Interactions between Global Change and Human Health
Pontifical Academy of Sciences, *Scripta Varia* 106, Vatican City 2006
www.pas.va/content/dam/accademia/pdf/sv106/sv106-lutz.pdf

GLOBAL DEMOGRAPHIC TRENDS, EDUCATION, AND HEALTH

WOLFGANG LUTZ

A Demographically Divided World

Current global demographic trends and the challenges associated with these trends are somewhat confusing to many observers. On the one hand, in many developing countries birth rates well above the replacement level (of two surviving children per woman) and a very young population age structure keep population growth rates very high. For these reasons, the population in a number of countries is likely to double over the coming decades. At the global level, we expect that the world population will increase from its current 6.4 billion to somewhat below 9 billion by the middle of the century. On the other hand, in an increasing number of countries the birth rate has fallen well below replacement level and the population is aging rapidly. For these countries we expect even more rapid population aging in the future, and in many cases, a shrinking of total population size. Because demographic trends differ significantly in different parts of the world, concerns about the negative consequences of rapid population growth exist simultaneous to concerns about the negative implications of rapid population aging.

The fact that this demographic divide does not always follow the traditional divide between industrialized and developing countries further complicates this picture. Some developing countries have recently seen very rapid fertility declines, and the number of 'poor' countries with subreplacement fertility is increasing. China is the most prominent example, where fertility has fallen to an (uncertain) level between 1.4 and 1.8. Over the coming two decades, China will have significant further growth and significant population aging. The momentum created by a very young present age structure will cause the population to grow by around 200

million people, with the consequence that more women will enter reproductive age. At the same time, the one-child family policy will continue to cause serious problems in terms of the support of the rapidly increasing number of elderly. The United States will also be among the countries that simultaneously experience growth and aging, because – unlike Europe – the United States is expected to grow significantly due to high levels of immigration and higher birth rates than in Europe.

Figure 1 illustrates these trends in population growth rates for different world regions from 1950 to 2050, based on UN data estimates and projections. It shows that Europe consistently has the lowest population growth rate of all continents, falling from 1% per year in 1950 to zero growth today and an expected 0.5% per year decline by 2050. The figure also shows that all world regions have passed their peak growth rate and entered a declining trend that is expected to continue over the next half century. The only continent to depart from this general pattern is North America, which saw mostly stable population growth of around 1% from 1965 to present. That growth is expected to decline only moderately in the future. Actually, the UN expects North America to have a higher population growth than Latin America, and than the world average, by 2050.

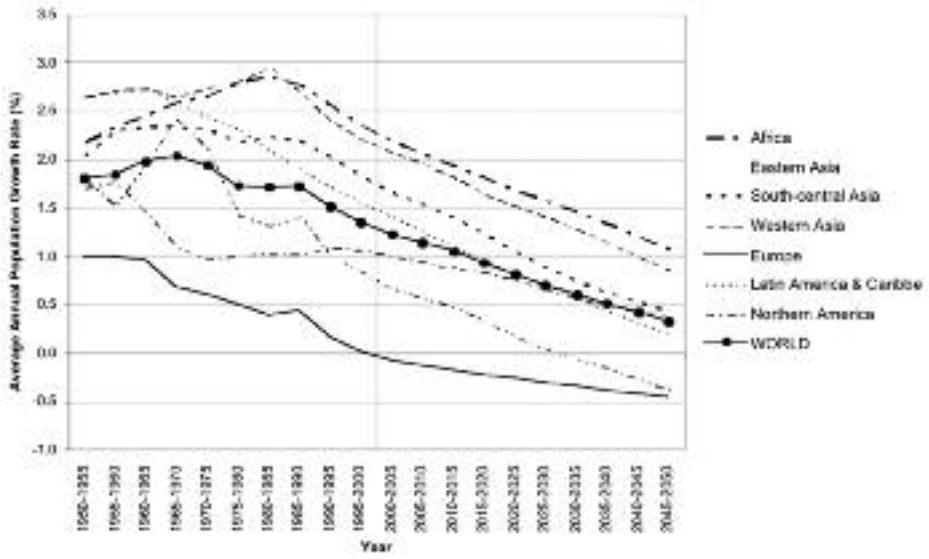

Figure 1. Average annual population growth rates of selected world regions, 1950-2050. Source: United Nations (2003) (medium variant).

