assets have to be divided among more survivors. In short, the natural desire of the younger generation to maintain or improve upon the living standards of its parents is jeopardized and this pressure stimulates a reduction in childbearing. In a simple statistical test using data from 184 countries, economist Diane Macunovich found that increases in the ratio of males aged 15 to 24 years to males aged 25 to 59 were more strongly predictive of declines in fertility than were declines in infant mortality. Pending further assessment of such linkages, this thesis remains an interesting possibility.

Conclusion

Mortality decline must remain at the center of attempts to understand the fertility transition of the past 120 years. Steep declines in childbearing from over five births to around two births per woman were only possible in the context of vastly improved survival. Beyond this obvious truth, few other generalizations can be stated with confidence. Because fertility decline occurs under widely differing mortality conditions, it is clear that improved survival, while it is probably the underlying cause, is not the sole nor, in the short term, necessarily the dominant influence.

See also: *Demographic Transition; Fertility Transition, Socioeconomic Determinants of.*

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John G. Cleland

MORTALITY MEASUREMENT

This article gives a nontechnical account of the principal indexes used by demographers to measure the level of mortality in a population. For each index, the main advantages and disadvantages are also noted.

Crude Death Rate

The crude death rate is the number of deaths in a population during a specified time period divided by the population "at risk" of dying during that period—that is, for a time period measured in years, the number of person-years lived during the period. For a one-year period, the population at risk is simply the average population size over the year; for a calendar year, the mid-year population is usually taken. By convention, the resulting fraction is applied to a standard-sized population of 1,000, thus making the crude death rate the number of deaths per 1,000 population per year. The adjective "crude" is used since none of the structural characteristics of the population that might affect the number of deaths that occur in the time period—in particular the age distribution—is taken into account, only total population size.

The crude death rate is normally calculated for a single calendar year, although in order to smooth out year-to-year fluctuations, published estimates often give an average rate over several years—typically a five-year period. Calculation of the crude death rate for France in 2000 is shown in Item 1 of the Formula Table.

Pros: It requires less detailed data than other mortality measures, and uses data that are more likely to be available for a very recent time period. The crude death rate is needed for calculation of the rate of natural increase (the crude birth rate minus the crude death rate).

FORMULA TABLE

Examples of Calculation of Mortality Rates

ITEM 1: CRUDE DEATH RATE, FRANCE, 2000

$$\textit{Crude Death Rate (CDR)} = \frac{\textit{Deaths in } 2000}{\textit{Total Population, } \text{July 1, 2000}} = \frac{536{,}300}{58{,}891{,}913} = 0.00911 = 9.11 \textit{ per } 1{,}000$$

ITEM 2: AGE-SPECIFIC DEATH RATE, RUSSIA, 1999 (MALE)

Age Specific Death Rate (ASDR) for males in age group 55–59

$$= \frac{\textit{Deaths in 1999 to males aged } 55\text{–}59}{\textit{Number of males aged } 55\text{–}59 \textit{ at mid year}} = \frac{87{,}584}{2{,}780{,}444} = 0.031 = 31.5 \textit{ per } 1{,}000$$

ITEM 3: INFANT MORTALITY RATE, IRELAND, 1999

$$\textit{Infant Mortality Rate (IMR)} = \frac{\textit{Deaths in 1999 to infants under age one}}{\textit{Live births in 1999}} = \frac{293}{53{,}354} = 0.0055 = 5.5 \textit{ per } 1{,}000$$

ITEM 4: STANDARDIZED DEATH RATE, EGYPT, 1995

Standardized Death Rate for Egypt 1995 (US standard) — see Table 1

$$= \frac{4{,}443{,}559}{262{,}755{,}270} = 0.0169 = 16.9 \textit{ per } 1{,}000$$

SOURCE OF DATA: Council of Europe (2000); Goskomstat of Russia (2000); National Center for Health Statistics (1997), United Nations Statistics Division (2000).

Cons: It is affected by the population age structure—in particular, by the proportions of elderly, who have a higher than average probability of dying in any given period. For that reason, the crude death rate is not a good indicator of overall mortality for comparisons among countries or regions with differing age structures. For example, the crude death rate of Sweden in 2000, 11 per 1,000 population, is much higher than that of Venezuela, 5 per 1,000. But Sweden had a proportionately much larger elderly population than Venezuela: 17 percent of the population of Sweden was aged 65 and over, compared to only 5 percent in Venezuela. By the measure of life expectancy at birth, Sweden has the lower mortality: its life expectancy in 2000 was 80 years, compared to Venezuela's 73 years.

