I POPULATION PERSPECTIVE

1. INTRODUCTION

The health professions that most people interact with are clinically oriented. These professions – medicine, dentistry, nursing, pharmacy, physical therapy, occupational therapy, for example – are primarily focused on individuals. In contrast, epidemiology and other public health professions have as their primary concern the health of populations. This population perspective distinguishes public health from clinical professions. This lecture will describe and illustrate the population perspective. Demography is a science that studies populations, though without a specific focus on population health. Epidemiologists make extensive use of demographic concepts, techniques, and information, as we shall see during the course of this lecture.

This lecture will illustrate the population perspective as used in epidemiology and discuss population heterogeneity and demographic characteristics that have a major impact on health.

All of us see the world through our perspectives. My perspective as a faculty member is different from your perspective as a student. Your perspective is different from your parents' perspective. Primary care physicians have different perspectives than do specialist physicians – and both have very different perspectives than do physicians who review claims on behalf of a managed care organization. Each of us employs numerous perspectives, according to our role and responsibilities in a given activity and our objectives.

In public health we differentiate between two types of perspective – the individual perspective and the population perspective. Epidemiology emphasizes the population perspective.

The individual perspective focuses on the health, risk factors, exposures, and causal mechanisms in people as individuals. Coronary heart disease, cancer, stroke, injury, hypertension, infections, birth defects, asthma, dementia – these are all conditions and events that occur to or in individuals. Each individual has a genetic make-up, early life experience, diet, substance use, physical activity, use of medical care and other characteristics that affect her or his risk for various health outcomes. Preventing and treating health conditions at the individual level is the focus of clinical professions – and also of the public health professions. For example, many epidemiologic studies seek to identify risk factors and causal mechanisms linking those factors to individual health outcomes.

By contrast, the population perspective focuses on disorders that occur in large numbers of people, sometimes referred to as "mass disease", and how these disorders are influenced by the physical and social environment. The exposures and causal mechanisms involved are those that function at the level of the group. We can illustrate the population perspective by considering the lung cancer epidemic of the 20th century in the United States.

The graph in this slide shows age-adjusted death rates from seven types of cancer [colon & rectum, leukemia, liver, lung & bronchus, pancreas, prostate, and stomach] in U.S. males for the years 1930-2005.

The graph comes from the American Cancer Society's publication *Cancer Facts & Figures* and is based on data from the National Center for Health Statistics and the Bureau of the Census. Notice that these death rates are age-adjusted. We will explain the concepts of age-adjustment and age-standardization later.

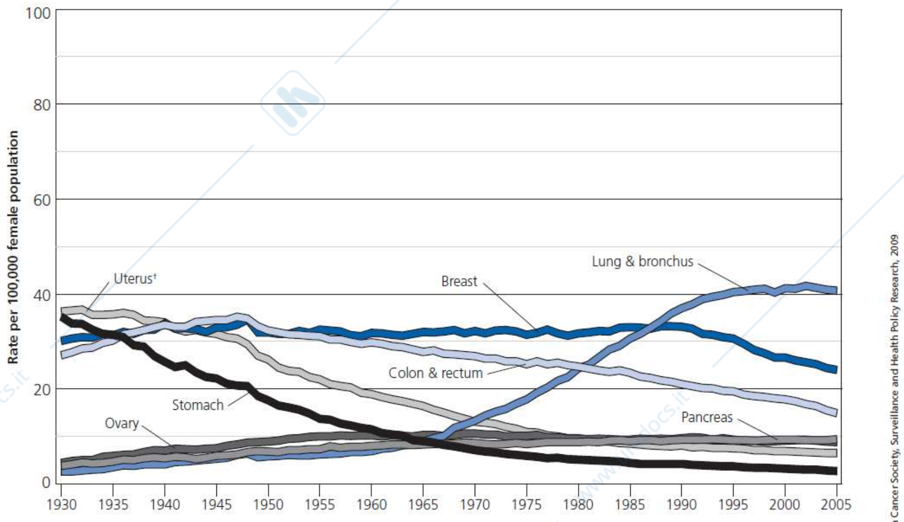
What do we see in this graph? For one, we see that death rates for the seven types of cancer have been changing in different ways during the period. At the beginning of the period the death rate from stomach cancer was the highest cancer death rate, about twice as large as the second highest, which was cancer of the colon and rectum. By the end of the period, the stomach cancer death rate was the lowest for these seven cancer sites. Death rates for the other cancer sites changed more modestly, and in different ways – with one exception.

Which is that?

Exactly. The clear exception, and it is the most striking feature of the graph, is the dramatic rise in death rates from cancer of the lung and bronchus from among the lowest death rates in the figure to a death rate nearly twice that of stomach cancer at the beginning of the period. The lung cancer death rate peaked in 1990 and by 2005 had fallen nearly 20% from its peak. What is happening here?

Before we try to answer that, let us examine the data for women.

Age-adjusted Cancer Death Rates,* Females by Site, US, 1930-2005



*Per 100,000, age adjusted to the 2000 US standard population. †Uterus cancer death rates are for uterine cervix and uterine corpus combined.
Note: Due to changes in ICD coding, numerator information has changed over time. Rates for cancer of the lung and bronchus, colon and rectum, and ovary are affected by these coding changes.
Source: US Mortality Data, 1960 to 2005, US Mortality Volumes, 1930 to 1959, National Center for Health Statistics, Centers for Disease Control and Prevention, 2008.

Here is the companion graph showing age-adjusted cancer death rates for U.S. females for the same period. This graph also shows the marked decline in stomach cancer death rates during the period. The highest cancer death rate in 1930, however, was that for cancer of the uterus, including the uterine cervix, which also had a marked decline during the period, though not to the same level as stomach cancer. The death rate from cancer of the colon and rectum rose until about 1945 but then began a steady decline to a level substantially below that for males. Breast cancer death rates rose modestly from just below the stomach cancer death rate, becoming the highest death rate between about 1948 and 1986. But again, the most dramatic increase in cancer death rates is that for cancer of the lung and bronchus, which rises from the lowest position in 1930 to be highest by far by the end of the period. The rise in the lung cancer death rate in women comes later than that in men and is not as steep, but it depicts the same phenomenon – an epidemic on a large scale.

It is noteworthy that a major fatal disease could increase to such an extent with so little national outcry – imagine if these deaths were due to West Nile Virus, anthrax, or airplane crashes. Moreover, to the shame of all of us in the health professions – most of the increase in women and about half of that in men occurred after scientists, health professionals, political leaders, and the public knew – or at least should have known – the primary cause of this epidemic.

In the words of Jan Stjernsward of WHO, the escalation in tobacco-related deaths has been one of "the most tragic developments in the modern history of medicine" (Jan Stjernsward (WHO), Battle against tobacco. Editorial. *Journal of the National Cancer Institute* 1989; 81:1524-1525).

In the 1950's a large number of epidemiologic and other studies tied cigarette smoking to a number of fatal diseases, particularly lung cancer. In 1964 the U.S. Surgeon General issued a landmark report that declared the relation a causal one and subsequently led to mandatory warnings on cigarette packages and advertisements. Television commercials for cigarettes were banned and in the 1970's and 1980's a movement grew to restrict smoking in public places. But throughout the entire period cigarettes remained (and remain today) one of the most heavily advertised products, and the tobacco industry was (and is) one of the major lobbying forces in Washington and state capitals throughout the country. The lung cancer epidemic is a vivid demonstration of an epidemic of mass disease and of the need for a population perspective.

2. POPULATION PERSPECTIVE VS. THE INDIVIDUAL PERSPECTIVE

Let's contrast the individual and population perspectives on the lung cancer epidemic and its control. The individual perspective is concerned with identifying the factors at the individual level that cause lung cancer. Following the demonstration that smoking is a very strong risk factor for lung cancer, the individual perspective examines the factors that lead people to start smoking and help them to quit, and with provision of services to help individuals quit smoking. Smoking cessation clinics, for example, assist people who want to quit to become free of their addiction.

In contrast, the population perspective is concerned with the environmental factors – social, economic, technological, political, etc. – that promote smoking in the population. Tobacco has been smoked by people in the America's even before Cristóforo Columbo brought the practice back from Cuba in 1493. Tobacco figured prominently in the economics of the American colonies and was used throughout the 19th century. Yet the lung cancer epidemic did not become evident until the 20th century.

