

Department of Economic and Social Affairs
Population Division

World Population Prospects

The 2006 Revision

Highlights



United Nations
New York, 2007

V. ASSUMPTIONS UNDERLYING THE 2006 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 1950-2005) are presented in volume III of *World Population Prospects: The 2006 Revision* (forthcoming).

The future population of each country is projected starting with an estimated population for 1 July 2005. Because population data are not necessarily available for that date, the 2005 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 2005 using all available data on fertility, mortality and international migration trends between the reference date of the population data available and 1 July 2005. In cases where recent data on the components of population growth 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 necessary⁸.

To project the population until 2050, 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 2005 and ending in 2050.

The *2006 Revision* includes eight projection variants and three AIDS scenarios. The eight variants are: low; medium; high; constant-fertility; instant-replacement-fertility; constant-mortality; no change (constant-fertility and constant-mortality); and zero-migration. The *World Population Prospects Highlights* focuses on the medium variant of the *2006 Revision*, and results from the first four variants are available on-line and are published in volume I of *World Population Prospects* (forthcoming). The full set of results for all variants and scenarios are available only on CD-ROM.

The first five variants, namely, the low, medium, high, constant-fertility and instant-replacement-fertility, differ among themselves exclusively in the assumptions made regarding the future path of fertility. The sixth variant, named "constant-mortality", differs from the medium variant only with regard to the path followed by future mortality. The seventh variant, denominated "no change", has constant mortality and constant fertility and thus differs from the medium variant with respect to both fertility and mortality. The eighth variant, denominated "zero-migration", differs from the medium variant only with regard to the path followed by future international migration. Generally, variants differ from each other only over the period 2005-2050.

In addition, the *2006 Revision* includes three AIDS scenarios named No-AIDS, high-AIDS and AIDS-vaccine. These scenarios are variations of the medium variant and differ from each other and from the medium variant in terms of the path mortality follows because they each incorporate different assumptions regarding the course of the HIV/AIDS epidemic. Note that only

⁸ For a general description of the procedures used in revising estimates of population dynamics, see "Chapter VI. Methodology of the United Nations population estimates and projections" (pp. 100-104) in *World Population Prospects: The 2004 Revision*, vol. III, *Analytical Report* (United Nations publication, Sales No. E.05.XIII.7) and for the current Revision, *World Population Prospects: The 2006 Revision*, vol. III, *Analytical Report* (United Nations publication, forthcoming).

62 countries are considered to be significantly affected by the epidemic. Consequently, the AIDS scenarios produce different projections only for those countries.

To describe the different projection variants and scenarios, the various assumptions made regarding fertility, mortality and international migration are presented below.

A. FERTILITY ASSUMPTIONS: CONVERGENCE TOWARD TOTAL FERTILITY BELOW REPLACEMENT LEVEL

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

- *High-fertility countries*: Countries that until 2005 had no fertility reduction or only an incipient decline;
- *Medium-fertility countries*: Countries where fertility has been declining but whose level was still above 2.1 children per woman in 2000-2005;
- *Low-fertility countries*: Countries with total fertility at or below 2.1 children per woman in 2000-2005.

1. Medium-fertility assumption

Total fertility in all countries is assumed to converge eventually toward a level of 1.85 children per woman. However, not all countries reach this level during the projection period, that is, by 2045-2050. Projection procedures differ slightly depending on whether a country had a total fertility above or below 1.85 children per woman in 2000-2005.

Fertility in high- and medium-fertility countries is assumed to follow a path derived from models of fertility decline established by the United Nations Population Division on the basis of the past experience of all countries with declining fertility during 1950-2000. The models relate the level of total fertility during a period to the average expected decline in total fertility during the next period. If the total fertility projected by a model for a country falls to 1.85 children per woman before 2050, total fertility is held constant at that level for the remainder of the projection period (that is, until 2050). Therefore, the level of 1.85 children per woman represents a floor value below which the total fertility of high- and medium-fertility countries is not allowed to drop before 2050. However, it is not necessary for all countries to reach the floor value by 2050. If the model of fertility change produces a total fertility above 1.85 children per woman for 2045-2050, that value is used in projecting the population.

