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7 Billion and Counting

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REVIEW

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The world is currently in the midst of the greatest demographic upheaval in human history. Dramatic reductions in mortality, followed (but with a lag) by equally marked reductions in fertility, resulted in a doubling of world population between 1960 and 2000. A further increase of 2 to 4.5 billion is projected for the current half-century, with the increase concentrated in the world's least developed countries. Despite alarmist predictions, historical increases in population have not been economically catastrophic. Moreover, changes in population age structure have opened the door to increased prosperity. Demographic changes have had and will continue to have profound repercussions for human well-being and progress, with some possibilities for mediating those repercussions through policy intervention.

Throughout most of human history, the pace of growth of world population has been extremely slow (*1*–*3*). World population did not reach 1 billion until around 1800, and it took another century and a quarter to reach 2 billion. But the world is currently in the midst of a period of substantially faster population growth, increasing from 3 to 7 billion within the space of the past half-century (*4*, *5*). In 2011, there will be ~135 million births and 57 million deaths, a net increase of 78 million people. According to the latest medium-fertility projections of the Population Division of the Department of Economic and Social Affairs of the United Nations (UN) (*5*), world population will continue to grow throughout this century, reaching 9.3 billion in 2050 and 10.1 billion in 2100 (*6*). There is, however, considerable uncertainty surrounding these projections, especially as one looks further into the future (*7*). For example, UN Population Division projections of world population in 2050 range from 8.1 billion to 10.6 billion under the low- and high-fertility projections, respectively; the corresponding range for 2100 is 6.2 billion to 15.8 billion (*8*, *9*). In the low-fertility projection, world population will peak at roughly 8.1 billion around 2045. In the high-fertility projection, it will peak after 2100 at a figure higher than 15.8 billion.

Population Size and Growth

China, with 1.35 billion people, currently has the largest population in the world, followed by India, with 1.24 billion. Three developed countries (the United States, Russia, and Japan) are in the top 10. In 2050, India will be the most populous country, with a projected population of 1.69 billion, compared with China's 1.30 billion. At that time, the United States will be the only currently developed country among the world's 10 largest countries. Particularly notable will be Nigeria's rapid rise, from the seventh- to the fourth-largest population (and with a population nearly equal to that of the United States), and the disappearance of Russia and Japan from the top 10 list.

Table 1 reports summary data from (*5*). The figures show that population growth rates have varied greatly by level of development. As currently categorized by the UN Population Division, "less developed regions" have long been growing much faster than "more developed regions." The former, which accounted for 68% of world population in 1950, represent 82% in 2011 and are projected to constitute 86% by 2050. Nearly all (97%) of the 2.3 billion population increase projected to occur between now and 2050 will take place in the less developed regions, with 38% taking place in the "least developed countries" (*10*, *11*). Those countries, which currently make up 12% of world population, tend to be the economically, socially, environmentally, and politically most fragile countries of the world.

The UN Population Division divides the world into six geographic regions: Africa, Asia, Europe, Latin America and the Caribbean, North America, and Oceania. The data in Table 2 show that there is considerable demographic heterogeneity across these regions, although the projected rate of growth between 2000 and 2050 is lower than the rate of growth between 1950 and 2000 in all of them. During 1950 to 2000, Africa had the highest regional rate of population growth (2.5% per year), followed by Latin America (2.3%) and Asia (1.9%). During this half century, the rates in Latin America and Asia are expected to fall to 0.7% and 0.6%, respectively, whereas Africa's rate will remain high (2.0%), corresponding to a population doubling time of roughly 35 years. The population of Europe is projected to remain essentially flat.

Asia is and will continue to be home to a dominant share of the world's population (60% today and 55% in 2050). Africa, the second most populated region, also stands out in the UN Population Division figures. Africa's billion represents only 15% of world population today, but the UN Population Division projections indicate that Africa will account for 49% of global population growth over the next four decades, increasing its share of world population to 24%.

Even within geographic regions, there is much variation in the rate of population growth. In Asia, for example, population growth varies widely, from a current annual rate of 3.1% in Afghanistan and Iraq to 0.5% in China, −0.1% in Japan, and -0.6% in Georgia. The rate in Latin America and the Caribbean ranges from 2.5% in Guatemala to 0.9% in Brazil to −0.04% in Cuba. The rate in African countries ranges from 3.5% in Niger to 0.6% in Mauritius and South Africa. Among developed countries, rates include 1.4% in Australia, −0.04% in Japan, and −0.8% in Moldova.

The urban share of global population increased from 29% in 1950 to 51% in 2011 and is projected to reach 69% in 2050 (Table 1). Asia and Africa are the least urbanized regions of the world (43% and 40%, respectively), and North America, at 82%, is the most urbanized (Table 2). (But many locations that are classified as nonurban according to a particular country's definition are effectively part of a nearby urban area and might be classified as urban by another country's definition or even by its own definition at some other point in time.) Urbanization may spur economic growth due to economies of scale, but it has also created problems (such as intense pressure on land, air, and water resources and life in squalid slum conditions, under which an estimated 1 billion people live) associated with sprawling megacities [urban areas with a population of 10 million or more, which, despite their prominence, account for less than 5% of world population (*12*)]. Although the role of urbanization in fostering economic growth continues to be debated, there are many examples of cities that appear to demonstrate the importance of urbanization in creating strong economies (*13*, *14*).

Population density varies considerably across regions, and it has increased greatly over time. Asia is by far the densest region, with 132 people per km^2—roughly four times the corresponding figures for Africa, Europe, and Latin America and the Caribbean. North America and especially Oceania are much less densely populated. The most densely populated countries are Monaco (nearly 24,000 people per km^2), Singapore (7600), and Bahrain (1900), whereas the least dense are Mongolia (1.8), Namibia (2.8), and Australia (2.9). Population density was, of course, much lower in 1950, when it ranged from 1.5 in Oceania to 44 in Asia.