Table 1 presents the trends in the two main drivers of population growth, namely mortality and fertility. As it shows, over the past half century, life expectancy has increased considerably in all parts of the world. Only in Africa over the past decade has there been a moderate decline at the continental level, as a result of HIV/AIDS, with life expectancy having declined considerably in some of the hardest hit countries. Projections assume a recovery in Africa, along with a continued increase in life expectancy in all parts of the world. Fertility rates have declined considerably around the world over the past decades. With less than 1.4 children per woman, Europe has the lowest fertility rate; the other extreme is Africa, where the average is around 4.9 children per woman. For the coming decades, the UN assumes continued declines in fertility around the world with the exception of Europe, where a recovery is assumed. Although the assumed continuation of the fertility transition in developing countries is uncontroversial, the assumption of substantial fertility increases in Europe is more disputed.

Demographic Transition as the Main Driver

Explanations and projections of fertility trends in different parts of the world generally have been guided by the paradigm of demographic transition. This paradigm assumes that after an initial decline in death rates,

Region	Life Expectancy at Birth (both sexes)					Total Fertility Rate				
	1950-1955	1975-1980	2000-2005	2025-2030	2045-2050	1950-1955	1975-1980	2000-2005	2025-2030	2045-2050
Africa	37.8	48.2	48.9	57.1	64.9	6.74	6.59	4.91	3.23	2.40
Eastern Asia	42.9	66.4	72.1	75.0	77.7	5.68	3.13	1.78	1.83	1.85
South-central Asia	39.4	52.6	63.2	69.1	74.0	6.08	5.09	3.25	2.18	1.91
Western Asia	45.2	60.6	69.1	75.2	78.0	6.46	5.30	3.45	2.57	2.19
Europe	65.6	71.5	74.2	78.1	80.5	2.66	1.97	1.38	1.63	1.84
Latin America & Caribbean	51.4	63.0	70.4	75.5	78.5	5.89	4.48	2.53	1.98	1.86
Northern America	68.8	73.3	77.4	79.7	81.8	3.47	1.78	2.05	1.96	1.85
WORLD	**46.5**	**59.8**	**65.4**	**70.2**	**74.3**	**5.02**	**3.90**	**2.69**	**2.25**	**2.02**

Table 1. Life expectancy at birth and total fertility rates by selected regions (1950-2050). Source: United Nations (2003) (medium variant).

birth rates also start to fall after a certain lag. In this general form, the model has received overwhelming empirical support in its ability to capture the remarkable fertility changes that happened over the 20th century.

The demographic transition began in today's more developed countries (MDCs) in the late 18th and 19th centuries, and spread to today's less developed countries (LDCs) in the last half of the 20th century (Notestein, 1945; Davis, 1954; Davis, 1991; Coale, 1973). The conventional 'theory' of demographic transition predicts that, as living standards rise and health conditions improve, mortality rates decline first, followed somewhat later by fertility rates. During the transition, population growth accelerates because the decline in death rates precedes the decline in birth rates. The demographic transition 'theory' is a generalization of the typical sequence of events that occurred in what are now MDCs, where mortality rates declined comparatively gradually, beginning in the late 1700s and then more rapidly in the late 1800s, and where, after a varying lag of up to 100 years, fertility rates declined as well. Different societies experienced this transition in different ways and various regions of the world are now following distinctive paths (Tabah, 1989). Nonetheless, the broad result has been a gradual transition from a small, slowly growing population with high mortality and high fertility to a large, slowly growing or even slowly shrinking population with low mortality and low fertility.

Figure 2 illustrates the demographic transition for two distinct world regions. It plots the crude birth and death rates (births and deaths per 1,000 of the population) for Europe and India. In the 1950s, the birth rates were almost twice as high as the death rates, which resulted in significant population growth. In Europe, the gap between birth and death rates closed during the 1990s. Looking ahead, Europe is expected to have a birth deficit, resulting in negative natural growth (with actual growth still depending on net migration). By comparison, India is in a much earlier phase of its demographic transition. Death rates have declined significantly, and with some lag, the birth rates also have started to decline, although from a much higher level than in Europe due to universal and very early marriage in India. India is expected to have completed its demographic transition by the middle of the 21st century.

