Demography

Demography is the study of human populations with respect to their size, structure, and dynamics. For demographers, a population is a group of individuals that coexist at a point in time and share a defining characteristic such as residence in the same geographical area. The structure or composition of a population refers to the distribution of its members by age, sex, and other characteristics, such as place of residence and marital or health status. The age and sex structure of a population results from past trends in fertility, mortality, and migration. Thus, these processes comprise the components of demographic change. The age and sex structure of a population, in turn, affects birth rates, death rates, and rates of migration. Changes in status such as getting married or divorced interact with population structure in a similar way.

Some authorities reserve the term demography for the mathematical and statistical study of the interrelationships between population size and structure and the components of demographic change. According to this terminology, demography can be contrasted with population studies, which investigate the determinants and consequences of demographic phenomena drawing on the concepts and theories of disciplines such as the **social sciences**, health sciences, and history. Others encompass population studies within demography and use the term *formal demography* to distinguish the statistical core of the discipline. Demography (according to this wider definition) is a multidisciplinary field: subdisciplines such as economic demography, historical demography, anthropological demography, and mathematical demography exist. They differ not only in their subject of study but also in their theoretical orientation and methods.

The term demography has been ascribed to a Belgian statistician, Achille Guillard, who coined it in 1855. However, the origins of modern demography are usually traced back to **John Graunt**'s quantitative analyses of the "Bills of Mortality" published in 1662 [5]. The "Bills of Mortality" provided weekly lists of burials and baptisms in the parishes of London. Graunt used these data to examine the sex ratio at birth and to estimate the population of London. He showed that more deaths than births occurred in London, implying that the growth of the capital was due to in-migration from the countryside. He also estimated the proportion of births surviving to a range of ages, thereby developing the basic concept of the **life table**. Graunt's research prefigures modern applications of demographic science: information on fertility and mortality and population estimates for small areas (*see* **Small Area Estimation**) remain the fundamental results of demographic analysis required by those engaged in policy formulation and planning.

Demographic Data

In most developed countries, civil registration of births and deaths is the primary source of fertility and mortality data. Government agencies routinely collect demographic information when births and deaths are certified for administrative purposes (*see* **Vital Statistics, Overview**, Overview). The primary source of data on the size, structure and distribution of national populations is the population census. **Censuses** aim to enumerate the whole population of a defined geographical area. They collect individual-level data on the population's characteristics that refer to a single point in time. As well as collecting data on the size and composition of the population, most censuses also ask about moves in a fixed period of time before the enumeration. In countries where vital statistics data are incomplete, questions may also be asked about fertility and mortality. Countries that issue identity numbers and require their population to report their place of residence can maintain continuous population registers. In a few European countries these registers now fuse the functions of the registration system with those of the census.

The evolution of demographic analysis and of routine collection of data on populations by the government were interlinked. Standard demographic measures and techniques of analysis were developed largely for the study of vital statistics with census-based denominators. In recent decades, however, demographers have relied increasingly on survey data to supplement those from traditional sources (*see* **Surveys, Health and Morbidity**). In particular, in countries where registration of vital events is incomplete national sample surveys are the main source of vital statistics. One of the first subjects to be investigated in demographic surveys was family planning (*see* **Reproduction**). Other early surveys collected women-based fertility histories to supplement the event-based data generated by birth registration. Fertility history and family planning data remain the focus of many demographic surveys, including the two major international programs of surveys conducted since the 1970s, namely the World Fertility Survey and the Demographic and Health Surveys.

Issues

Between the mid-nineteenth and mid-twentieth centuries the more developed regions of the world went through a *demographic transition* from a high-fertility, high-mortality, and low-growth demographic regime to a low-fertility, low-mortality, and low-growth demographic regime. As mortality tended to fall before fertility, this transition was marked by rapid population growth. Since 1945, a similar transition has begun in most less developed countries. As a result, the world's population has grown from about 2.5 billion to about 6 billion in the second half of the twentieth century. It is expected to grow to between 9 and 16 billion by 2100.

Efforts to understand the determinants of the transition of fertility and mortality to low levels are a central concern of demography. Many demographers now believe that explanations that focus on economic factors and the provision of health and family planning programs are inadequate and need to be supplemented by accounts that take into account the ideational and cultural determinants of demographic behavior.

Thomas Malthus was the first author to develop a systematic argument that high fertility leading to **population growth** could have adverse effects on economic welfare [7]. He argued that a growing population must eventually outstrip its subsistence base, bringing about rising mortality from famine, pestilence, and war. Although the past two centuries of human history have followed a very different path from that envisaged by Malthus, concern still exists about the impact of population growth on economic development and the environment. Today, however, economic demographers tend to be more sanguine about the consequences of population growth than those with a background in ecology [3].

Many demographic outcomes are of concern to policy makers and much demographic research has an avowedly applied intent. Demography bears on the efforts of international agencies and national governments to promote family planning and improve health in the developing world. In the developed world, population growth has slowed but low fertility and the reduction in death rates in old age are producing an increasingly aged population. Recent changes in patterns of marriage and divorce and of childbearing inside and outside marriage also have major implications for the family and public policy.

Demographic studies of mortality tend to focus on the analysis of routine data. Demographers' research into health and mortality cannot be distinguished clearly from that of epidemiologists. However, demographers tend to be concerned with the distribution of disease and premature death (*see* **Descriptive Epidemiology**) across social groups (*see* **Social Classifications**) and their implications for other aspects of social life, rather than with measuring risk factors for specific conditions.