Is population growth impoverishing? The impact of population growth on economic growth is one of the oldest issues in the field of economics, dating back at least to Thomas Malthus's 1798 *An Essay on the Principle of Population*. Malthus argued that population would grow geometrically, as a result of the irrepressible "passion between the sexes," and ultimately faster than the arithmetic rate of growth of output. He direly predicted that

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Table 1. Main demographic indicators by level of development. Source: For urban share, (*12*); all other data from (*5*). Note: "More developed regions" comprise Europe, North America, Australia/New Zealand, and Japan. "Less developed regions" comprise Africa, Asia (excluding Japan), Latin America and the Caribbean, Melanesia, Micronesia, and Polynesia. This highly aggregated country classification dates from the 1960s and has been quite stable over time. It changed most notably after the breakup of the former Soviet Union in 1991, with Belarus, Estonia, Latvia, Lithuania, Moldova, Russia, and Ukraine being grouped with the more developed regions (in Europe), and the other new countries becoming part of the less developed regions (in Asia). Before that, the USSR was included among the more developed regions (in Europe).

Year(s)	World	More developed regions	Less developed regions
	Population (billions)		
1950	2.5	0.8	1.7
2000	6.1	1.2	4.9
2011	7.0	1.2	5.7
2050	9.3	1.3	8.0
2100	10.1	1.3	8.8
	Annual average population growth rate, %		
1950–2000	1.8	0.8	2.1
2000–2050	0.8	0.2	1.0
2050–2100	0.2	0.0	0.2
	Total fertility rate		
1950	5.0	2.8	6.2
2000	2.7	1.6	2.9
2011	2.5	1.7	2.6
2050	2.2	2.0	2.2
2099	2.0	2.1	2.0
	Life expectancy		
1950	46	65	41
2000	66	75	64
2011	69	78	67
2050	76	83	75
2099	81	88	80
	Under-five mortality rate		
1950	209	79	240
2000	78	10	85
2011	62	8	68
2050	30	6	33
2099	14	4	16
	% aged 60 and older		
1950	8	12	6
2000	10	20	8
2011	11	22	9
2050	22	32	20
2100	28	32	27
	Ratio of working-age to non–working-age population		
1950	1.53	1.84	1.41
2000	1.70	2.07	1.62
2011	1.91	2.05	1.89
2050	1.72	1.36	1.79
2100	1.49	1.28	1.52
	Youth dependency ratio		
1950	0.57	0.42	0.64
2000	0.48	0.27	0.53
2011	0.40	0.25	0.44
2050	0.32	0.29	0.33
2100	0.30	0.30	0.30
	Urban share, %		
1950	29	53	18
2000	46	73	40
2011	51	75	46
2050	69	86	66
2100	Not projected		

Table 2. Main demographic indicators by geographic region. Source: For urban share, (*12*); all other data from (*5*). For region definitions, see http://esa.un.org/unpd/wpp/Excel-Data/country-classification.pdf (View interactive map at www.scim.ag/oJ8l8Y.)

Year(s)	Africa	Asia	Europe	Latin America and the Caribbean	North America	Oceania
			Population (billions)			
1950	0.2	1.4	0.5	0.2	0.2	0.0
2000	0.8	3.7	0.7	0.5	0.3	0.0
2011	1.0	4.2	0.7	0.6	0.3	0.0
2050	2.2	5.1	0.7	0.8	0.4	0.1
2100	3.6	4.6	0.7	0.7	0.5	0.1
			Annual average population growth rate, %			
1950–2000	2.5	1.9	0.6	2.3	1.2	1.8
2000–2050	2.0	0.6	0.0	0.7	0.7	1.1
2050–2100	1.0	–0.2	–0.1	–0.2	0.3	0.4
			Total fertility rate			
1950	6.6	6.0	2.6	5.9	3.1	3.7
2000	5.1	2.5	1.4	2.6	2.0	2.4
2011	4.4	2.2	1.6	2.2	2.0	2.5
2050	2.8	1.9	1.9	1.8	2.1	2.2
2099	2.1	1.9	2.1	1.9	2.1	2.0
			Life expectancy			
1950	37	42	64	50	68	60
2000	52	67	73	71	77	74
2011	57	70	76	74	79	77
2050	69	77	82	80	83	83
2099	77	82	88	85	89	87
			Under-five mortality rate			
1950	294	230	93	198	35	92
2000	150	66	11	36	8	35
2011	116	50	9	25	8	25
2050	45	26	6	11	6	11
2099	19	14	4	4	4	6
			% aged 60 and older			
1950	5	7	12	6	12	11
2000	5	9	20	8	16	13
2011	6	10	22	10	19	15
2050	10	24	34	25	27	24
2100	20	32	33	34	31	30
			Ratio of working-age to non–working-age population			
1950	1.23	1.46	1.91	1.29	1.82	1.69
2000	1.20	1.75	2.09	1.66	1.98	1.81
2011	1.29	2.08	2.13	1.89	2.01	1.87
2050	1.69	1.82	1.34	1.75	1.49	1.58
2100	1.75	1.39	1.29	1.27	1.30	1.38
			Youth dependency ratio			
1950	0.76	0.61	0.40	0.71	0.42	0.48
2000	0.78	0.48	0.26	0.51	0.32	0.40
2011	0.71	0.38	0.23	0.42	0.30	0.37
2050	0.49	0.27	0.28	0.27	0.31	0.33
2100	0.34	0.27	0.30	0.28	0.31	0.30
			Urban share, %			
1950	14	16	51	41	64	62
2000	36	37	71	75	79	70
2011	40	43	73	80	82	70
2050	62	65	84	89	90	75
2100			Not projected			