A confluence of factors created the conditions for cigarette smoking to mushroom and, along with it, lung cancer. Until late in the nineteenth century, tobacco was used primarily in pipes, cigars, snuff, and chewing forms, mainly because cigarettes had to be hand-rolled (Ravenholt RT. Tobacco's impact on Twentieth-Century U.S. mortality patterns. *Am J Prev Med* 1985;1(4):4-17). The invention of the cigarette-rolling machine in 1880 revolutionized tobacco use (Ravenholt, 1985). Around this period, the advent of new approaches to curing tobacco produced a variety ("flue-cured") whose smoke was less irritating. These changes in manufacturing technology, along with the introduction of mass production techniques, improvements in transportation, the growth of the media and the advent of mass marketing (pioneered by the tobacco industry) created the conditions for the explosion of cigarette smoking. Cigarettes' addictive properties, the glamour of Madison Avenue imagery, and cooperative governmental actions (including distribution of free cigarettes to the armed forces during the First and Second World Wars) helped cigarette smoking to become widespread in the U.S. and the industrialized world (Ravenholt, 1985).

The epidemic probably began early in the century, but its recognition awaited improvements in diagnosis, which according to the late Sir Richard Doll were responsible for much of the lung cancer increase observed during the first half of the 20th century (Progress against cancer: an epidemiologic assessment. The 1991 John C. Cassel Memorial Lecture. *Am J Epidemiol* 1991;134:675-).

Another major pandemic* of the 20th – and apparently the 21st – centuries is HIV/AIDS (human immunodeficiency virus and acquired immunodeficiency syndrome). The individual perspective on the HIV pandemic focuses on avoiding individual exposure through unprotected sexual intercourse, use of nonsterile drug injection equipment, and exposure to infected blood products. The Centers for Disease Control and Prevention (CDC) has invested millions of dollars in programs to educate, counsel, and test people to teach them about HIV and its transmission, enable them to know whether or not they are infected (i.e., their serostatus), and promote prevention-oriented attitudes and behaviors, such as safer sex and sterilizing of drug injection equipment. [*A pandemic is an epidemic that spreads throughout much of the world.]

The population perspective, by contrast, focuses on the demographic, economic, social, political, and technological factors that have disseminated the virus. HIV probably existed in isolated locations in SubSaharan Africa for many years before the 1970's. Factors that contributed to worldwide dissemination include (1) migrant labor patterns and long-distance truck driving that take African men far from their villages and keep them apart from their families for prolonged periods; (2) subordination of women in Africa and many other countries, limiting their ability to decline sex and forcing large numbers into commercial sex work; (3) airline travel and globalization, which helped to carry the virus to other continents, (4) changes in sexual mores, (5) and societal responses to sex, homosexuality, and drug use that have obstructed prevention efforts.

We can also compare the individual and population perspectives in terms of how they approach health problems.

The individual perspective emphasizes diagnosis (based on a patient's presenting complaint, history, physical examination, and laboratory test results) and treatment derived from the biomedical understanding of the etiology of the disease. Pathology, cellular biology, pathophysiology, microbiology, immunology, and pharmacology are the basic sciences that reveal the etiologic processes within the individual. These sciences underlie diagnosis and treatment, which is applied to people as individuals.

The population perspective employs "community diagnosis", through collection and analysis of disease surveillance information, descriptive data, surveys and analytic studies) and interventions through changes in the health care system, governmental policy, and environmental changes.

It is tempting for people in public health to champion the population perspective over the individual perspective, and ride off into the sunset holding the population perspective banner high. However, the two perspectives are really complementary to each other. They also represent two ends of a continuum rather than two discrete alternatives.

Almost every health condition results from a combination of individual-level factors and population-level factors. The former tend to be proximal – they are immediate antecedents of the health outcome. The latter tend to be distal – they often determine the presence of the individual-level factors. But the modes of prevention for mass disease often include individual-level interventions, such as immunizations. Thus, both perspectives are important for and used by public health and clinical medicine. But the emphases are different.

Great advances in the understanding and treatment of disease have been achieved within the individual-level perspective. And, for historical and cultural reasons, the individual-level perspective is more congenial to the U.S. political and institutional framework. There are thus important conceptual, methodological, institutional, and practical advantages for the individual-level perspective. But mass disease – the primary concern of public health – of necessity arises from population-level influences. So the population perspective is fundamental to public health and epidemiology.

3. POPULATIONS ARE DYNAMIC, DIVERSE, HETEROGENEOUS - DEMOGRAPHIC FACTORS

In this second part of the lecture we will present data from around the world for a number of demographic factors, to illustrate ways in which populations are dynamic – changing over time, diverse – different from one another, and heterogeneous – composed of disparate subpopulations. Among the key health-related characteristics of populations are their:

- size and density
- age distribution

- sex ratio
- geographical distribution
- ethnic composition
- level and distribution of education
- level and distribution of economic resources

Key health-related demographic events and processes include:

- birth
- marriage
- migration
- aging
- death

Most of the data that I will present in the rest of this lecture comes from publications of the Population Reference Bureau. This organization is a terrific source for demographic and related data and analysis, and publishes very informative and readable reports. You can find it at www.prb.org, and I encourage you to join it.

[The following graphs and tables come from four issues of the *Population Bulletin*:

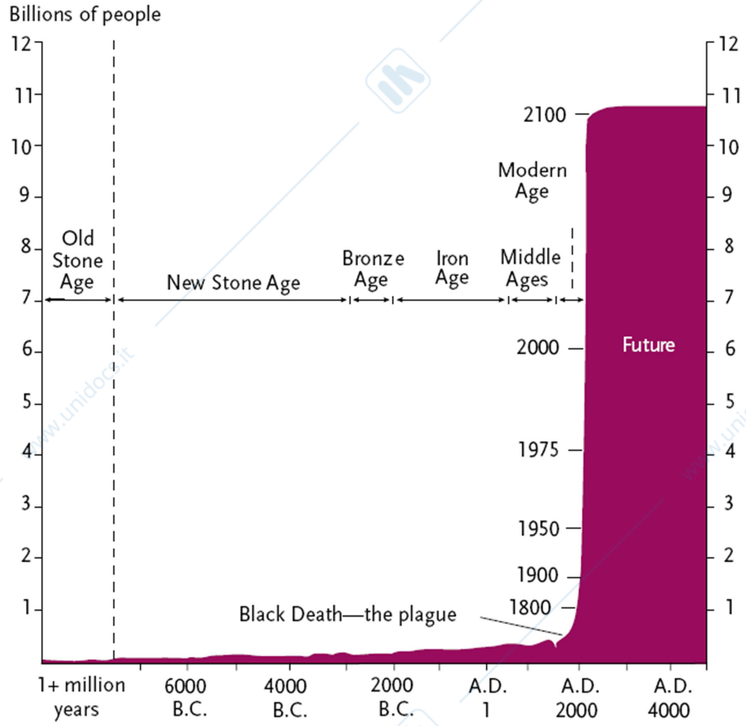
Population: a lively introduction (October 1991)

Asian Americans: diverse and growing (June 1998)

Elderly Americans (December 2001)

India's population in transition (October 1995)]

Figure 10
World Population Growth Through History



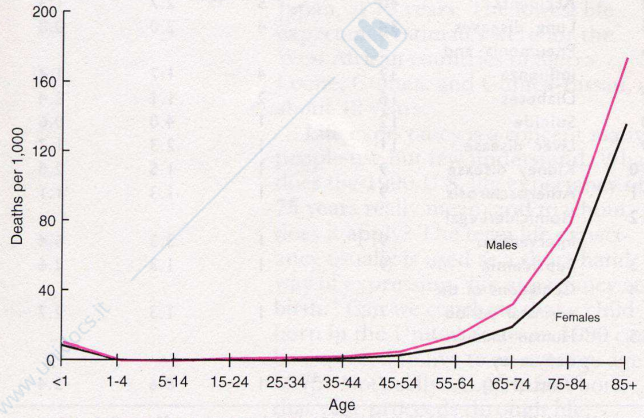
Sources: Population Reference Bureau; and United Nations, *World Population Projections to 2100* (1998).

There is an epidemic of humanity. We cannot continue to grow multiply, yet moving toward zero population growth presents many challenges.

First, we'll take a look at data on mortality, life expectancy, health status, and fertility.