In all cases, the projected fertility paths yielded by the models are checked against recent trends in fertility for each country. When a country's recent fertility trends deviate considerably from those consistent with the models, fertility is projected over an initial period of 5 or 10 years in such a way that it follows recent experience. The model projection takes over after that transition period. For instance, in countries where fertility has stalled or where there is no evidence of fertility decline, fertility is projected to remain constant for several more years before a declining path sets in.

Fertility in low-fertility countries is generally assumed to remain below 2.1 children per woman during most of the projection period and reach 1.85 children per woman by 2045-2050. For countries where total fertility was below 1.85 children per woman in 2000-2005, it is assumed that over the first 5 or 10 years of the projection period fertility will follow the recently observed trends in each country. After that transition period, fertility is assumed to increase linearly at a rate of 0.05 children per woman per quinquennium. Thus, countries whose fertility is currently very low need not reach a level of 1.85 children per woman by 2050.

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 2045-2050, 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 1.85 children per woman in the medium variant have a total fertility of 2.35 children per woman in the high variant at the end of the projection period.

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 2045-2050, 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 1.85 children per woman in the medium variant have a total fertility of 1.35 children per woman in the low variant at the end of the projection period.

4. Constant-fertility assumption

For each country, fertility remains constant at the level estimated for 2000-2005.

5. Instant-replacement-fertility assumption

For each country, fertility is set to the level necessary to ensure a net reproduction rate of 1 starting in 2005-2010. 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 incorporating a slow pace of mortality decline has generally been used so as to reflect a slowdown in the reduction of mortality risks not related to HIV/AIDS.

2. The impact of HIV/AIDS on mortality

In the *2006 Revision*, all countries with HIV prevalence among persons aged 15 to 49 equal to or greater than one per cent are considered as seriously 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 individuals infected is large, such as Brazil, China or the United States. In total, 62 countries are considered to be highly affected by the HIV/AIDS epidemic in the *2006 Revision*.

The model developed by the UNAIDS Reference Group on Estimates, Modelling and Projections⁹ is used to fit past estimates of HIV prevalence provided by UNAIDS for each of the

⁹ UNAIDS Reference Group on Estimates, Modelling and Projections (2002). Improved methods and assumptions for estimation of the HIV/AIDS epidemic and its impact: Recommendations of the UNAIDS Reference Group on Estimates, Modelling and Projections. *AIDS*, vol. 16, pp. W1-W14. URL: <http://www.epidem.org>.

affected countries so as to derive the parameters determining the past dynamics of the epidemic for each of them. For most countries, the model is fitted assuming that the relevant parameters have remained constant in the past. Beginning in 2005, 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 transmitting the virus.

In the *2006 Revision*, prevention of mother-to-child transmission is modelled using estimated country-specific coverage rates that average 13 per cent in 2005 among the 62 affected countries, but vary between 0 and 90 per cent among them. These coverage rates are projected to reach 60 per cent, on average, by 2015, varying between 40 per cent and 100 per cent among the affected countries.¹⁰ The coverage rate is assumed to remain constant between 2015 and 2050 at the level reached by 2015 in each of the affected countries. Among women receiving treatment, the probability of transmission from mother to child is assumed to be 1 per cent. These assumptions produce a reduction in the incidence of HIV infection among children born to HIV-positive women, but the size of the reduction varies from country to country depending on the level of coverage that treatment reaches in each of them.¹¹