poverty and human misery would be the unavoidable result. Malthus's perspective was subsequently and loudly echoed in 1968 (*15*) while the world was in the midst of adding 3 billion people to double its population in the space of four decades. Other scholars adopted the diametrically opposite perspective, arguing that resource shortages would stimulate human ingenuity and lead to rapid technological advancement and institutional innovation—and that these developments would spur rapid increases in food production and living standards and avoid mass misery (*16*–*18*). In the mid-1980s, yet another view—population neutralism—surfaced, according to which there was no appreciable connection between population growth and economic growth (*19*). See (*20*) for an ambitious examination of the interplay of demographic change and economic growth over the very long term.

Demographic Transition

The standard framework used by population specialists to describe the dynamic process of population growth is known as the demographic transition [see (*21*–*23*) for good historical overviews]. Figure 1 presents a stylized version of this framework under the assumption of zero net migration, showing the transition from a regime of high fertility and mortality to one of low fertility and mortality (with low population growth at both ends). A key feature of the transition is that the mortality decline (in brownish red) precedes the fertility decline (in green), the result being a transitional period of population growth (*24*–*27*).

Mortality decline is conventionally understood to be reflective of some combination of medical advances (especially vaccines and antibiotics); dietary improvements; and public health measures focused on sanitation, safe drinking water, and vector control. As development proceeds, the process gains further impetus from income growth, the expansion of education (especially that of mothers), declines in the level of fertility, and increases in the length of interbirth intervals.

Fertility decline is often triggered by parents' realization that they no longer need to bear as many children to achieve their desired family size, and desired family size may itself moderate with education and income gains, especially among women. Fertility decline is further enabled by access to contraception, such as female sterilization (currently used by 19% of women worldwide), intrauterine devices (14%), oral contraceptives (9%), and male condoms (8%) (*28*). Approximately 215 million women in the developing world have an unmet need for family planning (*29*–*31*). Lower fertility, in turn, promotes improvements in child survival and well-being because of improvements in maternal health and because parents can devote more resources to each child in smaller families. A higher rate of child survival further reinforces low fertility.

In addition to population growth, the demographic transition also leads to change in population age structure. This change occurs because the initial decline in mortality is disproportionately enjoyed by infants and children, which effectively launches a "baby boom" generation that lasts until fertility subsequently declines. Age structure figures prominently in Coale and Hoover's (*32*) seminal analysis of the effect of population change on economic growth and also in more recent literature on the "demographic dividend," discussed below.

Mortality

Although life expectancy at birth incorporates information on mortality but not morbidity, it is the most common indicator of overall population health (*33*). Among the most notable human achievements ever is the fact that life expectancy, which hovered in the vicinity of 30 years throughout most of human history, rose by more than two decades since 1950 for the world as a whole. In the more developed regions, the increase was from 65 to 78; in the less developed regions, life expectancy rose from 41 to 67 (Table 1). The contribution of medical and public health innovations to long-term health improvements is highlighted by Preston and Cutler *et al*. (*34*, *35*), whereas McKeown and Fogel (*36*, *37*) place more emphasis on improved nutrition.

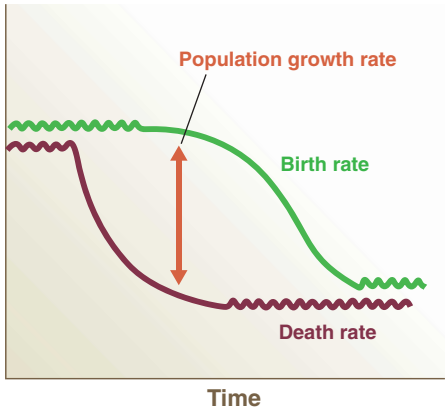

Fig. 1. Stylized model of the demographic transition.

Life expectancy varies modestly among developed countries (Switzerland stands at 82, the United States at 79, and Hungary at 74). Variation is substantially greater among developing countries (life expectancy in Costa Rica is 79 versus 73 in Egypt and 53 in South Africa). Worldwide, life expectancy varies by a factor of 1.7, from 48 in Sierra Leone to 83 in Japan (*38*, *39*). Other indicators of substantial cross-country health inequities include disparities in rates of infant mortality (which varies by a factor of 67), under-five mortality (factor of 88), and maternal mortality (factor of 2100) (*40*–*42*).

Historically, life expectancy has been powerfully driven by the infant mortality rate (IMR); that is, the number of children who die before their first birthday in a given year per thousand live births in that year. Worldwide, IMR fell from 139 in 1950 to 43 at present. In more developed regions, it fell from ~68 in 1950 to 6 today. In contrast, IMR in the less developed regions was 156 in 1950 and currently stands at 47. Similarly, since 1950, the under-five mortality rate (U5MR, deaths under age five per 1000 live births) has declined by 90% (to 8) in more developed regions and by 72% (to 68) in less developed regions. Notably, there is not a single country in the world for which IMR and U5MR have not fallen since 1950. The infant mortality rate has been identified as a strong and robust predictor of state failure, presumably because of the erosion of public trust that results when government is unable to provide for parents' fundamental interests in the survival of their children (*43*–*45*).

Infant mortality rates tend to be substantially lower in urban areas than rural areas, primarily because of higher income and education and better access to emergency care and skilled health personnel. However, poor urban women are much less likely than well-off urban women to deliver with a skilled birth attendant, indicating some inequities in this urban-based advantage.

