Human population explosion
Published: July 26, 2010, 9:54 pm
Edited: December 14, 2010, 9:23 am

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Introduction

Approximately 6.6 billion humans now inhabit the Earth. By comparison, there are about 20 million mallard ducks and, among a multitude of threatened and endangered species, perhaps 100,000 gorillas, 50,000 polar bears, and less than 10,000 tigers, 2,000 giant pandas and 200 California condors. Notably, the human population has grown nearly ten-fold over the past three centuries and has increased by a factor of four in the last century. This monumental historical development has profoundly changed the relationship of our species to its natural support systems and has greatly intensified our environmental impact. Equally amazing are the signs that, in our generation, the human population explosion has begun to abate (Figure 1; note that, here and below, many of the values given are estimates and, after the year 2005, projections). Our numbers are expected to rise by another 50% before reaching a peak some demographers expect late in this century; many researchers posit that a decline is likely to follow. What caused this population surge; where are we headed; and how might the proliferation of our species affect its future well-being?

Some current demographic trends

Until recently, the growth of our numbers was slow and variable. A pronounced expansion began with the advent of the Industrial Revolution, about two centuries ago. Whereas tens of thousands of years passed before our species reached the one billion mark, around 1800 AD, it took only 130, 33, 15, 13 and 12 years to add each succeeding billion. This accelerating rate of increase is what is meant by the term population explosion. Around year 1970, population growth reached a maximal rate of about 2% per year—perhaps a thousand times faster than growth in prehistoric times. The annual increment has since dropped from 2.0 to 1.1% (or, as demographers prefer, to 11 per thousand), and it is still going down. The greatest annual increment in population, about 90 million individuals, occurred in 1995, while our numbers grew by only around 76 million in 2004 (Figure 1). Nevertheless, this cohort is comparable to adding the population of Germany to the planet each year.
Figure 1. Long-term world population growth, 1750-2050. Source: United Nations Population Division

Figure 2 shows that fertility is declining with time. It has now dropped to below replacement level (i.e., below 2.1 children in a woman's lifetime) in most of the developed countries. Worldwide, the average woman currently bears 2.6 live offspring. In some African nations, fertility still exceeds seven live births per female. At the other extreme, the average woman in Japan and in much of Europe bears approximately 1.3 live babies. Correspondingly, population growth rates vary with locale, from more than 3% per year in some African nations to a slightly negative rate (i.e., population loss) in some Eastern European states. Among industrialized nations, the U.S. has the highest rates of both procreation and immigration, giving it the greatest overall population growth rate of any industrialized nation—roughly 1% per year.
The average human life-span has risen from 30-40 years in pre-industrial times to about 65 years today (Figure 3). Longevity is still not much greater than 40 years in Angola but it is more than double that in Sweden and Japan. In developing nations, longevity has sometimes increased by more than half a year in a calendar year. At the same time, the average life-span has been deflected downward in parts of Africa by infectious diseases such as AIDS and by the sociopolitical upheaval that followed the end of communist rule in Eastern Europe.
The demographic transition

The aforementioned historic trends are well understood. Excluding migration, the rate of change of the number of individuals in a population is the difference between birth rate and death rate. The explosion in human population thus reflects the excess of births over deaths fostered by the Industrial Revolution. Until about two centuries ago, birth rates and death rates were both high. Because these two rates were about equal in magnitude, the population grew slowly and unevenly. For example, human numbers grew at roughly 0.25% per year in 1700 C.E. Soon thereafter, as discussed below, institutional and technical advances caused death rates to fall in one nation after another around the globe. But because birth rates remained high, population growth rates soared, an unintended consequence of the alleviation of human hardship in the modern era. Then, after a few decades of declining death rates, families in those nations developed the inclination and found the means to dramatically limit procreation. As a result, fertility rates fell, often rapidly, to approach the low death rates, and population growth slowed.
A theoretical model called the demographic transition explains the pattern of population growth in these stages. Figure 4 illustrates its four stages in an idealized fashion. In early times, birth and death rates are high (perhaps both near 5% per year), and there is little sustained growth in the population. In the second stage, death rates decline but birth rates remain high; consequently, the rate of net population growth increases, as indicated in the figure by the shaded area labeled natural increase. Third, birth rates decline to approach the low death rate, causing population growth to subside. Finally, low birth and death rates ensue (each perhaps 1% per year) and growth abates or even becomes negative. The outcome is not a return to the pre-transition state, since the size of the population will have expanded and longevity increased during the demographic transition.

The demographic transition paradigm can be applied both to individual nations and the world population as a whole. The historical prototype is 19th century England. In short order, the transition spread, along with industrialization, to Western Europe and then to the United States. As they modernized in the 20th century, Japan and then certain other Asian nations replicated this transformation. The decades following World War II and the end of the colonial era saw most developing nations embark on this path; now, their death rates are typically at low levels and their birth rates are on the way down. Thus, most nations are currently somewhere in the third stage of their demographic transition and some are in stage four. In fact, the growth rate of the world population in year 2006 was 1.1%, the difference between a birth rate of 2.0% and death rate of 0.9% per year.