MORTALITY

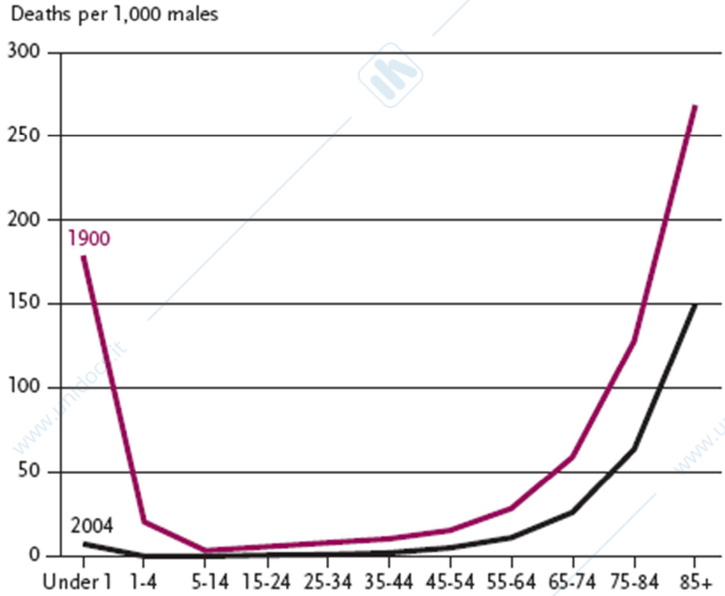
Figure 3
U.S. Death Rates by Age, 1990



Source: National Center for Health Statistics.

Mortality is a key indicator of population health, and age is a key determinant of mortality. This graph shows U.S. death rates by age and gender in 1990. Death rates in the U.S. decline from a relatively low level in infancy, remain very low during childhood, adolescence, and the young adult years, begin to rise in the mid-20's, continue rising during the 30's and 40's, continue to accelerate during the 50's and 60's, and turn sharply up thereafter. The mortality rate for females is lower than that for men and rises more slowly than that for men, at every age. Thus, any comparison of mortality rates across populations or groups within a population must in some way account for the age and gender distributions of the groups being compared.

Figure 3
Death Rates for U.S. Males, by Age, 1900 and 2004



Source: U.S. Bureau of the Census, *Sixteenth Census of the United States: 1940, Vital Statistics Rates in the United States 1900-1940*, (1943): table 5; and National Center for Health Statistics, National Vital Statistics System, *Mortality, 2004* (forthcoming).

This graph shows the dramatic reduction in mortality rates for males during the 20th century. Reductions in the beginning of the century were especially great for infants and young children. Later in the century there were substantial reductions in mortality at older ages. The graph does not show the tremendous improvements in maternal mortality – mortality among women giving birth – that also occurred during the first part of the century.

Table 3
Life Expectancy at Birth and at Age 65 in Years, by Sex, 1900, 1950, and 2000

	At birth			At age 65		
	Total	Male	Female	Total	Male	Female
1900	47.3	46.3	48.3	11.9	11.5	12.2
1950	68.2	65.6	71.1	13.9	12.8	15.0
2000	76.9	74.1	79.5	17.9	16.3	19.2

Sources: National Center for Health Statistics, *Health, United States, 2000* (2001): table 28; and A.M. Minino and B.L. Smith, *National Vital Statistics Reports* 49, no. 12 (2001): table 6.

This table shows life expectancy at birth and at age 65, by sex, in three different years. Life expectancy is essentially a summarization of the mortality rates at each age, such as those presented in the preceding slide.

To estimate life expectancy in a given year, we take a hypothetical cohort of people and imagine that they pass through life from birth to death, being subjected to the mortality rates that we are summarizing. So if we began with 100,000 babies, estimate how many would still be alive by their first birthday, then estimate how many of these would still be alive by their second birthday, and so on until the cohort had all died, we could add up the number of years lived by each person in the cohort and divide by 100,000. The result is the life expectancy at birth. So, the female life expectancy at birth in 1900 – 48.3 years, as given in the table – is obtained as the average number of years that each member of a cohort of females would have lived if they experienced the mortality rates recorded in 1900 for each age group. The life expectancy at age 65 is estimated by taking the number of years lived after age 65 and dividing by the number of people who reached age 65.

Note that life expectancy is not a projection or prediction. For the life expectancy in 1900 we use the mortality rates for each age as they were in 1900. But mortality rates have been declining over time, and by the time that someone born in 1900 was age 50, she would experience the mortality rate in 1950 rather than that from 1900. So life expectancy is a way of summarizing the mortality rates across all ages at a specific time, rather than a prediction.

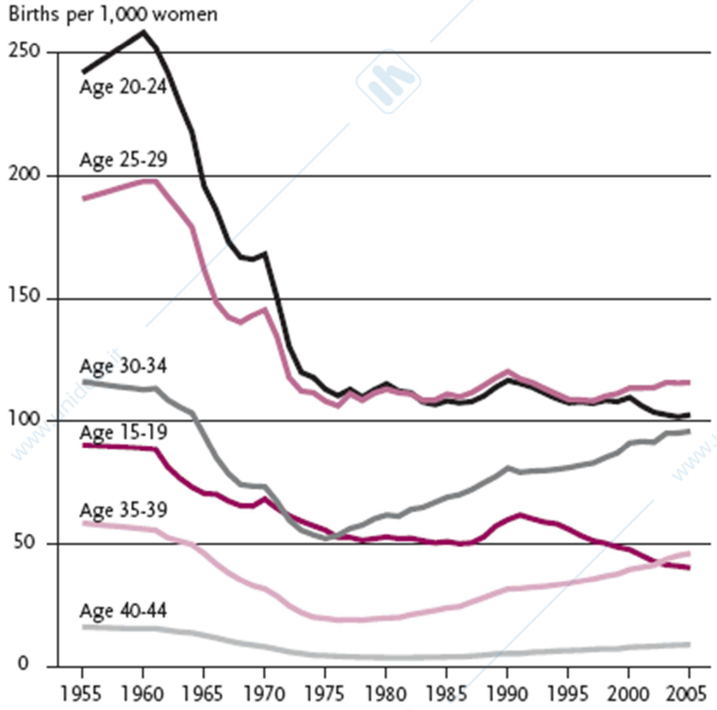
The life expectancies shown in the table, which come from the National Center for Health Statistics, show that life expectancy increased substantially during the 20th century, more so for females than for males. Life expectancy at birth was 46.3 and 48.3 years, respectively, for males and females in 1900. By 2000 these figures had become 74.1 and 79.5 years, an increase of about 30 years. The male-female gap in life expectancy, which was two years in 1900, had grown to over 5 years by 2000.

Life expectancy is most heavily influenced by mortality rates at young ages. Improvements in nutrition, hygiene, and conditions of living (housing, child labor), immunizations, and reductions in maternal mortality reduced mortality among infants, children, and women in their reproductive years. These reductions were responsible for much of the increase in life expectancy during the first half of the 20th century.

Reductions in childhood mortality, of course, have no effect on life expectancy at age 65. Even the elimination of a cause of death such as heart disease can increase life expectancy only modestly, since mortality rates from other causes are so high. Nevertheless during the 20th century life expectancy at age 65 increased by about 4 years for males and 7 years for females, a substantial gain.

A thought question: life expectancy at birth in 2000 was 76.9 years. Why is this so much less than 65 plus the 17.9 years of life expectancy at age 65?

Figure 2
U.S. Birth Rates By Age of Mother, 1955–2005



Sources: J.A. Martin et al., "Births: Final Data for 2004," *National Vital Statistics Reports* 55, no. 1 (2006); NCHS, *Live Births by Age of Mother and Race, United States, 1933-1998* (www.cdc.gov/nchs, accessed Jan. 19, 2007); and B.E. Hamilton, J.A. Martin, and S.J. Ventura, *Births: Preliminary Data for 2005* (www.cdc.gov/nchs, accessed Jan. 22, 2007): table 1.

The graph above shows U.S. birth rates by the mother's age, during the period 1955 to 2002. Again, the data come from the CDC National Center for Health Statistics. Each line on the graph shows the birth rate per 1,000 women for women of different age groups. Birth rates to women in all age groups have come down substantially during the period. Most of the reduction occurred between 1960 and 1975, at which time rates increased for the older age groups.

The peak child-bearing ages are age 20-24 years (the top line) and 25-29 years (the second line). These rates have sharply declined and converged; women in their early twenties are delaying giving birth. The trend toward older mothers is also reflected in the rebound after 1975 in the birth rates for women age 30-34 [the third highest line in 1955] and age 35-39 years [the next to the lowest line, probably mislabeled 34-39].

The rate of births to teenagers age 15-19 years old [the fourth highest line in 1955], an important public health indicator, has declined somewhat during the period. Some of that decline, especially before 1975, may reflect delayed marriage and family formation.

We've been referring to birth rates, mortality rates, and so forth, without defining them. Let's make sure that we all understand these important demographic measures.

A birth rate is a ratio of the number of births during a period divided by a reference population. The most commonly-cited birth rates are "crude" birth rates for specific years, calculated as the total number of live births in the year divided by an estimate of the total population at mid-year. The reason for using the mid-year population is that if the population is steadily increasing, as is commonly the case, the mid-year population provides a close approximation to the average number of people in the population on any given day. The use of the mid-year population as a kind of compromise between the starting and ending populations is a common practice for vital statistics rates. Note that the denominator for the crude birth rate consists of both women and men, of all ages, even though most can neither bear children nor father them.