In most countries and at most times since 1950, life expectancy has been increasing. A notable exception was the mortality pattern in Russia after the dissolution of the Soviet Union. According to UN data, life expectancy in what is now the Russian Federation part of the former Soviet Union rose from 64 in 1950 to 69 in 1961, a figure that remained fairly steady (with some small deviations) through the late 1980s. In the early 1990s, at the same time that it became a country separate from the other former Soviet republics, Russia saw a precipitous drop in life expectancy: to 65 in 2000. This decline corresponds to roughly 1.5 million premature deaths, which affected working-age men more than any other demographic group. The underlying causes of the precipitous fall in life expectancy are not certain. But the many dislocations—physical, economic, and psychological—brought about by the fall of the Soviet Union are probably a core part of the explanation. In addition, these changes may have had their effects amplified by alcohol consumption, the weakening of the health system, and deteriorating environmental conditions (*46*–*49*). By 2009, life expectancy in Russia had recovered to its Gorbachev-era level of 68.

In some countries, life expectancy has also been substantially depressed by HIV/AIDS. Of the 57 million people who died of all causes, globally, in 2009, 1.8 million (or 3.2%) died of AIDS. Among those who died of AIDS, 72% lived in sub-Saharan Africa. In some countries, the AIDS epidemic temporarily reversed the substantial increase in life expectancy that had taken place between 1950 to1980. For example, life expectancy in Zimbabwe fell from a high of 61.7 in 1987 to a low of 43.2 in 2003, although it has now made

a partial recovery to 51.4. To varying lesser extents, Botswana, Lesotho, South Africa, Swaziland, and Zambia, experienced much of the same pattern. Overall, AIDS has had a particularly large effect on life expectancy in part because it disproportionately affects people in the prime reproductive years. Nearly three-quarters of people who died of AIDS during the past 15 years were between the ages of 15 and 49 (*50*).

One of the more interesting issues in the field of demography pertains to the future of longevity. Olshansky *et al*. (*51*) and Fries (*52*) argue that infant and child mortality are already so low that future increases in life expectancy cannot be more than minimal; advocates of this view also highlight the effects of major new health threats such as avian flu, antibiotic resistance, war, climate change, and obesity. In contrast, Oeppen and Vaupel (*53*) emphasize the large potential increase in life expectancy inherent in a "perfectly healthy" life-style (i.e., one in which people receive all available vaccinations and take advantage of continually improving medical care; adopt low-fat, low-calorie diets; use seat belts; increase levels of physical activity; cease the use of tobacco; and do not abuse alcohol or other drugs). Both views are consistent with a compression of the morbid years (in which people suffer from chronic disease, their minds and bodies break down, and they lose their functional independence) into a smaller part of the life cycle, either absolutely or relatively. They are also consistent with growing evidence of other improvements in people's capacities in their 60s and beyond (*54*).

On average, a woman's life expectancy is 4.5 years greater than a man's (71.2 versus 66.7), up from just 2.1 years in 1950, presumably reflecting a rise in the education and autonomy of women relative to that of men. The female advantage is greater (6.8 years) in more developed regions and smaller (3.7 years) in less developed regions. Women have the largest life-expectancy advantage in Russia (12 years), a gap that has widened considerably over the past two decades (since the transition of the Soviet Union to a market economy). Biological differences account for some, but not all, of the difference in life expectancy between women and men; life-style and environmental factors matter as well (*55*).

Some countries have higher sex ratios at birth and ratios of boys to girls, aged 0 to 4 years, than do other countries. In the more developed regions, the ratios of 0- to 4-year-olds are 1.06 and 1.05, respectively. In less developed regions, both ratios are 1.07 [and in India they are 1.08 and 1.09; for more on India, see (*39*, *56*)]. China is perhaps the most notable case: Its sex ratio at birth was 1.07 in 1970, but it rose rapidly beginning in the late 1980s and stands at 1.18 today. Similarly, the ratio of boys to girls, aged 0 to 4, rose from 1.08 in 1970 to an astounding 1.21 today. China's long-standing one-child policy, operating in conjunction with son preference, is thought to be the reason for the high sex ratio in that country. Son preference results in discrimination against girls through such mechanisms as in utero sex determination coupled with sex-selective abortion, female infanticide, and neglect of female children (*57*) [for more on China, see (*58*)]. Guilmoto (*59*) provides a comprehensive review of sex selection in Asia, including the fact that in some areas the high sex ratio at birth is beginning to decline, along with a discussion of the factors that may lead to it increasing in other areas.

Fertility

Declining fertility is another aspect of the major demographic upheaval the world has undergone in the past 60 years. Table 1 shows that the world's total fertility rate (TFR) fell quite sharply from 5.0 in 1950 to 2.5 at present. The decrease is largely attributable to fertility decline in the developing world (from 6.2 to 2.6). TFR currently stands at 4.4 in Africa, 2.2 in Asia, 2.2 in Latin America and the Caribbean, 2.0 in North America, and 1.6 in Europe.

There is considerable heterogeneity in TFR within regions. In Tunisia, for example, TFR stands at 2.0, as compared with 3.2 in Namibia, 5.3 in Angola, and 7.0 in Niger. Asia's TFRs include 1.4 in Japan, 1.6 in China, 2.6 in India, and 6.2 in Afghanistan. Latin America and the Caribbean has less but still notable variation: 1.8 in Brazil and 3.9 in Guatemala. Europe has minimal heterogeneity, with TFR in all countries falling between 1.1 and 2.2.