This demographic transition paradigm, which has been useful for explaining global demographic trends during the 20th century and has strong predictive power for projecting future trends in countries that still have high fertility, has nothing to say about the future of fertility in Europe. The recently popular notion of a 'second demographic transition'

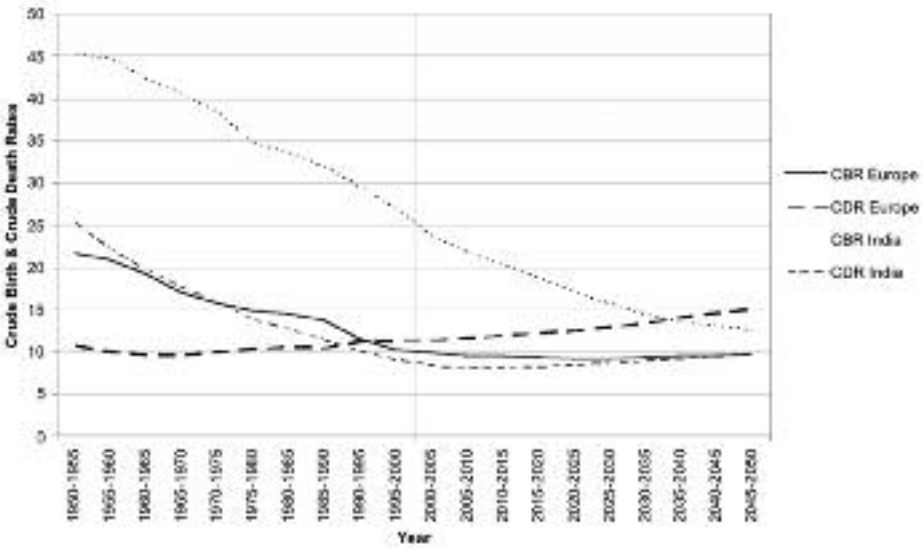

Figure 2. Crude birth and crude death rates for Europe and India, 1950-2050. Source: United Nations (2003) (medium variant).

is a useful way to describe a bundle of behavioral and normative changes that have emerged in Europe, but the concept has no predictive power. The social sciences have not yet developed a useful theory to predict the future fertility level of post-demographic transition societies. All that forecasters can do is try to define a likely range of uncertainty.

Mapping the Uncertainty Range of Demographic Trends in the 21st Century

The future trends of all three components of demographic change – fertility, mortality, and migration – are uncertain. The UN medium variant presented above is based on assumptions about what is most likely from today's perspective. But we already know that there is a high probability that the actual future trends will be either above or below the medium assumption. How should we deal with this significant uncertainty in population forecasting? This same question is asked by a recent special issue of the *International Statistical Review* (Lutz and Goldstein, 2004). The state-of-the-art report shows that the field of population fore-

casting is currently seeing a paradigm change to move from scenarios to probabilistic forecasting. Scenarios, as used in many fields of forecasting and as described by Huynen and Martens (2006, this volume), are descriptions of possible future paths without any statement of their likelihood. Particularly in cases of deep uncertainty, i.e., when there is not only parameter uncertainty but the entire model is uncertain, scenarios have become a standard tool for thinking about the future. Because in population forecasting we know the model, as described by the cohort component model of population projections, only the parameters are uncertain. For this reason, forecasting agencies around the world some decades ago followed the example of the United Nations Population Division and produced high and low variants in addition to the medium variant. This high-low range is supposed to indicate a 'plausible range' of future population trends. But a high-low range can only be defined in terms of one of the three components of change and as a result is mostly based on alternative fertility assumptions, while uncertainty in mortality and migration is disregarded.

To remedy such shortcomings, IIASA (Lutz *et al.*, 1997) produced the first fully probabilistic projections of the world population. These were based essentially on subjective probability distributions for future fertility, mortality, and migration, as defined by a group of experts. In 2001, IIASA performed new probabilistic projections based on a synthesis of three alternative approaches (time series analysis, ex post error analysis, and argument-based expert views) (Lutz *et al.*, 2001). The examples below are taken from this most recent forecast. Such probabilistic projections go beyond the traditional scenario analysis in several important dimensions: they are able to simultaneously consider the uncertainty in all three components of change; they can define in more precise quantitative terms what uncertainty intervals the given ranges cover; and, based on the assumption of certain correlations, they can aggregate from the regional to global level in a probabilistically consistent way. These important advantages of a probabilistic approach over a scenario approach suggest that other fields such as environmental change or future health should consider moving beyond scenarios.