In some developing nations, in which custom may outweigh modern alternatives, the demographic transition has stalled midstream. That is, low death rates (say, 1-2% per year or less) may have been achieved but birth rates linger at 3 to 5% per year. Thus, as in Niger, Mali and Uganda, population growth can exceed 3% per year, making the corresponding doubling time of the population less than 25 years. (Doubling time in years is approximately equal to
70%/growth rate in percent per year. In this example, the doubling time would be 70/3 or 23 years.) This situation can lead to a demographic trap where rapid growth undercuts the very technical, social and economic progress that might otherwise resolve it. The developing nations as a group now have 80% of the world’s population and generate 96% of its growth. The ongoing increase of world population can therefore be understood to represent unfinished demographic transitions in diverse pre-industrial societies.

**Why death rates have declined**

Infectious disease has always been a major cause of human mortality. Over the years, these diseases have included malaria, influenza, tuberculosis, cholera, and a variety of parasitic infections. In particular, childhood diarrhea and respiratory diseases of bacterial or viral origin ravage the young in poor nations; infant mortality can amount to more than 10% of the live births in those settings, more than 20-times that in many industrialized states. The battle against infectious diseases gained force early in the modern era through the development of public health regimes. Thus, long before the era of twentieth-century patient-directed medicine, we learned how to avoid the perils of contaminated drinking water, to drain swamps where mosquitoes harbor the malaria parasite, to immunize the young, to quarantine the infected and to teach public hygiene. (A classical example of an early public health intervention was the introduction of vaccination against smallpox by Edward Jenner more than two centuries ago; this scourge has now been entirely eradicated.) In addition, improved nutrition not only saved lives by itself but also strengthened resistance to infection. These simple preventive strategies were inexpensive and colonists brought them along to protect themselves and their workers. Even today, the transfer of readily-available technology and know-how from more developed countries (MDCs) continues to reduce mortality rates in less developed countries (LDCs).

**Why birth rates have declined**

Children are naturally loved and valued for themselves. But, especially in traditional (i.e., pre-modern) settings, children are also economic assets: a ready source of capital and security when alternatives are out of reach. Sons are of particular value, since it is they who typically inherit both the family plot and the responsibility for caring for aging parents. For practical reasons, daughters are often less desired: they may be regarded as not as productive and as likely to marry and move on, often with a costly dowry payment. Thus, time-honored wisdom might suggest an investment strategy of having, say, eight offspring. A parent can then expect four sons, one or two of whom will hopefully survive childhood and be there to serve with devotion in the distant future. Such views become institutionalized in cultural norms and shared practices.

While it is possible for a woman to bear as many as 15 children in her lifetime, this is rare. Rather, parents universally chose to limit family size because too many children present costs in excess of benefits. Thus, many traditional values and practices foster procreative restraint. Pregnancy can be avoided by celibacy, late marriage and sexual abstinence; various other precautions such as the rhythm method also reduce the risk of conception. Of particular importance is prolongation of the nursing of children. (This is because lactation inhibits ovulation through the mother’s endocrine system, thereby thwarting pregnancy.) In addition,
desperate measures to control family size are frequently taken by those who lack better options. For example, perhaps 20 million pregnancies a year, more than one-tenth of the total, are ended by septic (criminal) abortion despite serious risks to the mothers. Infanticide is another long-standing expedient. Especially in hard times, the girls are selected against. For example, ultrasound previews, while typically illegal, are widely used in Asia these days to pick out female fetuses for abortion. The various practices favoring male heirs is said to account for “100 million missing women” world-wide.

Just as the Industrial revolution precipitated a fall in death rates with a consequent surge in population, it has also driven the subsequent fall in birth rates and the resolution of that explosion. This is because industrial societies have substituted alternative sources of economic security for large family size. This is not just a wealth effect. Rather, modern countries have elaborated civil institutions that provide a social safety net that makes possible smaller families with greater investment in each individual. The safety net promotes health and education; property rights (ownership) and civil rights (e.g., the vote, equality before the law and public safety); some measure of financial security (e.g., insurance, loans, retirement plans, unemployment benefits, job creation and retraining programs); and income redistribution (e.g., public welfare programs and graduated taxation). Individual aspirations then become reoriented from security to self-realization, and from subsistence to productivity, as desperate choices are replaced by good options.

Women in MDCs typically expect to have two children and generally have slightly fewer. In these nations, women tend to marry late—or not at all. Contraception is widespread and the choices are diverse; for example, condoms, cervical loops and caps, vaginal spermicides and surgical sterilizations for both of the sexes. There are also pills to prevent ovulation (i.e., oral contraceptives), to induce the early miscarriage of a pregnancy and to thwart the implantation of a fertilized egg “the morning after.” Surgical abortions are common and (quite the opposite of criminal or septic abortion) safer than live births.