The pace of TFR decline has varied widely across countries. TFR in Bangladesh, for example, fell by 4.2 children per woman in the space of 30 years. Iran's TFR fell even more rapidly: by 4.5 in just 20 years. Both countries had very active family planning programs. China's TFR began to decline in the 1970s with the "later, longer, fewer" campaign, and by the time its one-child policy was implemented at the end of the decade, TFR had already fallen to ~2.6; according to the UN Population Division, China's TFR now stands at 1.6. India was the first country to introduce a government-sponsored family planning program in 1951 (*58*). Concern about continued population growth led to the adoption of coercive measures for restricting births for nearly a year during the mid-1970s. The public opposed some aspects of this program, it was cancelled, and many Indians were left broadly wary of family planning programs. In contrast to rapid declines seen elsewhere, India's TFR has fallen steadily but gradually since the 1970s, reaching 2.6 today (*39*).

Unlike infant mortality, which has fallen reasonably steadily in nearly all countries, the pace of fertility decline has been slow in some regions and countries. In particular, although TFR decline has begun everywhere, it has been relatively slow in much of sub-Saharan Africa and in a few other countries, such as Afghanistan, Guatemala, Iraq, and Pakistan. Concomitant with high fertility in sub-Saharan Africa is the region's high desired fertility. Reasons for this include gender inequality; low levels of education and earnings among women; the relative absence of financial institutions that, in other regions, provide a means to save rather than relying on future support by children; the value of children as workers; and the absence of well-funded family planning programs that, among other activities, provide counseling on desired family size.

The effect of family planning on fertility is somewhat controversial. Demographers generally attribute a high share of fertility decline to the expansion of family planning programs (*60*, *61*). In contrast, some economists (*62*) argue that family planning has little effect on fertility, independent of changes in desired fertility, or that fertility decline is brought about primarily by economic advances, improved education (*63*), and greater opportunities for women, with the role of family planning programs being to enable these influences to affect fertility (*64*). Similarly, Miller (*65*) finds that "family planning explains less than 10% of Colombia's fertility decline during its demographic transition." Experience and studies in West Africa suggest that provision of family planning alone is not necessarily what appeals to families in high-fertility settings; in the Navrongo experiment in Ghana, family planning services were well-integrated with community health services, and that seems to have been a key to success (*66*). At issue is the extent to which "development is the best contraceptive" or as the originator of this phrase, Karan Singh, the former Minister of Health and Family Planning of India, more recently opined, "contraception is the best development."

Even as TFR falls toward 2.1 in most countries, it has already fallen that far or further in some others (e.g., Japan, Brazil, China, and nearly all of Europe) (*67*, *68*). TFR below replacement will eventually result in population decline (absent sufficient net in-migration), but not immediately, due to the phenomenon of population momentum. The large cohorts of babies born before fertility declines become large cohorts of childbearing-age adults. Even though these adults have fewer children per couple than did previous generations, the fact that they are so numerous means that a large number of babies are born. This process gradually damps down, but in the meantime, population has continued to grow even as TFR was declining. Population momentum explains why the U.S., which has had a TFR below 2.1 since the early 1970s, has grown by 100 million people since 1972 (well in excess of the 37 million net immigrants). It also explains why Africa's population is projected to increase by half a billion people by 2050 (a 50% increase over today's population), even if TFR were to drop to 2.1 today.

Age Structure

As pronounced as actual and projected rates of population growth are two sets of changes in the age structure of population. The first involves

changes in the working-age share of the population, due to contemporaneous and past changes in fertility and mortality. The second is the rising share of those who, by traditional standards, are considered to be elderly (that is, those aged 60 and over). This increase reflects a combination of influences: increased longevity, declining fertility, and the aging of "baby boom" generations.

Working-age share. Taking ages 15 to 64 as the working ages (as demographers often do), the ratio of the working-age to the non–working-age population increased in the developed countries from 1.84 to 2.05 from 1950 to 2011. In contrast, this ratio has been lower in the developing countries, but has also increased more sharply, from 1.41 to 1.89. Within the developing world, the fastest growth in this ratio during this period took place in East/Southeast Asia (from 1.51 to 2.39), and the slowest in sub-Saharan Africa (a decline, from 1.22 to 1.20).

Figure 2, A and B, allows us to compare population age structures in East/Southeast Asia and sub-Saharan Africa during 1950 to 2050. The slices represent age distributions at successive 5-year intervals (i.e., for "synthetic cohorts"). One can identify true birth cohorts by moving diagonally (adding 5 years of age for each successive slice).

Both graphs show the considerable rise in population that has taken place since 1950, with Fig. 2B also showing that the population of sub-Saharan Africa will continue to increase sharply in the next four decades. The graph for East/Southeast Asia shows that the age structure of the population has changed dramatically since 1950, when it was heavily skewed toward the young. The bulge in that region's age structure now is in the working-age population, and that bulge is gradually moving toward the older end of the working-age years. Sub-Saharan Africa, in contrast, shows a much slower change in population age structure, with continuing increases in the number of young people.

The demographic dividend. In recent years, economists have paid increasing attention to population age structure. This interest reflects the fact that large baby-boom cohorts initially contribute to a high rate of youth dependency (*69*), subsequently fueling growth of a relatively large working-age cohort, and eventually leading to a high rate of elderly dependency.

The literature now includes evidence of a "demographic dividend," the tendency for economic growth to be spurred by rapid growth of the working-age share of the population. The demographic dividend is a composite of accounting and behavioral forces that are key to the accumulation of physical and human capital and technological innovation. The accounting forces involve: (i) the swelling of the potential labor force as large youth cohorts reach working age and (ii) the tendency for savings rates to be relatively high during a key segment of the working-age years (*70*). The behavioral forces consist of: (i) society's reallocation of resources from investing in children to investing in physical capital, job training, technological progress, and stronger institutions, (ii) the rise in women's participation in the workforce that naturally accompanies a decline in fertility, and (iii) the boost to savings that occurs because the incentive to save for longer periods of retirement increases as people live longer.