In order to reduce the number of decimal places, birth rates are customarily expressed per 1,000. Although commonly omitted, the time units of the rate (usually "per year"), should be stated, since even though the births were accumulated during one year, the number itself can be expressed "per month", "per week", "per decade", or with respect to any other time unit.

Related to the birth rate is the general fertility rate, which expresses the number of births in a year relative to the number of women of reproductive age. Again, the estimated mid-year population is used, and the result is usually expressed per 1,000 women of reproductive age. Again, "per year" is generally intended but is stated only infrequently.

The fertility rate requires more information about the population and gives a more specific indication of reproductive behavior.

You've probably already guessed that an annual death (or mortality) rate is estimated as the number of deaths divided by the mid-year population per year and is often expressed per 1,000 people. Again, "per year" is generally intended but is stated only infrequently. As with the crude birth rate, the denominator for the crude death rate includes the total population (men, women, and all ages), even though mortality rates vary greatly by age and gender. For this reason, the overall death rate is not used very often. More typically death rates are calculated for specific subgroups defined by gender and age. When an overall figure is desired, the rates for the different age groups are combined as a weighted average – the resulting average is called an "age-adjusted" or "age-standardized" mortality rate and is typically computed separately for males and females.

As we have seen in earlier slides, death rates may be estimated for specific causes of death, such as all cancers, specific cancer sites, heart disease, and so on. A major concern in interpreting all vital statistics and epidemiologic rates is the quality of the data that were available to calculate them. In developed countries, birth records, death records, and population size estimates are generally available and accurate. Information on cause of death, however, is much less reliable, since there are various definitional and practical obstacles in accurately classifying deaths as to cause. Thus, before relying on data on cause-specific mortality, it is important to assess the likely accuracy for each specific cause of death being analyzed. More problematic is the situation in less-developed countries, where population counts and vital events registration may be incomplete to varying degrees.

When a rate is estimated from a small number of events, the resulting estimate is unstable. If even a few events were miscounted, or if there were a minor variation that particular year, the rate could be misleading. Estimates based on small numbers are called "imprecise" or "unreliable", and generally avoided.

A common strategy, therefore, is to estimate an average over several years, as a way of obtaining a larger number of events for the calculation. The slide above illustrates the calculation of an average annual death rate. Here the average number of deaths during the n year period is used in the numerator. The denominator estimates the average size of the population (as usual, by taking the size of the population at the midpoint). So for calculating the 3-year average annual death rate for 1999-2001, the numerator would contain all deaths during 1999-2001, divided by 3, and the denominator would be the population estimate for July 1, 2000. Since the year in which the Census count takes place has the most nearly accurate population size estimate, the period is usually chosen so that the Census year is in the middle.

Once again, as with the other rates we have seen, the denominator actually includes the time interval during which the deaths have accumulated, and therefore should include the units in which that time interval is expressed (e.g., years). Although the units are typically omitted when vital statistics rates are presented, they are in fact ambiguous without their units, usually "per year".

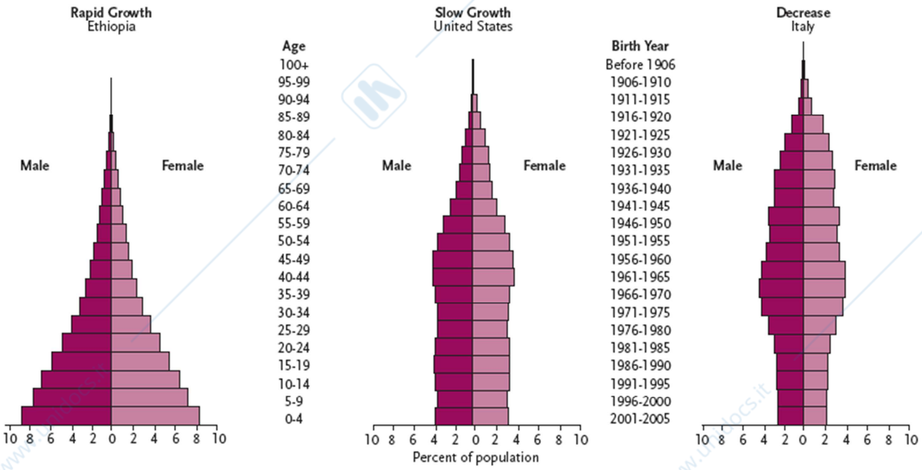
Now we will touch on several aspects of population structure and transformation, including population age structure, growth, fertility, fertility momentum, the demographic transition, and population aging.

4. POPULATION STRUCTURE.

The age-sex make-up of a population is often displayed in a "population pyramid". A population pyramid is constructed by drawing a series of horizontal bars stacked one on top of the other. The bars represent age strata and generally have the same height (e.g., representing 5-year age bands). The width of the bars is drawn to correspond to the proportion of all males (on the left) and all females (on the right) who fall into that age band. Since age and gender are such fundamental characteristics in many areas of life, including health, the age and gender structure of a population, as presented in its population pyramid, tells us a lot about the population growth

Population growth.

Figure 6
Population Pyramids: Ethiopia, United States, and Italy, 2005



Sources: UN, *World Population Prospects: The 2004 Revision, Online Data* (www.un.org/esa/population/unpop.htm, accessed Jan. 29, 2007); and U.S. Census Bureau, *National Population Estimates for the 2000s* (www.census.com, accessed Jan 29, 2007).

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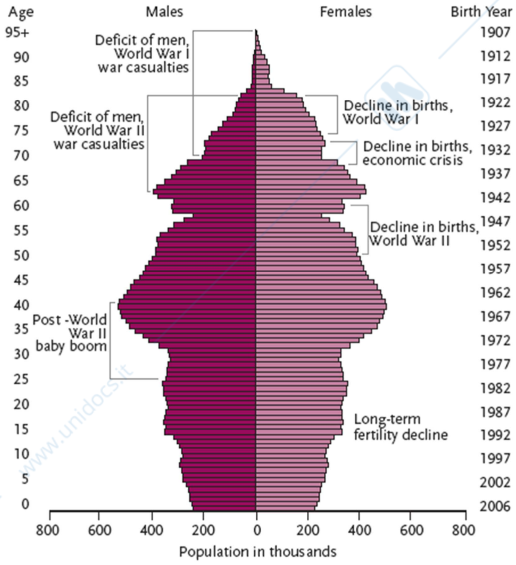
The graph in this Figure shows population pyramids for three different countries, illustrating three basic population structures. A population pyramid shows the record of a population's history. On the left, the pyramid for Kenya depicts a rapidly-growing population. How can we see that from the pyramid? The narrow middle and top and widening base indicate that each new birth cohort is larger than the previous one. With the passage of time, each age band moves up the pyramid, so these larger cohorts are expanding the total population. High adult mortality rates help to narrow the pyramid at the top.

The center pyramid shows the U.S., a slow-**growth population**. The bands at the base are narrower than those in the middle, indicating a lower fertility rate. The bulge in the middle corresponds to birth years 1945-1965, approximately the "baby boom". The pyramid for Denmark, on the right, depicts zero growth.

This figure for Germany's population in 2006 we see the deficits of men from casualties in the two World Wars as well as declines in fertility during the wars, during the economic crisis, and in the modern era.

Figure 7
Germany's Population by Age and Sex, 2006



Source: Germany, Federal Statistical Office (www.destatis.de/, accessed Feb. 1, 2007).

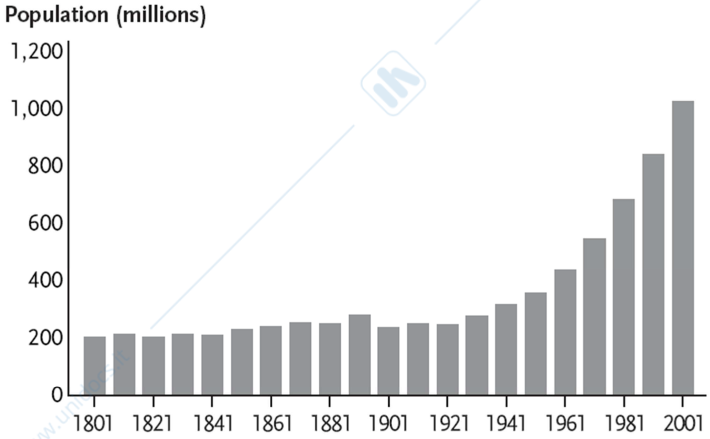
Comparing population pyramids over time shows how rising and falling birth rates and population aging influence the age-sex distribution over time. This slide shows the U.S. population by age and sex, in 1900, 1970, 2000, and projected for 2030. The graph for 1900 – in the upper left of the slide – actually looks like a pyramid, as did the one for Ethiopia. The slope of the sides of the U.S. pyramid is less steep, though, corresponding to a lower birthrate and perhaps higher infant mortality. The U.S. in 1900 was growing from immigration as well as births, which also makes for a broader pyramid.