Demographic Analysis

The aim of formal demographic analysis is to isolate the components of demographic patterns by dividing a population into relatively homogeneous subgroups. Analysis by age and sex has primacy over analysis by other compositional factors. Human biology causes the propensity to die and to give birth to be differentiated by age and sex everywhere. It imposes a degree of uniformity on age patterns of mortality and fertility in all human populations.

Classical demographic analysis is based on a fairly small set of measures and techniques. Most of these are also used in cognate disciplines. Calculation of **rates**, ratios, and proportions represent the basic way for controlling for population size. In demography, rates calculated for the whole population that make no allowance for the influence of population structure on the phenomenon of interest are referred to as *crude rates*. Examples are the crude birth rate and crude death rate (*see* **Vital Statistics, Overview**).

Calculation of age-specific rates and rates specific to other subgroups of the population allow the analyst to isolate the propensity to experience the event being studied from the influence of population structure. A range of methods of standardization are used to produce synthetic indices that summarize such specific rates (*see* **Standardization Methods**). The distinction between cohort analysis and **cross-sectional** or period analysis is fundamental to demography. Demographers use the term *cohort* to refer to groups of individuals who experience a defining event at the same time. Examples include **birth cohorts** and marriage cohorts. Cohort analysis studies the subsequent experience of such groups. This contrasts with epidemiologic usage, which refers to all those eligible for recruitment into a longitudinal study as a **cohort**.

Period measures are often treated as referring to a synthetic or hypothetical cohort, so that summary indices can be calculated that indicate what would happen to a cohort that went through life experiencing the specific rates of the period under study. For example, the most widely used index of period fertility is the *total fertility rate*. This measures how many children women would bear on average if they went through life with the fertility of a specific period. It is calculated by summing the age-specific fertility rates of a particular year, usually for five-year age groups, over all ages at which women bear children. The total fertility rate is thus a form of directly standardized rate, calculated using a uniform age distribution as the standard.

Two basic aspects of any demographic process are its intensity, or quantum, and its timing, or tempo. The intensity of a nonrenewable event such as death or first marriage can be measured by the proportion of a cohort who eventually experience the event. Both the expected timing of any nonrenewable process and the distribution of times of its occurrence can be studied using **life table** methods. The intensity of a renewable process such as birth or disease incidence can be measured by the **mean** number of events per person, and their tempo by the characteristics of the distribution of the events in time. Renewable events can be categorized by the order of their occurrence, and events of a particular order can be analyzed as a nonrenewable process. For example, the proportion of women who have had a birth of order i that go on to bear a child of order $i + 1$ is known as a *parity progression ratio*.

Investigation of the determinants of fertility and mortality has been facilitated by making a distinction between proximate and distal determinants. The approach is most developed with respect to fertility. A proximate determinant is one that has a direct impact on the outcome of interest while a distal determinant can only affect the outcome via a proximate determinant. The proximate determinants of fertility are those factors that determine a woman's exposure to sexual intercourse, her probability of conceiving, and the probability that a pregnancy ends in a live birth. The strength of the approach is that only a few of the proximate determinants of individuals' fertility differ between populations in their impact at the aggregate level. Thus, the four main proximate determinants of fertility differences between groups and over time are the proportion of women in sexual unions, postpartum infecundity associated with breast-feeding, contraception, and abortion. Socioeconomic determinants of fertility must operate through these few proximate factors and a single characteristic may have countervailing effects on fertility via different proximate determinants.

Demographic Models

Analysis of data on actual populations is paralleled by mathematical models of the interrelationship between population size and structure and the components of demographic change. Stable population theory as developed by Lotka in the 1920s and 1930s demonstrates that any closed single-sex population subject to constant fertility and mortality rates converges on an unchanging age structure and a constant rate of growth. This stable outcome is independent of the initial age structure of the population. The special case of a stable population that is unchanging in size is termed a *stationary population*. Its age structure is a function of the life table. Recent developments, known as generalized stable population theory, demonstrate that the mathematics of stable populations can be extended to populations in which growth rates vary by age because of a history of fertility and mortality change and to populations subject to decrements other than mortality [8].

One crucial application of demography is to the forecasting of future population change. This is usually undertaken using cohort-component methods of population projection [2]. These methods provide a precise way of controlling for the influence of population structure and of working out the implications of any scenario postulated for future vital rates. Despite this, population forecasts have often proved wide of the mark. Fertility, mortality, and migration remain difficult to predict. Forecasts informed by a theoretical understanding of the determinants of these components of population change often perform little better than the simple extrapolation of past trends in vital rates.

The increasing availability of survey data and information technology that makes it practicable to undertake individual-level analysis of data on large samples, have facilitated convergence between demographic methods and other forms of statistical analysis. Thus, many of the developments in demographic analysis during the past few decades have been closely linked to those in statistical methods more generally. Demographers have both adopted and contributed to the development of methods such as event history analysis [10], the modeling of unobserved heterogeneity, and **random-effects** models [4]. Other fields of methodologic research in recent years include the extension of life table methods into multistate models that allow for increments as well as decrements from each state [6] and methods and models for the study of families and households [1]. (*see* **Multilevel Models**)

One particularly successful field has been the development of indirect methods for estimating vital rates in populations with limited and defective vital statistics [9]. Indirect methods use stable population theory and its extensions to describe the relationship between conventional indices of fertility, mortality, and migration and items of information that can be collected more reliably in single-round surveys and censuses in less developed countries. For example, it is possible to estimate life table indices of child mortality from data on the proportion of women's children ever-born who have died, tabulated by the age of the women concerned [9].

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(*See also* **Actuarial Methods**)

IAN M. TIMÆUS