Past differences in age structure between East/Southeast Asia and sub-Saharan Africa are consistent with higher and more rapidly growing income in the former than in the latter. Figure 3 shows the rapid rise in the ratio of working-age to non–working-age people in Indonesia and the similarly timed rise in gross domestic product (GDP) per capita, along with the corresponding figures for Nigeria (which show comparatively little variation in the same demographic and economic indicators). These countries provide an especially interesting comparison, as they both have substantial Muslim populations, are major oil exporters, and had roughly similar GDP per capita and age structures in 1960 and similar infant mortality rates and life expectancies in the 1950s.

Estimates indicate that as much as one-third of the "miracle" economic growth in East Asia between 1965 and 1990 can be accounted for by changes in age structure associated with the region's rapid demographic transition (*19*, *71*). Similarly, the process of legalizing birth control in Ireland that began around 1980 sparked a decrease in fertility that helped spur its rapid economic growth in the 1990s (*19*). The economic slowdown that began in Ireland in the 2000s highlights the fact that demography is, in reality, not destiny, and that economic performance has myriad drivers. In contrast, the chronic burden of youth dependency in most of sub-Saharan Africa has contributed to that region's decades-long economic struggle. However, between now and 2050, the working-age to non–working-age ratio is projected to increase sharply in sub-Saharan Africa. This creates the prospect of a demographic dividend in the poorest region of the world, although there is considerable uncertainty about the magnitude and timing of the dividend, corresponding to demographic uncertainty.

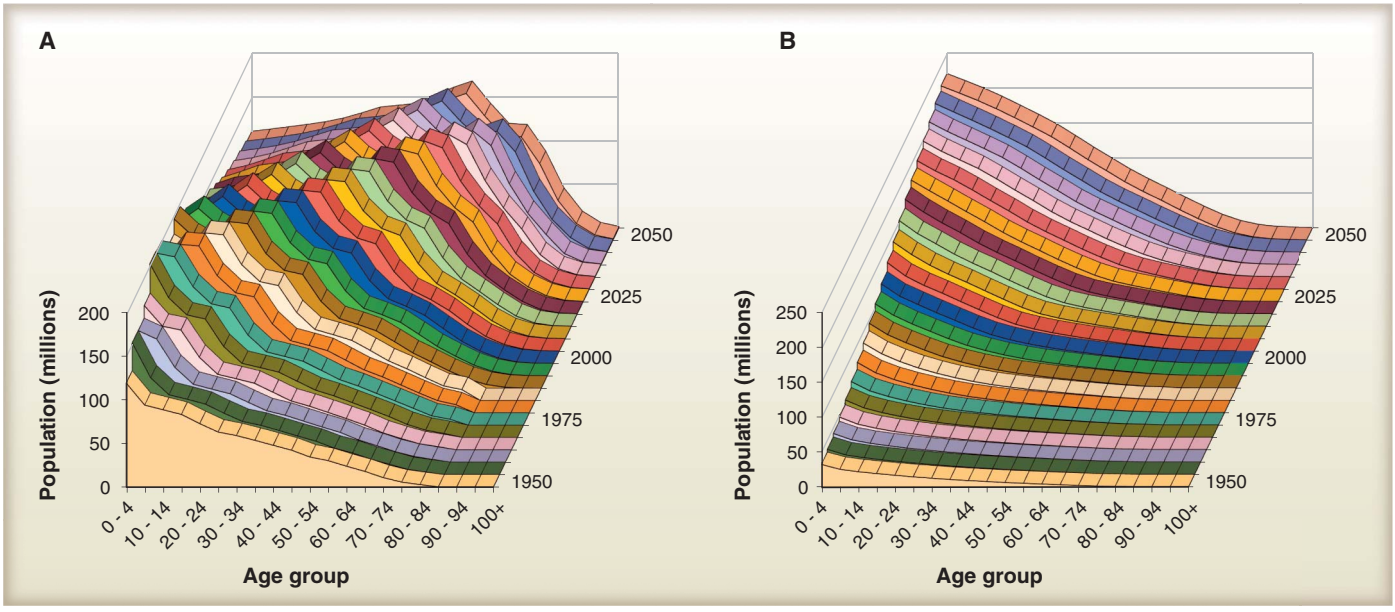

Fig. 2. (**A**) Age structure of East/Southeast Asia, 1950 to 2050. The countries and areas of East/Southeast Asia are Brunei Darussalam, Cambodia, China, Hong Kong, Indonesia, Japan, South Korea (Republic of Korea), North Korea (Democratic People's Republic of Korea), Lao PDR, Macao, Malaysia, Mongolia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, and Vietnam. (**B**) Age structure of sub-Saharan Africa, 1950 to 2050. Sub-Saharan Africa includes 49 countries or areas.

The current ratio of 1.20 working-age people to non–working-age people is projected to increase to 1.89, 1.67, and 1.49 under the low-, medium-, and high-fertility projections, respectively. In every other region, this ratio is projected to decline (under the medium-fertility assumption).

Where a country stands in the demographic transition will determine the kinds of policies and initiatives it can most usefully undertake to help bring about a demographic dividend. For example, some countries could catalyze the demographic transition by taking steps to lower infant and child mortality—crucial precursors of fertility decline—through the expansion of childhood immunization and the provision of safe water and sanitation. Others might accelerate the transition by encouraging a voluntary reduction of fertility, perhaps through efforts to broaden access to primary and reproductive health services and to girls' education. But economic growth does not automatically accelerate as fertility declines and the working-age share of a population increases. Taking advantage of a demographic opportunity (that is, capturing the demographic dividend) depends on a conducive policy environment. Good governance matters, as do solid macroeconomic management; a carefully designed trade policy; efficient infrastructure; well-functioning financial and labor markets; and effective investments in health, education, and training that promote a broad distribution of the benefits of economic growth [for more on education, see (*63*)].