The pyramid in the upper right (1970) looks markedly different, almost as if the 1900 distribution had had a girdle placed around the 30-39 year age band, so that the younger population had not been allowed to grow up. The narrowing in the age groups from ages 25-39 reflects the decline in fertility during the Great Depression of the 1930s and World War II. Children born in 1944 were about 26 in 1970 (see my picture?), those born in 1939 were 31 in 1970, and those born in 1930 were 40. The younger age bands – ages 5 through 24 – show the Baby Boom. In this way, a population pyramid displays the reproductive history of a population. Reflecting on the shape of the 1970 pyramid, with its substantially greater ratio of youth to parents, it's no wonder that the 1960s and 70s were such a transforming time in the U.S.

Coming closer to home, chronologically speaking, the lower left pyramid for the year 2000 shows the Boomers at maturity and the "Boomlet" of their offspring. In the spirit of "Where's Waldo", find my picture next to the caption "Men". By 2030, I predict that funding for the NIA will have eclipsed that for NICHD.

Moving to the other Figure of the globe, this graph shows population growth in India during the 200 years from 1801-2001. The second country to pass the one-billion population mark, India is home to about one-sixth of the world's population. The population growth curve mirrors that for the world as a whole. Each year there are more women in their reproductive years and, even with the same fertility rate, there are more babies. If the curve were redrawn to show the percentage increase in population each year (e.g., by plotting the data on a logarithmic scale), the decline in the growth rate would be visible.

Figure 2
India's Population Growth, 1801–2001

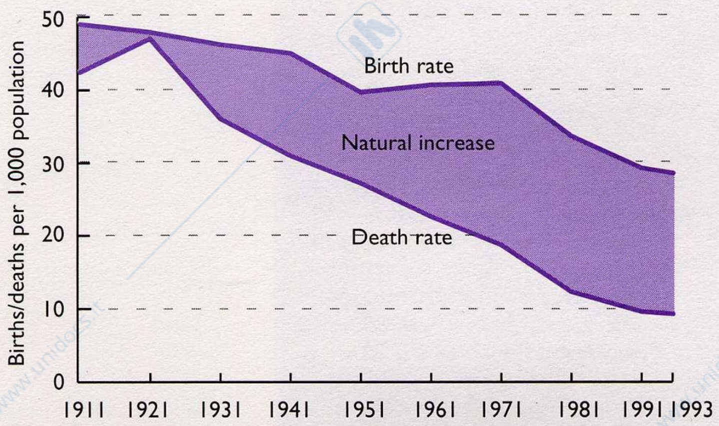


Note: Estimates prior to 1901 include other parts of the Indian subcontinent. Estimates for 1901 and later conform to the current national boundaries.

Sources: 1801 to 1971: United Nations, *Population of India: Country Monograph Series* No. 10 (1982): tables 2 and 4; 1981 to 2001: Registrar General and Census Commissioner, India, *Census of India 2001: Provisional Population Totals* (2001).

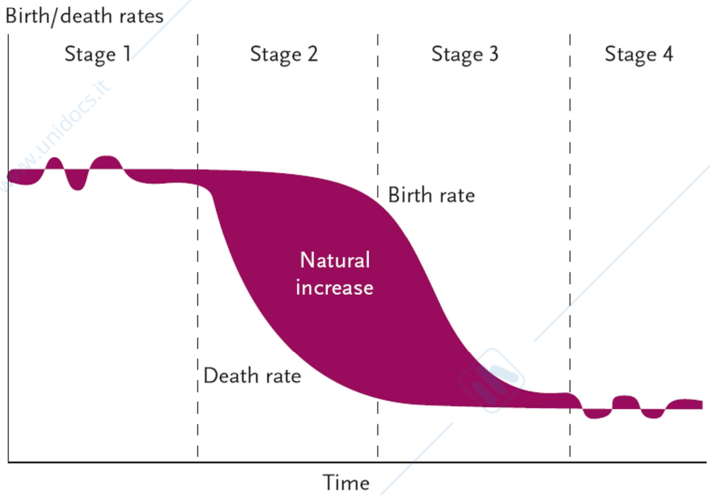
Fertility

Figure 5
Trends in Fertility, Mortality, and Natural Increase in India, 1911–1993



This graph shows trends in fertility, mortality, and natural increase in India during the same period, revealing the dynamics of India's population growth. The birth rate has declined during most of the century. The death rate has declined more rapidly, however, an achievement of public health measures. The difference between the two is called the rate of natural increase and constitutes one component of the population growth rate (the other is immigration, which in the case of India is relatively minor). The rate of natural increase grew rapidly from 1921 to 1971, when the birth rate began to decline more steeply. This pattern illustrates what has been called the demographic transition, which we describe next.

Figure 11
The Classic Stages of Demographic Transitions



Note: Natural increase or decrease is produced from the difference between the number of births and deaths.

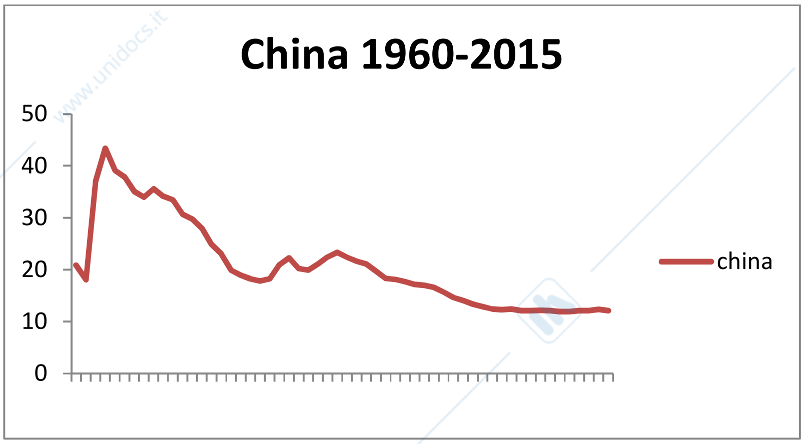
The demographic transition is a general pattern of changes in death rates, population growth, and birth rates that appears during the process of modernization. Demographers distinguish four stages. Stage 1 is the period before the transition begins. Birth rates are high, but so are death rates, so population size is stable. The transition period begins when death rates fall, as improvements in agricultural productivity, economic development, and introduction of modern sanitation, immunization, improved nutrition, and other public health measures become available. However, cultural values, considerations of personal security, personal preferences, and the priorities of the health professions continue to support the high birth rate. The population begins to grow rapidly.

The transition from stage 2 to stage 3 begins when, under the influence of such factors as the effects of land shortages, urbanization, education of women, and introduction of family planning programs, the birth rate begins to decline. In stage 3, the decline in the birth rate exceeds that in the death rate, which comes to stabilize at a low level. Population growth continues, but at a declining rate.

In stage 4, the transition has been completed, as the birth rate joins the death rate at a stable, low rate, and population size stabilizes. The lower birth rate can produce a “demographic dividend” from fewer dependents per working-age adult, giving a country the opportunity to invest in health care, education, economic development, and infrastructure before the population ages.

Demographic Transition

Let’s pause here to explain the concept of the total fertility rate (TFR). The TFR is a summary measure, constructed in a manner reminiscent of life expectancy. For biological and social reasons, fertility (the number of babies divided by the number of women in their reproductive years) varies greatly by age. If we want to characterize fertility with a single number, we need a way to summarize the overall picture. The measure that is typically used for this purpose is the TFR, and it can be regarded simply as the sum of the age-specific fertility rates for each year of age between 15 years and 44 (or 49) years, inclusive. TFR is typically described as the number of births expected per woman for an imaginary a cohort of women moving through their reproductive lifetimes (generally taken as ages 15-44 or 15-49 years). The expectation is based on the current fertility rates at each age in a given year. The next slide shows an example of such a calculation.



Age-specific fertility rates are usually calculated for 5-year age intervals, so that is the starting place for calculating the TFR. Suppose, as shown on the slide, there were 5,000 births to 48 thousand women age 15-19 years, 6,000 births to 44 thousand women age 20-24, 5,000 births to 39,000 women age 25-59 years, and so on. So the average fertility rate for women age 15-19 years old in that year was 5,000/48,000 = 0.104, or 104 per 1,000 women-years. The average fertility rate for women 20-24 years old in that year was 6,000/44,000 = 136 per 1,000 women years, etc.