The key findings of Lutz *et al.* (2001), with a high probability of above 80%, are that world population will peak over the course of this century and then start to decline. The findings also show that the 21st century will bring significant population aging in all parts of the world. In short, where the 20th century was the century of population growth, with the

world growing from 1.6 to 6.1 billion people, the 21st century will be the century of population aging, with the global proportion above age 60 increasing from currently 10% to between 24 and 44% (80% uncertainty interval). Even more significant, the proportion of the world population above age 80 will increase from currently 1% to between 4 and 20%, depending largely on the future course of life expectancy.

Figure 3 (see page 416) shows that in Western Europe the proportion of the population above age 80 might increase much more dramatically than it will at the global level. As the figure shows, currently around 3% of the population in Western Europe is above age 80, and this proportion will not change much over the coming decade. After the year 2030, however, the uncertainty range opens up very quickly. In 2050, the 95% interval already ranges from around 4% at the low end to more than 20% at the high end, with the median at around 10%. In other words, in 2050 the proportion above age 80 is likely to be three times as high as today, but it could even be six times as high. Its actual level will depend mostly on future old-age mortality – whether life expectancy will level off toward a maximum or whether it will continue to increase unabated. This difference becomes much more significant during the second half of the century. By the end of the century, the 95% interval is extremely wide, ranging from essentially the current level of 3% to an incredible 43% of the population above age 80. Even the median shows a proportion of about 20%. Societies with significant proportions of the population above age 80 will clearly be very different from today's societies, although it is likely that an average 80-year-old person during the second half of the century will be in much better physical health than an average 80-year-old person today. Clearly, the future course of old-age mortality and disability provides us with many difficult but highly important research questions.

Figure 3 also shows two blue lines for the year 2100. These give the proportions of the population above age 80 as provided by the 'high' and 'low' variants of the most recent UN long-range projections (United Nations, 1999). Because the UN does not use alternative mortality assumptions in their variants, it is not surprising that the range is quite narrow. Also, the UN projections seem to anticipate much lower improvements in life expectancy in Western Europe. This difference illustrates that the traditional variants approach, which only varies the fertility assumptions, is a highly problematic way of dealing with uncertainty and should not be interpreted as giving a 'plausible range', as is often done.

The Changing Global Distribution of Population and Human Capital

The demographic trends of the past decade, together with those projected, have and will continue to result in major changes in regional population distribution on our planet. Figure 4 plots the continents' changing shares of the world population. Asia, which holds the giant share of the world population and stays at a rather stable 55-60% over the entire 100-year period, is not included in the graph. The shares of North America, Latin America, and Oceania are also surprisingly stable over time. Big changes affect only Europe and Africa, where over the course of 100 years they fully exchange their positions. In 1950, Europe (including Russia) was home to some 550 million people constituting 22% of the world population. At present, Europe has increased to 725 million, but because the world population has increased much more rapidly, Europe's share has declined to only 12%. By 2050 Europe is expected to shrink to some 630 million, which at that point will only be 7% of the world population. Africa, on the other hand, which started at 8% in 1950, is likely to grow to around 1.8 billion by 2050, almost three times the expected population of Europe at that time.

Although these changes in relative population size are significant, it is not clear what they imply for a region's geopolitical standing. The strength and influence of a nation or a continent is not directly a function of its population size. If this were the case, then Africa today should have a similar standing in international politics, economics, or military strength to that of Europe; this is not remotely the case. What seems to count more than solely the population size of a country is its level of human capital, which can be defined in a simplified way by stratifying the people of working age by their level of education. The global distribution of human capital is changing, but the pattern looks rather different from that of population numbers alone.

