to zero starting in 2010-2015.

D. EIGHT PROJECTION VARIANTS

The *2010 Revision* includes eight different projection variants (table 1). Five of those variants differ among themselves only with respect to the level of fertility in each, that is, they share the assumptions made with respect to mortality and international migration. The five fertility variants are: low, medium, high, constant-fertility and instant-replacement fertility. A comparison of their results allows an assessment of the effects that different fertility paths have on other demographic parameters.

In addition to the five fertility variants, a constant-mortality variant, a zero-migration variant and a constant variant have been prepared. The constant-mortality variant and the zero-migration variant both have the same fertility assumption (i.e., medium fertility). Furthermore, the constant-mortality variant has the same international migration assumption as the medium variant. Consequently, the results of the constant-mortality variant can be compared with those of the medium variant to assess the effect that changing mortality has on other demographic parameters. Similarly, the zero-migration variant differs from the medium variant only with respect to the underlying assumption regarding international migration. Therefore, the zero-migration variant allows an assessment of the effect that non-zero net migration has on other demographic parameters. Lastly, the constant variant has the same international migration as the medium variant but differs from the latter by having constant fertility and mortality. When compared to the medium variant, therefore, its results shed light on the effects that changing fertility and mortality have on the results obtained.

TABLE 1. PROJECTION VARIANTS IN TERMS OF ASSUMPTIONS FOR FERTILITY, MORTALITY AND INTERNATIONAL MIGRATION

	Assumptions		
Projection variant	*Fertility*	*Mortality*	*International migration*
Low fertility	Low	Normal	Normal
Medium fertility	Medium	Normal	Normal
High fertility	High	Normal	Normal
Constant-fertility	Constant as of 2005-2010	Normal	Normal
Instant-replacement-fertility	Instant-replacement as of 2010-2015	Normal	Normal
Constant-mortality	Medium	Constant as of 2005-2010	Normal
No change	Constant as of 2005-2010	Constant as of 2005-2010	Normal
Zero-migration	Medium	Normal	Zero as of 2010-2015

E. METHODOLOGICAL CHANGES INTRODUCED IN THE 2010 REVISION

The following changes and adjustments were made in the *2010 Revision* in relation to procedures followed in the *2008 Revision.*

- The *2010 Revision* uses a new stochastic model for fertility projection as described above in section A.1 of Chapter V, and the medium fertility variant corresponds to the median of 100,000 projected country trajectories.
- The *2010 Revision* uses a long term stabilization level of 2.1 children per woman (which for many countries might only be reached by the end of the century or even later) rather than 1.85 children per woman as in previous revisions when the projection horizon was only up to 2050.
- With the extension of the projection horizon for all countries up to 2100 as part of the *2010 revision* of the *UN World Population Prospects*, it was necessary to allow life expectancy at birth to go beyond the limits of the standard model life table families (Coale-Demeny 1966 and 1989, and United Nations, 1982) which are commonly used to derive a variety of mortality indicators and as underlying mortality patterns for estimation and projection. As part of the *2010 Revision* a new and extended version of Coale-Demeny and United Nations model life tables has been developed which extends the standard model life table families from 75 to 100 years of life expectancy at birth. This new version also insures greater consistency with the mortality experience of countries with the highest levels of life expectancy as recorded in the Human Mortality Database[20].
- In the *2010 Revision*, the impact of HIV/AIDS on mortality is modelled explicitly for all countries where HIV prevalence among persons aged 15 to 49 was ever equal to or greater than two per cent between 1980 and 2009 in the general population, and/or the maximum effect of HIV/AIDS on life expectancy at birth is two or more years. Also considered among the affected countries are those where HIV prevalence is lower than one per cent but whose population is so large that the number of people living with HIV in 2009 is more than 700,000 (i.e., China, India, Russian Federation, United States).
- Both the survival time of HIV-positive children receiving treatment and the survival time of HIV-positive adults receiving treatment (after developing full-blown AIDS) decreased with respect to that used in the 2008 Revision (mean survival was revised down for children from 15.6 years to 11.6 and for adults from 17.4 years to 9.1). The revisions are consistent with recommendations of UNAIDS Reference Group on Estimates, Modelling and Projections (web site: http://www.epidem.org).

[20] For further details about the new extended models, see http://esa.un.org/unpd/wpp/Model-Life-Tables/download-page.html and for the methodology, see annex in Li, N. and P. Gerland (2011). "Modifying the Lee-Carter Method to Project Mortality Changes up to 2100" Paper presented at the *2011 Annual Meeting of the Population Association of America* (PAA) in Session 125: Formal Demography I: Mathematical Models and Methods on Friday 1 April - http://paa2011.princeton.edu/sessionViewer.aspx?SessionId=1002