The survivorship of infected children⁹ takes account of varying access to paediatric treatment.¹¹ In the *2006 Revision*, HIV-infected children are divided into two groups: (i) for those infected *in-utero*, among whom the disease progresses rapidly, average survival is expected to be 1.3 years, and (ii) for those infected after birth through breastfeeding, among whom the disease progresses slowly, average survival is 14 years without treatment.^{11, 12} Explicit inclusion of paediatric treatment is done via country-specific coverage rates which average 9 per cent in 2005 but vary between 0 and 99 per cent among the 62 affected countries. By 2015, the projected coverage is expected to reach 60 per cent, on average, varying from 40 per cent to 100 per cent among the affected countries.¹⁰ Coverage levels remain constant from 2015 to 2050 at the level reached in each country by 2015. The annual survival of children receiving treatment is 95 per cent, so that their mean survival time is 19.5 years and the median survival time is 13.5 years in the absence of other causes of death.¹¹

The *2006 Revision* incorporates a longer survival for persons receiving treatment with highly active antiretroviral therapy (ART). The proportion of the HIV-positive population receiving treatment in each country is consistent with estimates prepared by the World Health Organization,¹³ which averaged 25 per cent in 2005 but varied between 0 and 100 per cent among the 62 affected countries. Coverage is projected to reach between 40 per cent and 100 per cent by 2015, averaging 60 per cent for the affected countries. Between 2015 and 2050, coverage levels

¹⁰ UNAIDS, UNICEF, WHO (2007). *Children and AIDS - A Stocktaking Report. Actions and Progress during the First Year of Unite for Children, Unite against AIDS* (with Statistical Annexes). See Table 1. Preventing mother-to-child transmission of HIV (pp. 29-31) and Table 2. Providing paediatric treatment (pp. 32-34). URL: www.unicef.org/uniteforchildren.

¹¹ Stover, J., N. Walker, N.C. Grassly, and M. Marston (2006). Projecting the demographic impact of AIDS and the number of people in need of treatment: Updates to the Spectrum projection package. *Sexually Transmitted Infections*, vol. 82, Supplement 3: iii, pp. 45-50. URL: http://sti.bmj.com/cgi/content/abstract/82/suppl_3/iii45.

¹² Boerma, J.T., K.A. Stanecki, M.L. Newell, C. Luo, M. Beusenber, G.P. Garnett, K. Little, J.G. Calleja, S. Crowley, J.Y. Kim, E. Zaniewski, N. Walker, J. Stover, and P.D. Ghys (2006). Monitoring the scale-up of antiretroviral therapy programmes: methods to estimate coverage. *Bulletin of the World Health Organization*, vol. 84, No. 2, pp. 145-150. URL: <http://www.who.int/bulletin/volumes/84/2/145.pdf>.

¹³ World Health Organization and UNAIDS (2006). *Progress on Global Access to HIV Antiretroviral Therapy. A Report on "3 by 5" and Beyond*. See Annex 1. Estimated number of people receiving antiretroviral therapy, people needing antiretroviral therapy, percentage coverage and numbers of antiretroviral therapy sites in low- and middle-income countries (pp. 71-76). URL: http://www.who.int/hiv/fullreport_en_highres.pdf.

remain constant at the level reached in each country by 2015. It is assumed that adults receiving treatment have, on average, a 90 per cent chance of surviving each year in the absence of other causes of death. Under this assumption, mean survival time after the initiation of therapy is 9.5 years and the median survival time is 6.6 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 two years after the onset of full-blown AIDS.¹²

3. No-AIDS assumption

For each of the 62 countries for which the impact of HIV/AIDS has been taken into account, mortality is estimated and projected by applying the mortality levels likely to be exhibited by the non-infected population to the whole population, thus excluding the direct impacts of the epidemic. Because AIDS started affecting the populations in the majority of the highly-affected countries around 1980, the results of the No-AIDS scenario differ from those of the medium variant not only during the projection period (2005-2050) but also during part of the estimation period (mainly during 1980-2005). As mentioned above, in countries highly affected by the HIV/AIDS epidemic, the slow pace of mortality decline has generally been used to project the reduction of mortality risks not related to HIV/AIDS.