The first global projections of human capital have been produced recently by IIASA (Lutz *et al.*, 2004b). Table 2 lists the persons of working age that have at least some secondary or tertiary education in 2000, and provides two alternative scenarios to 2030. The scenario 'constant' assumes that current school enrollment rates stay unchanged over time, which will result in significant human-capital improvements in many countries because of past improvements in education and the process by which the less educated older cohorts are replaced by better educated younger cohorts. The other scenario, called 'ICPD', assumes that the ambitious edu-

	Secondary and Tertiary					
	Base year		Constant		ICPD	
	2000	2000	2030	2030	2030	2030
Regions	Male	Female	Male	Female	Male	Female
North Africa	19	11	47	38	49	41
Sub-Saharan Africa	32	17	79	61	106	90
North America	88	89	100	99	100	99
Latin America	66	65	140	143	143	147
Central Asia	13	13	25	25	25	25
Middle East	17	12	50	40	53	46
South Asia	134	57	250	116	288	195
China region	238	153	416	354	406	346
Pacific Asia	53	41	99	90	106	99
Pacific OECD[a]	40	40	40	39	39	40
Western Europe	106	95	124	122	125	122
Eastern Europe	26	23	31	30	31	31
FSU Europe[b]	54	57	58	61	59	62
World	887	673	1,459	1,219	1,531	1,343

Table 2. Population (in millions) aged 20-65 by education and sex in 2000 and in 2030 according to the 'constant' and the 'ICPD' scenarios. Source: Lutz *et al*. (2004b: 149).

cation goals defined at the International Conference on Population and Development (ICPD) 1994 in Cairo will be achieved. These include a closing of the gender gap in education and universal primary education.

Table 2 shows that in terms of human capital, Europe (including Russia) is still a world power, with well over 350 million working age people who have received higher education – many more than in Africa, and even more than the huge South Asian subcontinent. This puts the pure population numbers into perspective. The table also shows that significant changes in the global distribution of human capital are to be expected, even under the constant enrollment scenario. Under this scenario, every world region will see some improvement of its overall human capital. On a relative scale, gains in today's least developed regions will be strongest, partly because the recent improvements in educating the younger generation are a significant gain in comparison to the virtual absence of education among the older cohorts. In absolute terms, even under this constant enrollment scenario, huge gains in the number of working age people with secondary or tertiary education are expected in

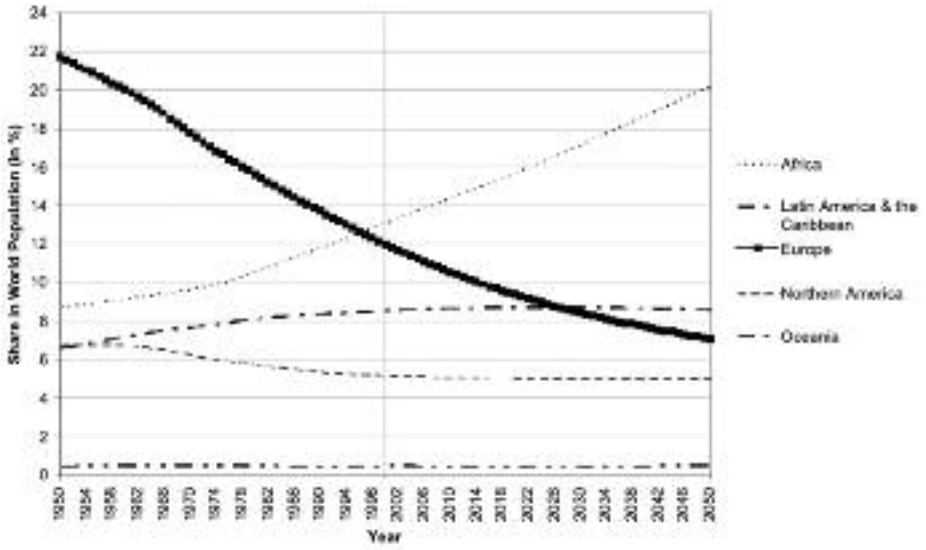

Figure 4. Share (in percent) of selected regions in world population, 1950-2050. Source: United Nations (2003) (medium variant).

Latin America, South Asia, and the China region. In today's industrialized countries, only moderate gains are expected. Comparing these results to the most optimistic scenario, which assumes the education goals of the ICPD, there is surprisingly little difference to the constant enrollment scenario. This is due to the great momentum of educational improvement. Increases in school enrollment today and over the coming decade will only very slowly affect the average educational attainment of the whole working age population. The difference between the scenarios is worth noting in Sub-Saharan Africa, where the current school enrollment rates are still far below the Cairo targets. Because the ICPD also implies lower fertility in some regions, the absolute numbers for human capital are smaller under the ICPD than under the constant rate scenario.