Demography and aging

For more on China's the demography in China during the 20th century, see:

Demographic Consequences of the Great Leap Forward in China's Provinces
Xizhe Peng, *Population and Development Review* 1987(Dec);13(4): 639-670, www.jstor.org/stable/1973026

Demographic Dimensions of China's Development, Eduard B. Vermeer, pp. 115-144, www.jstor.org/stable/20058946 in *Population and Development Review*, 2006;32. The Political Economy of Global Population Change, 1950-2050, www.jstor.org/stable/i20058940

Age band	Births	Women	Fertility rate*
15-19	5,000	48,000	0.104
20-24	6,000	44,000	0.136
25-29	5,000	39,000	0.128
30-34	4,000	35,000	0.114
35-39	1,000	30,000	0.033
40-44	500	26,000	0.019
	21,500	222,000	**2.67**

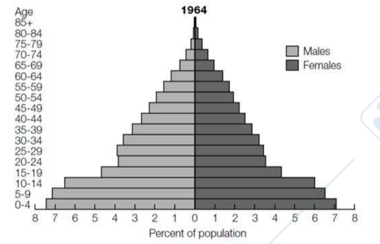
* Per woman-year

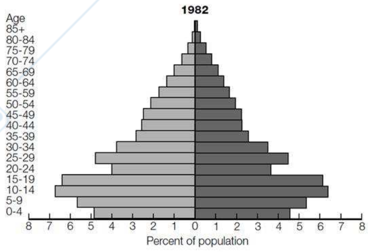
In this table the fertility rates are shown per 1,000 women per year.

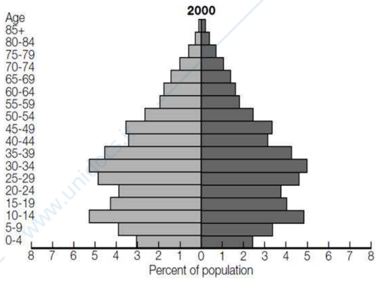
If these age-specific fertility rates were to stay that way for the next 30 years, a cohort of 1,000 women age 15 years old today would be expected to have about 104 babies at age 15, 104 babies at age 16, 104 babies at age 17, 104 babies at age 18, and 104 babies at age 19, or a total of 5 × 104 = 520 babies by the time the women reached their 20th birthday. As these women moved through the five years from age 20 to 24 years, the women would have another 136 babies each year, or 5 × 136 = 680 babies by the women's 25th birthday.

During their next five years (ages 25-29 years of age) the women would have 5 × 128 = 640 babies, and then 570, 165, and 95 babies, respectively, during the next three 5-year intervals. Adding these numbers up, we get 2,670 babies born to the 1,000 women, or 2.67 babies per woman, giving us the total fertility rate (if you calculate without rounding the intermediate results you will obtain 2.68, which is more nearly precise).

China's Age Distribution by age and sex, 1964, 1982, and 2000







From Figure 6. China's Population by Age and Sex, 1964, 1982, and 2000 from Nancy E. Riley, China's Population: New trends and challenges. *Population Bulletin* 2004: 59(2);21.

Original sources: Census Bureau, International Data Base (www.census.gov/ipc/www/idbnew.html, accessed April 7, 2004); and tabulations from the China 2000 Census.

Age band	Births	Women	Fertility rate*	Expected births**
15-19	5,000	48,000	104	520
20-24	6,000	44,000	136	680
25-29	5,000	39,000	128	640
30-34	4,000	35,000	114	570
35-39	1,000	30,000	33	165
40-44	500	26,000	19	95
	21,500	222,000		**2,670**

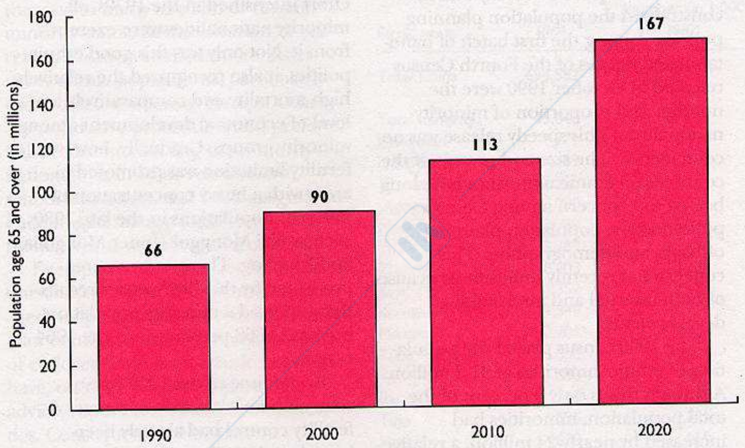
* Per 1,000 woman-years, ** Per 1,000 women x 5 years

This Figure shows three population pyramids for China. The constrictions at ages 15-24 years in 1964, which are echoed in ages 35-44 year in 1982 likely reflect the impact of World War II and the Japanese occupation. The 20-24-year-olds in 1982, whose numbers are severely curtailed, consists of people born during "The Great Leap Forward", described on the slide about fertility in China.

The widening of the 1982 pyramid at younger ages is partly due to a catch-up phenomenon of families having the babies which they would have had during 1958-1962. In the 2000 pyramid we see the "echos," one generation later, of the constriction from the Great Leap Forward and of the subsequent rebound.

Meanwhile the 1982 and 2000 pyramids, with their narrow bases, show the impact of China's successful though in some respects controversial population policies and the aging of the population that is occurring.

Figure 7
Population Age 65 and Older in China, 1990-2020

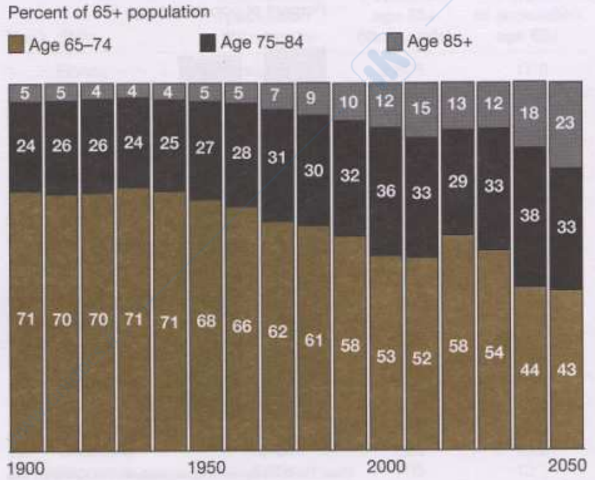


Source: United Nations, *The Sex and Age Distribution of Populations, the 1990 Revision* (New York: UN, 1991), pp. 132-133.

This Figure shows the number of people age 65 and older in China in 1990 and projected for 2000, 2010, and 2020.

Despite the fact that China is still in many ways a developing country, improved public health has extended lifetimes. With its large population size, increases in life expectancy imply substantial growth in the older population, which will nearly double between 2000 to 2020.

Figure 2
Age Distribution of Older Americans, 1900–2000, and Projection to 2050

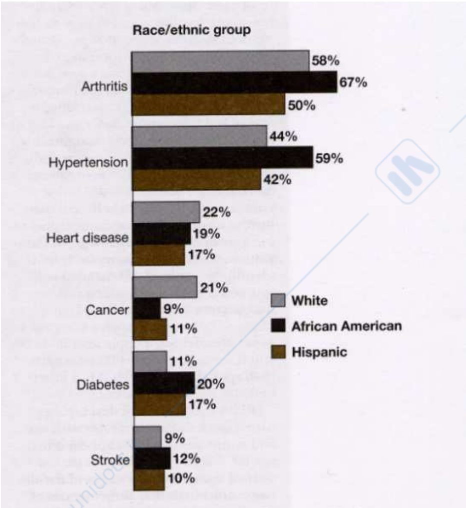


Sources: U.S. Census Bureau publications: *Historical Statistics of the United States: Colonial Times to 1970* (1975); *1980 Census of Population: General Population Characteristics* (PC80-1-B1); *1990 Census of Population: General Population Characteristics* (1990-CP1); *Census 2000 Demographic Profile* (www.census.gov/2001/tables/dp_US_2000.xls, accessed Sept. 19, 2001); and "Projections of the Resident Population by Age, Sex, Race, and Hispanic Origin, 1990-2100" (www.census.gov/population/www/projections/natdet-D1A.html, accessed July 6, 2001).

This graph shows a series of stacked bars with the age distribution of older Americans (age 65 years and above) from 1900-2000, and projected to 2050. The graph indicates how the age distribution among seniors has moved up the age ladder. In 1900, most seniors (65 years and older) were younger than age 75, and only 5% were 85+ years. By 2050, "young seniors" (age 65-74) will be a minority of all seniors, while nearly one-in-four will be 85+.