4. High-AIDS assumption

Mortality in the high-AIDS scenario is projected by assuming that the parameters of the model determining the path of the HIV/AIDS epidemic, specifically PHI and R, remain constant at their 2005 level. This assumption produces in the long run a relatively high endemic level of the disease. In contrast with the medium variant which includes the effect of AIDS, the effect of treatment is not incorporated in the high-AIDS scenario.

5. AIDS-vaccine assumption

The so-called AIDS-vaccine assumption refers to the ideal case in which a perfectly effective vaccine against HIV would be instantly available to everyone by 2010. Under this assumption, mortality is projected by assuming that no new HIV infections occur as of 2010. In terms of modelling, this assumption is equivalent to making the force of infection parameter R become zero in 2010 and remain at that level over the rest of the projection period.

6. Constant-mortality assumption

Under this assumption, mortality is maintained constant in each country at the level estimated for 2000-2005.

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 most of the projection period.

2. Zero-migration assumption

Under this assumption, for each country, international migration is set to zero starting in 2005-2010.

E. METHODOLOGICAL CHANGES INTRODUCED IN THE *2006 REVISION*

The following changes and adjustments were made in the *2006 Revision* in relation to procedures followed in the *2004 Revision*.

- In the medium variant, the fertility of countries with a total fertility below 1.85 children per woman in 2000-2005 is projected first by continuing recent trends and then by increasing fertility linearly by 0.05 children per woman per quinquennium instead of an increase of 0.07 children as in the *2004 Revision*. These countries do not necessarily reach a level of 1.85 children per woman by 2045-2050.
- The models of the incidence of HIV infection by age have been modified. In the new models, mean age at infection is generally higher than in the models used in previous revisions, particularly for males. A delay in contracting the disease reduces the impact of AIDS-related mortality on life expectancy.
- The survival of HIV-positive children was raised with respect to previously used models not only for those receiving treatment but also for those living without treatment.
- For HIV-positive adults receiving ART, survival after becoming infected was also increased in relation to previously used models.
- The effects of receiving ART have been modelled explicitly among both children and adults. In addition, the effects of mother-to-child transmission are projected to decline as access to treatment among women expands.

D. ELEVEN PROJECTION VARIANTS

The *2006 Revision* includes eleven different projection variants or scenarios (table V.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 no change variant (constant-fertility and constant-mortality) 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 no change variant has the same international migration as the medium variant but differs from the latter by having constant fertility and constant 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.

Lastly, as part of the modelling of the HIV/AIDS epidemic and to evaluate its demographic impact, three AIDS mortality scenarios have been computed. They all share the same fertility and international migration assumptions as the medium variant. Consequently, the results of the AIDS mortality scenarios can be compared with those of the medium variant to assess the impact of HIV/AIDS and the effect of changing mortality, respectively, on other demographic parameters. The AIDS scenarios are hypothetical and serve only as a basis for comparison.

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

<i>Projection variant or scenario</i>	<i>Assumptions</i>		
	<i>Fertility</i>	<i>Mortality</i>	<i>International Migration</i>
Low fertility	Low	Normal*	Normal
Medium fertility	Medium	Normal*	Normal
High fertility	High	Normal*	Normal
Constant-fertility	Constant as of 2000-2005	Normal*	Normal
Instant-replacement-fertility	Instant-replacement	Normal*	Normal
Constant-mortality	Medium	Constant as of 2000-2005	Normal
No change	Constant as of 2000-2005	Constant as of 2000-2005	Normal
Zero-migration	Medium	Normal*	Zero
No-AIDS	Medium	No-AIDS since 1980	Normal
High-AIDS	Medium	High-AIDS as of 2005	Normal
AIDS-vaccine	Medium	AIDS-vaccine as of 2010	Normal

* Including the impact of HIV/AIDS in 62 countries, as described in section B.2.