Adolescents and young adults are an often-unrecognized but important agent of change in many countries. Their energy and ideas may transform today's political and economic structures. Right now, people aged 15 to 24 outnumber those aged 60 and above by 54%, but the world's rapidly changing age structure will see the size of these two groups equalize shortly after 2025, after which those over age 60 will come to rapidly outnumber adolescents and young adults.

Population aging. The UN Population Division projects an increase in the number of those aged 60 or over from just under 800 million today (representing 11% of the world's population) to just over 2 billion in 2050 (representing 22% of the world's population). Even more noteworthy, the number of those aged 80 and over, whose needs and capacities are substantially different from those in their 60s and 70s, is projected to increase by 270% between now and 2050. Currently, Japan has the largest share of population aged 60 and over (31%); it is projected to reach 42% by 2050. Notably, 42 countries are projected to have a higher proportion of people aged 60 and over in 2050 than Japan has now.

Population aging has raised sharp concerns about the need for, and fiscal integrity of, healthcare systems, partly due to the fact that age is a major risk factor for noncommunicable diseases such as cardiovascular disease, cancer, and diabetes. Noncommunicable diseases, which are currently responsible for roughly 60% of all deaths (*72*), tend to have relatively high treatment and care costs (*73*), with the prospect of even greater costs as new medical technologies are introduced and access to health care becomes increasingly universal. To counterbalance these cost increases, we may expect to see a greater emphasis on disease prevention and on screening aimed at early detection.

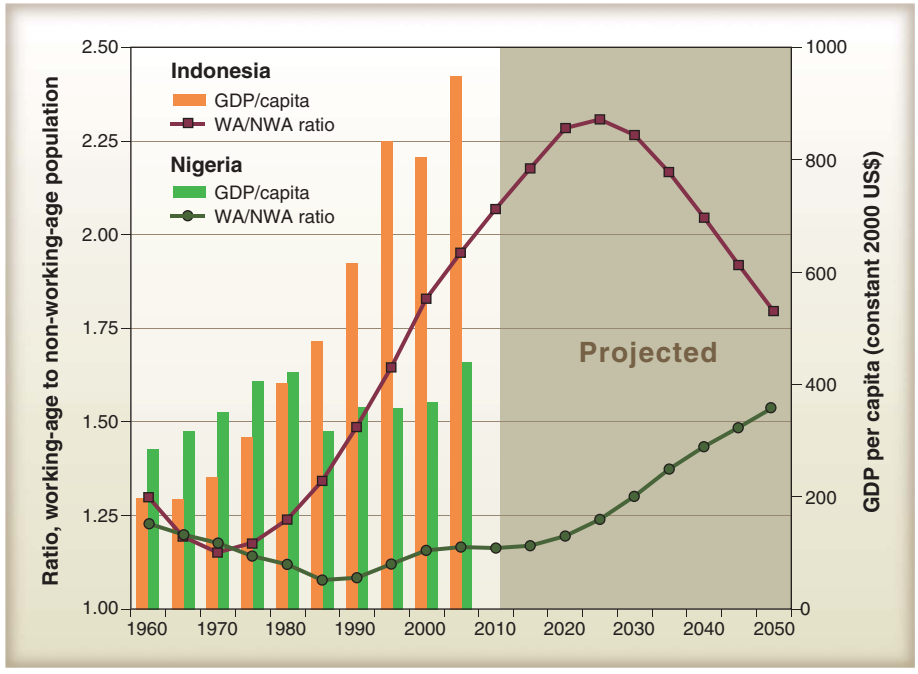

Fig. 3. Indonesia and Nigeria: Close alignment between changes in GDP per capita and ratio of working-age (WA) to non–working-age (NWA) population. Source: GDP per capita data are from (*41*).

Economic security of the elderly is also challenged by population aging. Pay-as-you-go pension systems, under which current workers fund the pension benefits of current retirees, can be undermined by population aging. Traditional family-based support systems can also be greatly stressed, especially under conditions of low fertility and increased mobility of the younger generation. Population aging also raises concerns about savings rates, falling asset values, the supply of workers, and economic growth.

Some of these concerns appear to be overstated. For example, the rise in elderly dependency will be substantially (and, in many countries, more than) offset by the fall in youth dependency associated with fertility decline (*74*). Even more notably, there are a wide range of behavioral adjustments and policy reforms that can mitigate the adverse economic and social effects of population aging. The legal age of retirement, which has been relatively stable in nearly all countries for the past several decades in the face of rising life expectancy, can be increased (*74*). Further increases in rates of female labor-force participation, which will be abetted by continued low fertility, can help to counteract potential labor shortages; so, too, will increased educational attainment and the resulting increase in worker productivity and "effective labor." Finally, and perhaps most important, most economies can be expected to adapt naturally to population aging, as wages and the price (and availability) of most goods and services will adapt to the changed availability of labor and, in most countries, to labor's increasing productivity.