The "graying" of American society has been underway since the middle of the 20th century and is transforming the nature of society in many respects. Older people vote differently from younger people, older people have different health conditions and concerns, older people have more expensive health problems than younger people (e.g., one-in-four persons age 80 and older have Alzheimer's disease), and older people for the most part are living on retirement assets and government programs.

The dependency ratio is the number of children and adults over 65 to the number of people of working age, who provide much of the financial and instrumental support for the young and the old. As the population ages, the dependency ratio will increase. Even if the retired population has substantial financial assets on which to live, it still takes people to provide the services they need. We can anticipate shortages even more severe then the current nursing shortage unless we greatly improve the educational preparation of young people and/or increase immigration.

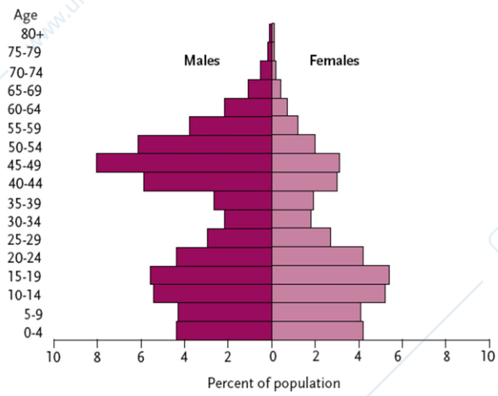


Note: Whites and African Americans are non-Hispanic. Hispanics may be of any race.
Source: Federal Interagency Forum on Aging-Related Statistics, *Older Americans 2000: Key Indicators of Well-Being* (2000): table 14.

This Figure illustrates the high prevalence of chronic medical conditions among Americans age 65 and above as well as substantial differences across three ethnic groups. Ethnicity refers to groups of people with shared culture, language, religion, and/or geographical origin. Many countries have multiple ethnic groups. In the United States the the term "race" is often used to classify people based on skin color and several other physical features. In the United States that distinction has been used as a basis for enslaving millions of African Americans, killing or dispossessing American Indians, and discriminating against Asians and others. A biological rationale for these actions was constructed on the foundation that people belonging to different "races" were fundamentally different. This view has been largely discredited, but race remains very much a reality because of its connection to social, economic, and political factors as well as cultural and historical experience. Disparities in health status for different ethnic groups are a major public health concern.

Population analysis by gender: SEX RATIO

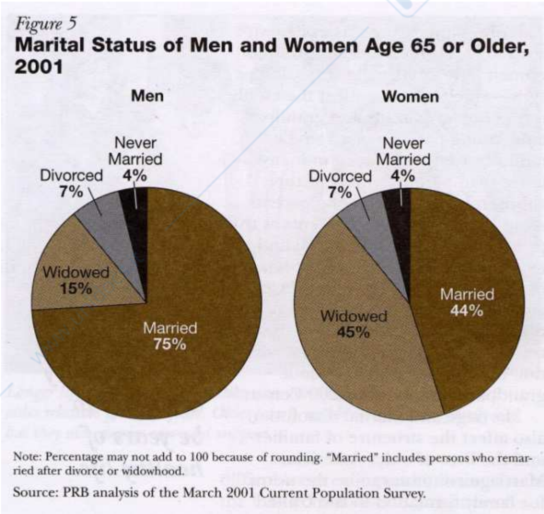
Figure 8
Population of the United Arab Emirates, by Age and Sex, 2000



Source: U.S. Census Bureau, International Data Base (updated July 17, 2003; www.census.gov/ipc/www/idbpyr.html, accessed Sept. 20, 2003).

This graph shows the age and sex profile of the United Arab Emirates in 2000.

Note the dramatic population imbalance in the among adults age 40-59 years old, representing the men who immigrated from neighboring countries and Asia decades earlier to work in the oil fields and in construction. The government discouraged the men's bringing their families, to reduce the probability that they would settle in the UAE. As you can imagine, such marked imbalances can produce interesting social dynamics.



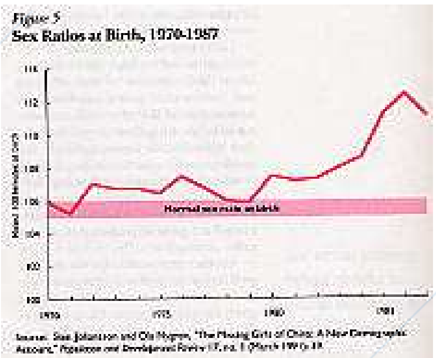
This s graph has pie charts showing the distribution of marital status of men and women age 65 and above, in the U.S. in 2001.

What do we see in this slide? 75% of men in this age group are married, compared to only 44% of women.

How can that be? Whom are the men marrying.

Since men typically marry women younger than themselves, some of these men have married women younger than age 65, who are not included in the graph.

Also, of course, there are more women than men in that age group, so the same number of married couples produces a larger proportion of men who are married than of women who are married. The sex ratio among people over age 65 in the United States is considerably below 100, i.e., fewer than 100 males for 100 females.



This graph shows sex ratios at birth, from 1970-1987, in China. Sex ratios in most periods and most countries we have data for are generally 105-106 (per 100 females) at birth and fall gradually with age. In the 1964 census in China it was 103.8 at birth and 105.3 at one year of age (Johansson and Nygren, 1991).

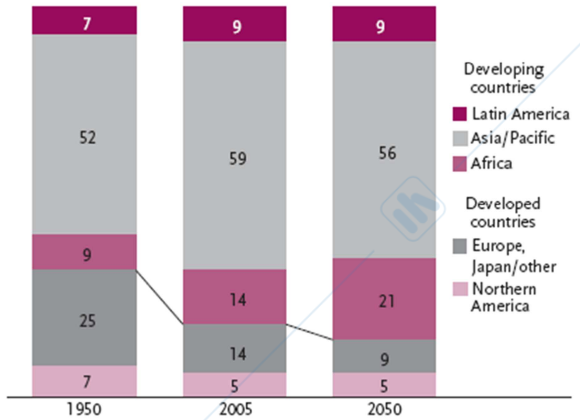
In this graph we see that the sex ratio at birth rose in the mid-1980s, rising to an exceptionally high level. What is happening here? Several explanations have been considered. China introduced a one-child policy in 1979, and there is a strong cultural preference for males. One effect was underreporting of female births so they would not count against the one-child quota per couple. Many of the unreported girls are apparently given away for adoption (Johansson and Nygren, 1991). Another part of the explanation may be higher mortality for female infants who are not reported, due to deliberate infanticide or relative neglect of female infants. The potential exists for a lot of Chinese men who will not be able to find Chinese women.

[See Johansson S, Nygren O. The Missing Girls of China: A New Demographic Account. *Population and Development Review*, 1991; 17(1): 35-51. (available through UNC libraries e-journals)

See also www.prb.org/Content/ContentGroups/Datasheets/Women_2002_Demography_Overview.htm

Socio-Demographic factors: place, education, statud of weomejn

Figure 9
World Population by Region, 1950, 2005, and 2050



Source: UN, *World Population Prospects: The 2004 Revision, Online Data* (www.un.org/esa/population/unpop.htm, accessed Jan. 29, 2007).

Along with the expansion of the world's population during the second half of the 20th century has come a dramatic shift in its global distribution. Asia and the Pacific, where a majority of the world's population live, have increased their dominance though their share is projected to decline modestly by mid-21st century. Europe's share of world population declined from 25% to 14% from 1950 to 2005 and is projected to decline to 9% by mid-21st century. Meanwhile, in spite of the AIDS epidemic Africa's share is projected to increase to 21% from 9% in 1950 and 14% in 2005. The Americas' share of world population has remained stable at 14%, but with a shift from Northern America to Latin America. In addition to the changes shown in the figure, the populations of Europe and especially Northern America are increasingly composed of immigrants from Africa, Latin America, and Asia.