Figure 5 presents the information of Table 2 in graphical form. In comparing the four 'mega regions', it shows that currently Europe and North America together dominate the world in terms of human capital, although South Asia and the China region are already bigger in terms of their working age populations. The figure also shows the different pathways of China and South Asia (India). Unlike South Asia, China has

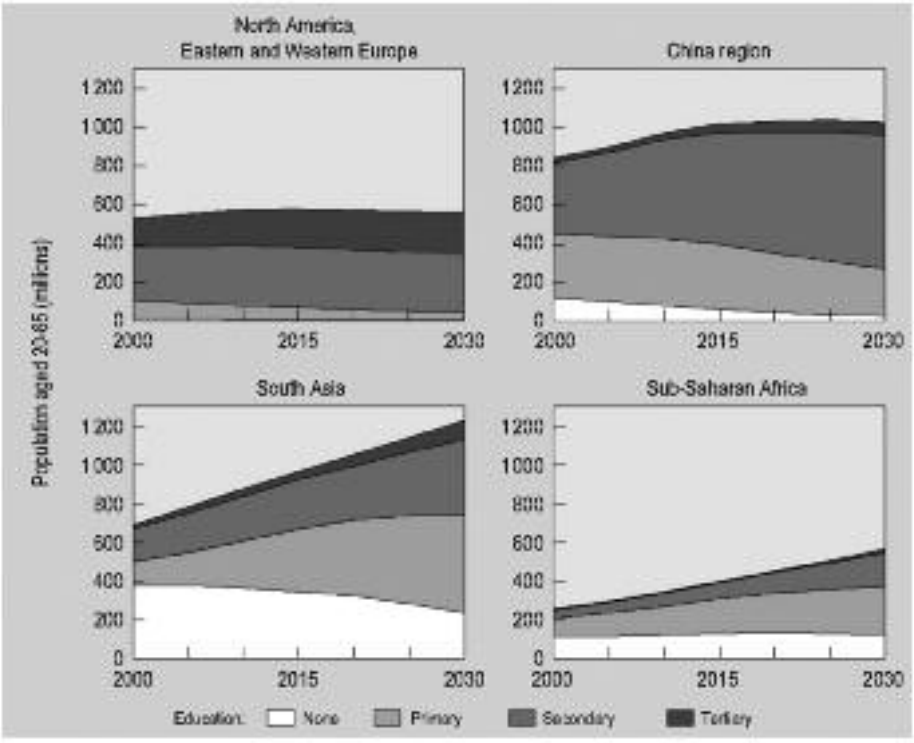

Figure 5. Population (in millions) aged 20-65 by level of education, according to the 'ICPD' scenario in four mega-regions, 2000-2030. Source: Lutz *et al*. (2004b: 138).

invested heavily over the past decades in primary and secondary education and will see a peaking of its population size over the coming decades. As a result, South Asia will soon surpass the China region in terms of population size, but will fall behind in terms of human capital. Even under the most optimistic scenario, Africa will see only very moderate increases in human capital. An interesting point is that China's human capital is increasing so rapidly that by around 2015 China will have more people of working age with secondary or tertiary education than Europe and North America together. These global shifts in human capital are likely to result in changing geopolitical and economic status and also have significant implications for global health and well-being.

Implications on Health

As outlined above, the major changes in the global population distribution – both in terms of age distribution and regional distribution – affect health in many dimensions, ranging from the implications of international mobility for infectious diseases, to the consequences of rapid population aging for the prevalence of disabilities, to the financial viability of health care systems in the face of major shifts in the ratio of contributions to entitlements. On top of these demographic changes, the outlined change in the educational composition of the global population is expected to have significant positive effects on health. At least on the individual level, education is probably the single most important determinant of health differentials. Almost universally, people with better education live longer, have better a health status, and have healthier children than less educated people of the same age in the same place of residence. The mechanisms by which education leads to better health are manifold and operate both in developing and developed countries. There are many implications of demographic and education trends on health, and we discuss only two interesting questions, one for the rapidly aging European society and one for some of the world's poorest countries.

To What Extent Will Population Aging in Europe Lead to an Increase in the Number of Disabled People?