Increased rates of international migration from labor-surplus to labor-shortage countries (e.g., from Africa to Europe) have been noted as another possible adaptation to population aging (i.e., the concept of "replacement migration"). For example, the 2010 ratio of the working-age to non–working-age population for Europe and sub-Saharan Africa combined is virtually identical to the projected ratio for 2050 (1.6), whereas this indicator is projected to decline sharply in Europe and to increase modestly in sub-Saharan Africa over that period. However, notwithstanding its potential economic benefits, international migration seems an unlikely means of responding effectively to global demographic imbalances. Only 3.1% of the world's population (214 million people) currently live in countries other than the one in which they were born [see (*75*), with online estimates for 2010]. Moreover, economic and institutional barriers to immigration remain considerable, in addition to social and political opposition to increased immigration in most developed countries. For their part, sending countries may also oppose migration insofar as it contributes to brain drain (e.g., of health professionals). Remittances can offset this problem: Funds sent back by migrants to their countries of origin are estimated to

have reached $325 billion in 2010 (*76*), more than double the amount of official development aid.

Conclusions

History may be a comforting guide, but it cannot guarantee our future. The world's demographic center of gravity will continue to shift from the more to the less developed countries and especially to the least developed countries, many of which will face unprecedented and daunting challenges related to the supply and distribution of food, water, housing, and energy. Population growth also raises many compelling concerns about environmental degradation and climate change, because of growing resource demands and additions to waste streams in an ecosystem that is complex and appears to be increasingly delicate (*77*, *78*). At the same time, acceleration in the pace of population aging among the wealthy industrial countries (and many developing countries as well) may pose a separate set of challenges in the realms of economic growth, financial security, and the provision and financing of health and physical care. The global outlook is greatly complicated by a slew of uncertainties involving, for example, infectious disease, war, scientific advance, political change, and our capacity for global cooperation.

In addition to challenges, demographic change also creates opportunities. Some of the opportunities involve actions aimed at shaping our demography, whereas others involve protecting against, or taking advantage of, reasonably foreseeable trends. Paying attention to demographic indicators and acting proactively on their determinants and consequences offers considerable potential to promote human well-being.

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REVIEW

The Outlook for Population Growth

Ronald Lee*

Projections of population size, growth rates, and age distribution, although extending to distant horizons, shape policies today for the economy, environment, and government programs such as public pensions and health care. The projections can lead to costly policy adjustments, which in turn can cause political and economic turmoil. The United Nations projects global population to grow from about 7 billion today to 9.3 billion in 2050 and 10.1 billion in 2100, while the Old Age Dependency Ratio doubles by 2050 and triples by 2100. How are such population projections made, and how certain can we be about the trends they foresee?

The growth rate of the global population increased slowly from 1700 to 1950, then accelerated rapidly until the mid-1960s, peaking at just over 2% per year before descending to 1.1% per year in 2010. Between 1800 and 2011, population size increased sevenfold, coinciding with an economic expansion. There are two grand perspectives that systematically link population growth and economic growth. According to Malthus, population growth responds to a wage or income signal that depends negatively on the size of the population in relation to the economy and its resource base, keeping living standards near an equilibrium level that is maintained through negative feedback (*1*). Technological revolutions raise incomes and call forth a corresponding increase in population. According to Boserup, population growth is the engine that drives progress by inducing technological innovation and hastening adoption of existing technologies (*2*). Combined, these theories suggest an upward spiral of population and technology with both negative and positive feedback. Such a process must ultimately be limited by natural resource constraints (*3*). More recent economic theories offer important insights (*4*), but do not lend themselves to forecasts.

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How, exactly, can these perspectives be brought to bear on our understanding of current population growth, and how can their insights guide our efforts to forecast population in the 21st century? In principle, one could develop a Malthus-style projection based on an estimate of the carrying capacity of each country, given its resources, institutions, and level of technology. Such estimates and projections are rarely attempted. The practical reality is that population forecasts largely ignore economic and resource constraints, and instead focus on other forces shaping fertility and mortality, forces that are weakly linked to economic and environmental change. It is indeed hard to see how else to proceed, given our current state of understanding.

In fact, demographers have been quite successful in their population forecasts, well represented by the biennial United Nations (UN) population projections for countries, regions, and the world population (*5*). Apparently, population growth since the Industrial Revolution has mainly occurred in a kind of neutral zone in which technological progress, economic growth, and migration have enabled populations to grow while avoiding the sort of negative feedback that would substantially alter fertility or mortality. Global population will reach 7 billion in late 2011, and the UN projects it will reach 10 billion by 2100. It is possible that desertification, global warming, shortage of fresh water, extinctions of species, and other man-made degradations of the natural resource base will lead to catastrophic effects on the population and its growth and change all that. However, despite abundant evidence of environmental change, little demographic response has so far been apparent.

The Demographic Transition

Lacking practical guidance from grand dynamic theories, forecasters rely on a largely descriptive framework known as the demographic transition, which summarizes historical patterns initially observed in Europe but which have been found appropriate for less developed countries (LDCs) as well (*6*). Over the course of the demographic transition, populations move from an initial state of high mortality and high fertility to a state of low mortality and low fertility. Typically mortality begins to decline first, continuing at a gradual and steady pace, with a later and faster decline in fertility that may move from a high to a relatively low level in a span of two or three decades.

These changes in vital rates cause dramatic changes in the population size, the rate of population growth, and the age distribution. During the period in which mortality has begun to decline but fertility remains high, the population growth rate rises and the proportion of youth in the population rises as well. Once fertility begins to decline the proportion of population in the working ages rises, and continues to rise for five or six decades, until well after fertility decline ceases. Eventually the growth of the working age population slows while that of the older population accelerates. The population ages, and the old age dependency ratio or OADR (the population aged 65 and over divided by the population aged 20 to 64) rises.

In Fig. 1, fertility (measured by the total fertility rate or TFR) is on the left vertical axis and life expectancy, e_0, is on the horizontal one. The figure plots specific historical combinations of fertility and mortality and projected trajectories for Europe and more developed countries (MDCs), for India and LDCs, and for Japan.

On the European and Indian trajectories the initial movement is horizontal to the right, as life