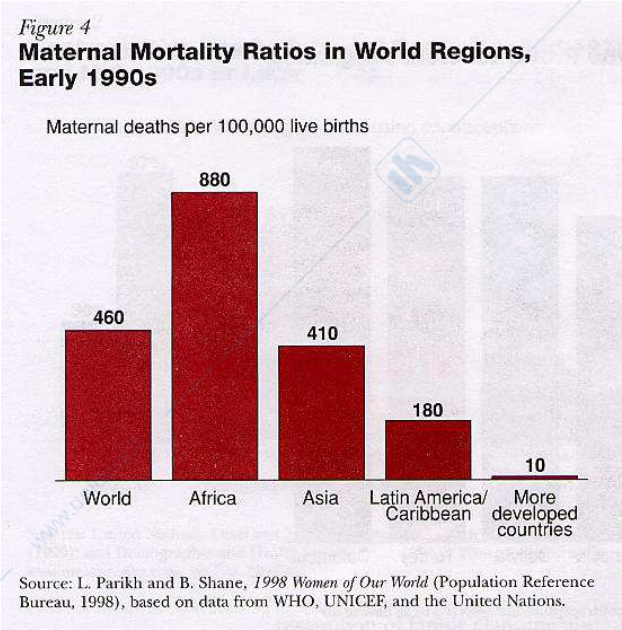


Figure 4
Maternal Mortality Ratios in World Regions, Early 1990s

Source: L. Parikh and B. Shane, *1998 Women of Our World* (Population Reference Bureau, 1998), based on data from WHO, UNICEF, and the United Nations.

This Figure shows maternal mortality ratios in world regions, in the early 1990s. In Africa, the figure was almost twice as high as in the world as a whole.

Maternal mortality is something that we know through public health and medicine how to prevent. In the developed countries, maternal mortality was 10 per 100,000 live births, one-eighteenth the rate in Latin America, less than a fortieth the rate in Asia. These dramatic disparities are a challenge to public health to which we will return to at the end of the course, when we take up the Role of Epidemiology in Public Health.

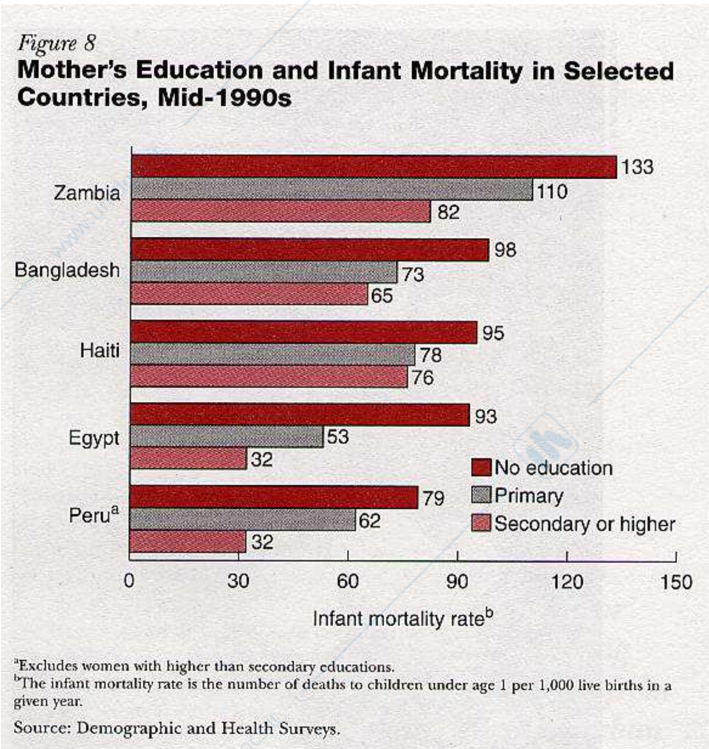


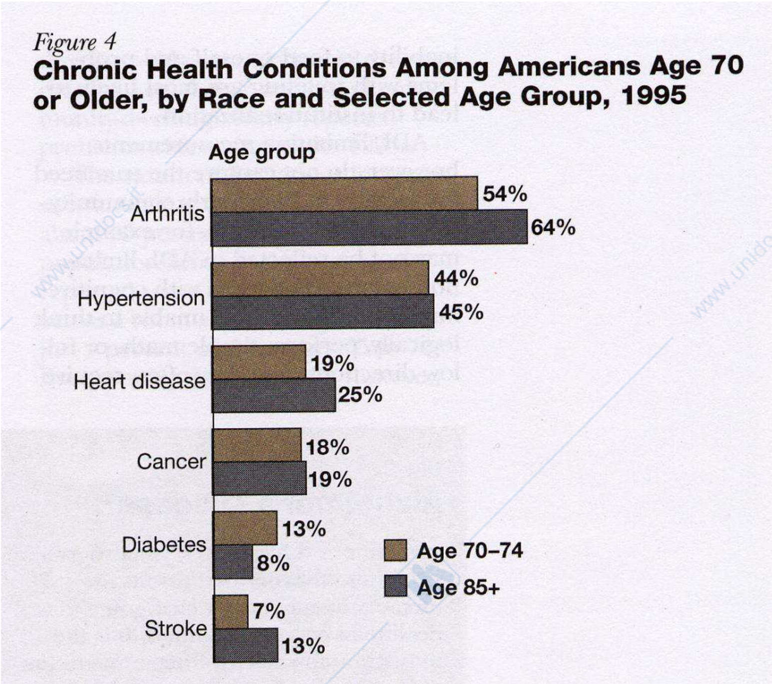
Figure 8
Mother's Education and Infant Mortality in Selected Countries, Mid-1990s

[a]Excludes women with higher than secondary educations.
[b]The infant mortality rate is the number of deaths to children under age 1 per 1,000 live births in a given year.

Source: Demographic and Health Surveys.

The status of women is a major determinant of many aspects of public health, including childhood mortality. This slide shows the infant mortality rates according to the education of the mother in various developing countries. In every country the infant mortality rate is highest for uneducated mothers and lowest for mothers with secondary education. But there are also large differences across countries at all educational levels.

Ethnicity



This graph shows the prevalence – that is, the percentage of the population who are afflicted – of six chronic conditions [arthritis, hypertension, heart disease, cancer, diabetes, and stroke] for two age groups: 70-74 years and 85+ years in 1995. Most of these conditions are more prevalent in the older age group, but what is perhaps most significant in the graph is the substantial prevalences of older Americans who have arthritis (over half), hypertension (nearly half), heart disease or a history of cancer (about one-in-five for each), diabetes and history of stroke (about one-in-ten for each).

Since the population of elderly is expanding rapidly, it is likely that we will see much larger numbers (though not necessarily larger percentages) of older people with chronic health conditions. We cannot automatically conclude that when today's 50-75-year-olds are 70-95 they will experience chronic health conditions at these percentages, since people who in 1995 were older than age 70 years were born before 1925, and therefore had different life experiences and exposures than people who will pass age 70 during the next two decades. But it is likely that the prevalence of these conditions will be at least as great, since prevention of arthritis and hypertension is not on the horizon, whereas survival from heart disease and cancer will probably increase. The obesity epidemic will probably contribute to higher rates of diabetes and probably heart disease and cancer – if survival improves, the prevalence of these conditions will increase.

a

FORMULAS

Birth (crude) rate	=	(number of births) ÷ (total population)	X	1,000
Age-specific birth rate	=	(number of live births to females in a specific age group) ÷ (female population in that age group)	X	1,000
Teen-age birth rate	=	(number of births to females aged 10-19) ÷ (female population aged 10-19)	X	1,000
Abortion rate	=	(number of abortions) ÷ (female population aged 15-44)	X	1,000
Teenage abortion rate	=	(number of abortions to females aged 10-19) ÷ (female population aged 10-19)	X	1,000
Estimated total fetal losses	=	20 percent of births + 10 percent of abortions		
Estimated pregnancies	=	number of births + number of abortions + estimated total fetal losses		
Pregnancy rate	=	(number of births + number of abortions+ estimated total fetal losses) ÷ (female population 15-44 years of age)	X	1,000
Teenage pregnancy rate	=	(number of births to females aged 10-19 + number of abortions to females aged 10-19 + estimated total fetal losses to females aged 10-19) ÷ (female population 10-19 years of age)	X	1,000
Total fertility rate	=	$\sum$ (five-year age-specific birth rates for females aged 10 to 49)	X	5

Percent low weight births	=	(number of births with a birth weight less than 2500 grams) ÷ (number of births)	X	100
Infant mortality rate	=	(number of deaths to live born infants under one year of age) ÷ (number of births)	X	1,000
Neonatal mortality rate	=	(number of deaths to live born infants occurring within the first 27 days of life) ÷ (number of births)	X	1,000
Postneonatal mortality rate	=	(number of deaths to live born infants occurring after the first 27 days of life but before one year of age) ÷ (number of births)	X	1,000
Death (crude) rate	=	(number of deaths) ÷ (total population)	X	1,000
Cause-specific death rate	=	(number of deaths for a specific cause) ÷ (total population)	X	100,000
Age-specific death rate	=	(number of deaths for a specific age group) ÷ (population for that age group)	X	1,000
Marriage rate	=	(number of marriages) ÷ (total population)	X	1,000
Divorce (dissolution) rate	=	(number of divorces and annulments) ÷ (total population)	X	1,000

Note: Population refers to the projected mid-year population.