It is evident as a feature of human life that the number of functional disabilities of all kinds increases with age. Surveys conducted in all EU member countries have collected systematic information on this progression. These surveys usually distinguish to some extent between categories of severely disabled and disabled. The data show, for instance, that on average only 2% of the women aged 25-34 are severely disabled. This proportion already reaches 10% for the age group 55-64 and further increases to almost 30% for women above age 85. The proportion of moderately disabled increases more rapidly, from 7.5% in the age group 25-34 to 36% for women above age 85.

It is equally evident and uncontested that the age structure of the European population will become significantly older over the coming decades. The proportion of the population above age 65 is expected to increase from its current 16% to possibly more than 30%. The proportion above age 80 is likely to increase even more rapidly. Combining these

observations about disability and aging, one would expect the number of disabled people in Europe to increase rapidly over the coming decades as more and more elderly people enter the ages of high disability rates. However, the calculations presented here show that this is not necessarily the case if the pattern of age-specific risk of disability continues to shift to higher ages, i.e., if at any given age the risk declines.

Figure 6 (see page 416) shows the population of the EU-15 in 2000 by age and sex and disability status as measured by the most recent health surveys. Here the red area includes both categories of the disabled, severe and moderate. The age pyramid shows a particularly large number of disabled women aged 55 to 80 at present.

Figures 7a and 7b (see page 417) present two alternative scenarios for the year 2030. Both are based on an identical projection of the total population of the EU-15, which includes the assumption of a two-year gain in total life expectancy per decade (as well as medium migration and fertility assumptions). Superimposed on this population forecast are two different assumptions about future trends in age-specific disability rates. Figure 7a presents the projected age pyramid under the assumption that currently observed age-specific proportions disabled do not change over time. This somewhat implausibly assumes that while mortality rates at higher ages decline due to improving life expectancy, the probability of becoming disabled at a given age does not change. The result of this first scenario shows that the number of disabled persons in the EU will indeed increase from currently around 60 million to around 75 million in 2030.

The second scenario shown in Figure 7b assumes that while life expectancy increases by two years per decade, the schedule of age-specific proportions disabled is also shifted to higher ages by two years per decade. This means, for example, that by the year 2030 the risk of being disabled at age 70 is equal to that the risk at age 64 in 2000. For this scenario, the results show almost no increase in the number of disabled people in Europe, with the total number increasing only from 60 to 62 million by 2030. Extended to 2050, this scenario results in slight declines in the disabled population.

In conclusion, these scenario calculations of Europe's future physically disabled population indicate that the number of elderly people in need of care and assistance will not necessarily increase as a consequence of population aging. The key factor will be the future trend in age-specific risks to become disabled, an area where preventive medicine and public health measures may be able to make a big difference.

The Effect of Improving Education on Adult and Child Mortality

In a recent paper, Lutz *et al*. (2004a) study the effects of changing educational structures on adult and child survival in Guinea, Zambia, and Nicaragua. Table 3 illustrates the considerable differences in the survival chances of children depending on the education of their mothers. In Nicaragua, the children of women without formal education die almost four times more often than the children of women with higher education. The reasons for this remarkable difference are not difficult to find. Women with a better education generally have a better social and economic standing, are better informed about healthy practices, and typically have better access to the health care system.

The same effects are likely to operate when it comes to adult mortality and total life expectancy. Table 4 shows that the difference in life expectancy among Nicaraguan men who have higher education and those who have no education is about 12 years. In Zambia, which is very hard hit by HIV/AIDS, the absolute difference is less because AIDS tends to affect all educational groups, but, even there, the more educated have a life expectancy that is 20% higher than that of the uneducated.

It is interesting to note that this important influence of education on health and survival does not disappear as countries become more developed. For example, a study using data from Austria in the 1980s shows that the mortality risk for the age group 35-64 is twice as high for men with basic education as it is for men with tertiary education. For women, the same ratio is about 1.5 (Lutz *et al*., 1999). Translated into life expectancy, this educational difference is 6-7 years, which is comparable to the differential between the sexes. In the countries of Eastern Europe, the educational mortality and health differential is even bigger.

	Guinea	Zambia	Nicaragua
No education	204	198	72
Primary	162	177	43
Secondary	104	124	26
Higher			19
Total	195	NA	45

Table 3. Under-five mortality rates (5q0) per 1,000 live births by mother's level of education in Guinea, Zambia, and Nicaragua. Sources: DHS Guinea 1999; DHS Nicaragua 2001; DHS Zambia 2002.

