

V. ASSUMPTIONS UNDERLYING THE 2008 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 (<http://esa.un.org/wpp/sources/country.aspx>) and in volume III of *World Population Prospects: The 2008 Revision* (forthcoming).

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 necessary⁷.

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 2010 and ending in 2050. A more detailed description of the different assumptions will be available in volume III of *World Population Prospects: The 2008 Revision* (forthcoming).

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 2007 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;
- *Low-fertility countries*: Countries with total fertility at or below 2.1 children per woman in 2005-2010.

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.

⁷ For a general description of the procedures used in revising estimates of population dynamics, see methodology chapter of the United Nations population estimates and projections in *World Population Prospects: The 2008 Revision*, vol. III, *Analytical Report* (forthcoming).

Projection procedures differ slightly depending on whether a country had a total fertility above or below 1.85 children per woman in 2005-2010.

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 been declining very slowly or where it has stalled, fertility is projected to fall more slowly over the first 5 or 10 years of the projection period than it would have according to the model. After that transition period, the model pattern of change is used.

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 2005-2010, 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 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 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 *2008 Revision*, countries where HIV prevalence among persons aged 15 to 49 was ever equal to or greater than one per cent during 1980-2007 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 has always been lower than one per cent but whose population is so large that the number of people living with HIV in 2007 surpasses 500,000 (i.e., Brazil, China, India, the Russian Federation and the United States of America). In total, 58 countries are considered to be affected by the HIV/AIDS epidemic in the *2008 Revision*.

The model developed by the UNAIDS Reference Group on Estimates, Modelling and Projections^{8,9} is used to fit past estimates of HIV prevalence provided by UNAIDS for each of the affected countries¹⁰ 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 2007, 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.

⁸ Ghys P.D., Walker N., McFarland W., Miller R., Garnett G.P. (2008). Improved data, methods and tools for the 2007 HIV and AIDS estimates and projections. *Sexually Transmitted Infections*. August 2008, Volume 84, Supplement 1, pp. i1-i4 ; doi:10.1136/sti.2008.032573 - http://sti.bmj.com/cgi/content/full/84/Suppl_1/i1.

⁹ Brown T., Salomon J.A., Alkema L., Raftery A.E., Gouws E. (2008). Progress and challenges in modelling country-level HIV/AIDS epidemics: the UNAIDS Estimation and Projection Package 2007. *Sexually Transmitted Infections*. August 2008, Volume 84, Supplement 1, pp. i5-i10. doi:10.1136/sti.2008.030437 - http://sti.bmj.com/cgi/content/full/84/Suppl_1/i5.

¹⁰ UNAIDS/WHO. (2008). *2008 Report on the global AIDS epidemic*. UNAIDS/08.25E / JC1510E. Geneva. Aug. 2008. 362 p. - http://www.unaids.org/en/KnowledgeCentre/HIVData/GlobalReport/2008/2008_Global_report.asp - See online table: "Adult (15-49) HIV prevalence percent by country, 1990-2007 (with 95% confidence intervals)": http://data.unaids.org/pub/GlobalReport/2008/080813_gr08_prev1549_1990_2007_en.xls.

In the *2008 Revision*, interventions to prevent the mother-to-child transmission of HIV are modelled on the basis of estimated country-specific coverage levels that, in 2007, averaged 36 per cent among the 58 affected countries, but varied from 1.5 to 95 per cent among them (with 22 countries having less than 20 per cent coverage of pregnant women in 2007, and only 8 countries with more than 75 per cent coverage). These coverage levels are projected to reach 63 per cent on average by 2015, varying between 40 per cent and 95 per cent among the affected countries.¹¹ After 2015, the coverage of interventions to prevent mother-to-child transmission of HIV is assumed to remain constant until 2050 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 19 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-prevention, or triple-prevention antiretroviral 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.¹²

The survivorship of infected children⁷ takes account of varying access to paediatric treatment.¹¹ In the *2008 Revision*, HIV-infected children are divided into two groups: (i) those infected in-utero, among whom the disease progresses rapidly and whose average survival is set at 1.3 years, and (ii) those infected through breastfeeding after birth, among whom the disease progresses slowly and whose average survival is set at 15.2 years without treatment.¹³ Explicit inclusion of paediatric treatment is done via country-specific coverage levels which average 34 per cent in 2007 but vary between 0 and 99 per cent among the 58 affected countries (with 14 countries having less than 10 per cent coverage in 2007 and only 12 countries having a coverage level above 75 per cent). By 2015, the projected coverage is expected to reach 60 per cent on average in the 58 affected countries, varying from 40 per cent to 99 per cent.¹³ Coverage levels are assumed to remain constant from 2015 to 2050 at the level reached in each country by 2015. The annual survival of children receiving treatment is 80 per cent during the first year, 90 per cent the second year, and 95 per cent thereafter, so that their mean survival time is 31.1 years and the median survival time is 20.5 years in the absence of other causes of death.¹¹