Increasingly, individuals in impoverished nations have become aware of modern lifestyles through education, trade, migration and mass media such as radio or television. Indeed, nearly half of the human population—a steadily rising fraction—now lives in cities from which they report trends to those back home. Cultural diffusion has also alerted pre-modern communities (and their national governments) to the socio-economic burden of high fertility. Their window on the outside world has also shown them ways to build social welfare in advance of industrialization and wealth creation (see Kerala). Foremost among these countervailing forces is a couple’s anticipation of improved longevity for the members of the family. Similarly, the sense of security of those in poverty increases with opportunities for education, physical and social mobility, economic advance and the accumulation of modest personal savings. The transfer of low-cost know-how and materials from developed nations has greatly benefited the poor. Food security in impoverished communities, while often problematical, has nevertheless risen steadily in recent decades just as infant mortality has fallen. Confidence in one’s government also helps. All of these factors have encouraged individuals in LDC to address poverty through personal and social measures that, among other effects, supplant the predisposition to large families. Economic development can then follow. As a result, population growth is declining in all parts of the world (Figure 5).
Figure 5. Average annual rate of change of the population of the world and major development groups, 1950-2050 (medium variant). (Source: United Nations Population Division, World Population Prospects: The 2004 Revision. Highlights)

The empowerment of women (e.g., their literacy and employment) has been of special importance, as have international efforts to provide access to family planning assistance and contraception where needed. The steady decline of LDC fertility and population growth documents the impact of these processes (Figures 2 and 5). Nevertheless, more than 300 million women in LDC presently express the unfulfilled desire for fewer children and for family planning assistance such as information and contraceptive devices. On the other hand, many traditional mothers still aspire to large families (Figure 6). Thus, the population explosion is far from over.

**Human population prospects in the twenty-first century**
The overall human death rate is not likely to change significantly in the foreseeable future. It will presumably decline in nations like Russia which have recently suffered sociopolitical upheavals. The opposite trend can be expected for developing nations as their youthful populations age. Globally, birth rates will probably continue to decline in the coming decades since, nowadays, couples are increasingly prone to limit their family size, whatever their wealth. Coercion by national governments, such as China’s one-child policy, appears to be unnecessary. If and when the global birth rate again matches death rate, we will hit zero population growth. This could occur by the year 2070 when the population might be 9.5 or 10 billion. Negative population growth may then ensue, as is now approaching in an increasing number of MDCs.

Although this is an era of decreasing birth rates, diverse constituencies nevertheless regard procreation as either a good in itself or as a practical imperative. Among these pro-natal voices are the following:

1. Standard economic thinking holds that human capital (e.g., labor and intellectual creativity) drives wealth creation; hence, the more people, the better off we are. Such a cornucopian view foresees no limits to an indefinitely expanding economy, environmental impacts notwithstanding. At the same time, many economists anticipate a point beyond which further additions to our numbers will diminish our well-being.

2. A large fraction of MDC governments would like the demographic profile of their nation to be youthful. Their premise is that the young provide the nation’s workforce and army with vitality and strength. In addition, young wage-earners are a source of tax revenues.

3. Those concerned with the well-being of the elderly see that an increasing dependency ratio (here, retirees per worker) will increasingly burden national retirement plans, such as U.S. Social Security. (The governments of some LDCs are grappling with the opposite issue: high population growth can undercut their social welfare and economic progress.)
4. Various cultural and religious norms encourage procreation. In some communities, men are expected to show virility by siring a large brood. It is sometimes a mother-in-law’s prerogative to press for more grandchildren.
5. Employers may welcome a large labor pool in the hope that competition for jobs will drive down workers’ wages.
6. Many in poverty still see their progeny as their best hope in desperate times.
7. With increasing affluence, many parents can afford to value children for their intrinsic worth and enjoy large families.

For these various reasons most MDC governments favor pronatal policies, and many now maintain programs that encourage procreation. Furthermore, the level of infant and child mortality in some LDCs is still so high that parents feel the need for larger families. Nevertheless, the trend toward decreasing family size continues around the globe, impelled in good measure by growing opportunities for women outside of the home. This unintended consequence of modernization and globalization is welcomed by those who, like Malthus early in the Industrial Revolution, view overpopulation as a fundamental threat to human welfare. From the field of ecology, with its concern for carrying capacity and overshoot, comes the question of whether humans might exceed the limits to growth in a finite habitat. One way this issue has been analyzed is the calculation of the ecological footprint; i.e., that portion of the ecosphere usurped by the activities of an individual, a group or a nation. Applications of this admittedly imprecise parameter have raised the possibility that our current practices exceed the bounty of this planet and are therefore unsustainable (see sustainable development). Another perspective posits that human impact increases with 1) our numbers; 2) material consumption per person (see Consumption and well-being); and 3) the extent of environmental damage caused by each unit of that consumption. (See the IPAT equation.) Since it seems unfair for the rich to thwart the material progress of the poor, politically difficult to reign in the appetites of the affluent and technically challenging to mitigate the impact of their consumption, curtailing population size offers a practical approach to mitigating human impact. While the Earth’s carrying capacity for our species is not known, the precautionary principle advises that it is better to be safe than sorry.

Further Reading