	Guinea	Zambia	Nicaragua
Males			
No education	46.7	30.7	62.7
Primary	51.5	32.7	68.2
Secondary	55.5	36.0	72.8
Higher	55.5	36.0	74.5
Total	48.8	32.7	67.2
Females			
No education	48.3	30.6	67.5
Primary	53.3	32.3	72.7
Secondary	59.0	36.0	76.7
Higher	59.0	36.0	78.3
Total	49.5	32.1	71.9

Table 4. Estimated life expectancy at birth by sex, education, and country in 2000-2005. Sources: DHS Guinea 1999; DHS Nicaragua 2001; DHS Zambia 2002.

Conclusions

Over the course of the 21st century the world will likely see large demographic changes quite different from those observed during the 20th century. The population will continue to grow substantially in some of the poorest countries, while it will age massively in the richer countries. For all countries, these trends will pose major new health threats. The 21st century will also see an increasingly urbanized population. It is estimated that more than half of the world population will live in urban areas within a few years. This will bring new health problems, such as those associated with a sedentary lifestyle, air pollution, and possibly higher transmission rates of infectious diseases. These well-established demographic changes have not yet been studied sufficiently well with respect to their consequences for human health and well-being.

This paper adds a potentially very important new aspect to the analysis – namely, global change in the composition of the population by education. Given the very strong link between education and health, the fact that we are likely to see significant improvements in the educational composition of populations around the world is good news. In addition, a better-educated population can be assumed to be less vulnerable to new health threats

resulting from environmental change or other global influences, and to show a greater adaptive capacity. Unfortunately, some countries are clearly falling behind in the improvement of their human capital.

REFERENCES

Coale, A.J. (1973), The demographic transition. In: *Proceedings of the International Population Conference*, Vol. 1, Liege, Belgium: International Union for the Scientific Study of Population.

Davis, K. (1991), Population and resources: fact and interpretation, pp. 1-21. In: K. Davis and M.S. Bernstam (eds.), *Resources, Environment and Population: Present Knowledge*, Oxford: Oxford University Press.

Davis, K. (1954), The world demographic transition, *Annals of the American Academy of Political and Social Science*, 237: 1-11.

Huynen, M., and P. Martens, Globalisation and human health: towards scenarios for the 21st century. In: *Interactions Between Global Change and Human Health* (*Scripta Varia* 106), edited by M.O. Andreae, D.E. Bloom, U. Confalonieri, & A.J. McMichael, pp. 269-289, The Pontifical Academy of Sciences, Vatican City, 2006.

Lutz, W. and J. Goldstein (Guest Eds.) (2004), How to deal with uncertainty in population forecasting?, *International Statistical Review 72* (1 & 2): 1-106, 157-208.

Lutz, W., A. Goujon, and A. Wils. 2004a, *Forecasting Human Capital: Using Demographic Multi-State Projection Methods to Show the Long-Term Effects of Near-Term Investments in Education*, World Bank Working Paper, Washington, D.C.: The World Bank (forthcoming).

Lutz, W., W.C. Sanderson, and S. Scherbov (Eds.) (2004b), *The End of World Population Growth in the 21st Century: New Challenges for Human Capital Formation and Sustainable Development*, London: Earthscan.

Lutz, W., W. Sanderson, and S. Scherbov (2001), The end of world population growth, *Nature*, 412: 543-545.

Lutz, W., A. Goujon, and G. Doblhammer-Reiter (1999), Demographic dimensions in forecasting: Adding education to age and sex, pp. 42-58. In: W. Lutz, J.W. Vaupel, and D.A. Ahlburg (eds.), *Frontiers of Population Forecasting*. A Supplement to Vol. 24, 1998, Population and Development Review, New York: The Population Council.

Lutz, W., W. Sanderson, and S. Scherbov (1997), Doubling of world population unlikely, *Nature*, 387: 803-805.

Notestein, F.W. (1945), Population: The long view, pp. 36-57. In: T.W. Schultz (ed.), *Food for the World*, Chicago: University of Chicago Press.

Tabah, L. (1989), From one demographic transition to another, *Population Bulletin of the United Nations*, 28: 1-24.

United Nations (2003), *World Population Prospects: The 2002 Revision*, New York: United Nations.

United Nations (1999), *Long-Range World Population Projections: Based on the 1998 Revision*, New York, United Nations, ESA/P/WP.153.