The *2008 Revision* incorporates a longer survival for persons receiving treatment with highly active antiretroviral therapy (ART).^{7,11} The proportion of the HIV-positive population receiving treatment in each country is consistent with estimates prepared by the World Health Organization,¹⁴ which averaged 36 per cent in 2007 among the 58 affected countries, but varied between 8 per cent and 99 per cent. Coverage is projected to reach between 40 per cent and 99 per cent by 2015, averaging 64 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 85 per

¹¹ UNAIDS, UNICEF, WHO (2008). *Children and AIDS - Third Stocktaking Report*. (with Statistical Annexes). Dec. 2008. See Table 1. Preventing mother-to-child transmission of HIV (pp. 33-35) and Table 2. Providing paediatric treatment (pp. 36-38). URL: www.unicef.org/uniteforchildren - http://www.uniteforchildren.org/uniteforchildren/knowmore/files/StocktakingReport08_Full_110708.pdf.

¹² Stover J, Johnson P, Zaba B, Zwahlen M., Dabis F., Ekpini R.E. (2008). The Spectrum projection package: improvements in estimating mortality, ART needs, PMTCT impact and uncertainty bounds. *Sexually Transmitted Infections*. August 2008, Volume 84, Supplement 1, pp. i24-i30. doi:10.1136/sti.2008.029868 - http://sti.bmj.com/cgi/content/full/84/Suppl_1/i24.

¹³ Marston M., Zaba B., Salomon J.A., Brahmbhatt H., Bagenda D. (2005) - Estimating the Net Effect of HIV on Child Mortality in African Populations Affected by Generalized HIV Epidemics. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. Volume 38, Number 2, February 1 2005. pp. 219–227 ; Newell, M-L. Coovadia H., Cortina-Borja M., Rollins N., Gaillard P., Dabis F. (2004). Mortality of infected and uninfected infants born to HIV-infected mothers in Africa: a pooled analysis. *Lancet*. Vol. 364. October 2, 2004, pp: 1236–43.

¹⁴ WHO/UNAIDS/UNICEF. *Towards universal access: scaling up priority HIV/AIDS interventions in the health sector, progress report 2008*. Geneva, WHO, June 2008. http://www.who.int/entity/hiv/pub/towards_universal_access_report_2008.pdf.

cent chance of surviving on the first year of treatment, and a 95 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 19.3 years and the median survival time is 10.9 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 3.2 years (and a median survival time of 3.0 years) after the onset of full-blown AIDS.^{7,11}

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.

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 2010-2015.

D. EIGHT PROJECTION VARIANTS

The *2008 Revision* includes eight different projection variants (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 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 V.1. PROJECTION VARIANTS IN TERMS OF ASSUMPTIONS FOR FERTILITY, MORTALITY AND INTERNATIONAL MIGRATION

<i>Projection variant</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 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 2010-15

E. METHODOLOGICAL CHANGES INTRODUCED IN THE 2008 REVISION

The following changes and adjustments were made in the *2008 Revision* in relation to procedures followed in the *2006 Revision*.

- The base year, that is, the year where the projections start changed from 2005 to 2010.
- In the 2008 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 one per cent during 1980-2007.
- The models of the incidence of HIV infection by age have been revised to take into account newly available data from nationally representative population surveys. Three new regional models, one for each Africa, Asia and the Caribbean, have been estimated by the United Nations Population Division for each sex using adult HIV prevalence rates by age and sex from 24 DHS surveys (covering 21 countries between 2001 and 2007).¹⁵ In the new models, mean age at infection is lower than in the models used in previous revisions, particularly for males. The mean age of infection for females varies between 25.0 (Asia) and 26.9 (Africa) years while for males it varies between 27.9 (Asia) and 31.9 (Africa).
- The survival of HIV-positive children receiving treatment increased with respect to that used in the 2006 Revision.
- The survival time of HIV-positive adults after developing full-blown AIDS increased with respect to that in models used previously, both for those receiving treatment and for HIV-positive persons not receiving treatment.

¹⁵ The approach is based on methodology presented at the UNAIDS Reference Group on Estimates, Modelling and Projections January 2008 meeting (London, UK) by Ray W. Shiraishi, Abhijeet Anand, R.W. Shiraishi, M. Morgan, W. Hladik, R. Bunnell, L.H. Marum, J. Aberle-Grasse, G. Bello, T. Diaz on "Using Population-based HIV Surveys to Estimate HIV Incidence in Kenya, Malawi and Uganda".