Age-Specific Death Rates

Age-specific death rates (or age-specific mortality rates) (ASDR) are similar to the crude death rate, but calculated for a individual age groups, typically five-year groups. If calculated for a single year, the numerator of the rate is the number of deaths to persons in the age group during the year and the denominator is the average population in the age group during the year (or the mid-year population). Age-specific death rates are often calculated for each sex separately.

Age-specific death rates normally have a J-shaped distribution over the age range. Death rates are relatively high for infants and young children, low for older children and from the young adult years to middle age, and then become higher with increasing age. (Countries with severe AIDS epidemics are an exception to this pattern: AIDS mortality among young adults and persons of middle age has created a sharp rise in age-specific mortality rates in those ages.) Calculation of the age-specific death rate for Russia in 1999 is shown in Item 2 of the Formula Table.

Pros: It allows analysis of mortality patterns by age and sex. Age-specific death rates are required for the calculation of life tables.

Cons: It requires detailed data on deaths by age group, data that are often not available in developing countries.

TABLE 1

Comparison of Death Rates in Egypt and in the United States, 1995

Age group	US population thousands	US ASDRs (x 1000)	Egypt ASDRs (x 1000)	Actual US deaths in 1995	US deaths in 1995 if Egypt's ASDRs applied
0–4	19,595	1.836	8.1	35,976	158.718
5–9	19.188	0.197	0.9	3,780	17.269
10–14	18,886	0.255	0.8	4,816	15,109
15–19	18.071	0.835	1.0	15,089	18.071
20–24	17,885	1.071	1.0	19.155	17,885
25–29	19.012	1.193	1.3	22,681	24,715
30–34	21,874	1.603	1.6	35,064	34,998
35–39	22,253	2.089	2.4	46,487	53,408
40–44	20,219	2.759	3.5	55,783	70,765
45–49	17,448	3.761	5.8	65,623	101.200
50–54	13,630	5.677	8.6	77,377	117,217
55–59	11,085	8.718	13.9	96,641	154,085
60–64	10,046	13.823	25.0	138,871	251,159
65–69	9.928	20.583	40.9	204,347	406,053
70–74	8,831	31.314	68.2	276,543	602,294
75+	14,773	82.138	162.5	1,213,436	2.400,613
Total	**262,755**			**2,311,669**	**4,443,559**

Note: ASDR is age-specific death rate.

SOURCE: U.S. Census Bureau (www.census.gov); National Center for Health Statistics. 1997. Report of Final Mortality Statistics, 1995; United Nations Statistics Division (2001).

Infant Mortality Rate

The infant mortality rate (IMR) is the proportion of infants who die in their first year. It is conventionally calculated as the number of deaths under age one in a given year divided by the number of live births, with the result expressed per 1,000 births. Calculation of the infant mortality rate for Ireland is shown in Item 3 of the Formula Table.

To be strictly accurate, the IMR in this case should be the number of deaths before age one to infants born in 1999 divided by the number of live births in 1999. This formula would relate infant deaths to the population at risk—in this instance, comprising the births among which such deaths could occur. (It is equivalent to the life table death rate between age zero and exact age one.) The practical problem this precise formulation raises is that deaths under age one from among births in a given calendar year consist of some fraction of infant deaths during the calendar year in question and some fraction of infant deaths that occur in the following calendar year. Hence the precise IMR calculation would require information about infant deaths in two calendar years, and the deaths would need to be classified by the double criterion of age and year of birth. Such detail is rarely available.

Pros: The infant mortality rate is usually considered a good indicator of overall health conditions in a country, particularly child health. Frequently it is used to infer ("impute") the entire age schedule of mortality, using a set of model life tables.

Cons: Accurate registration data on births and infant deaths are unavailable in many countries. (In the absence of such data, estimates of IMR—and of proportions of births surviving to later ages of childhood—at a period several years in the past can be derived from retrospective survey data on survivorship rates of children. Demographic surveys routinely ask women how many children they have had and how many are living.)

Standardized Death Rate

The standardized death rate of a population is the death rate that it would have if the population had the age distribution of some different specified population—the "standard." The concept can be explained in terms of weighted averages. The crude death rate of a population can be represented as the weighted average of the prevailing age-specific death rates, the weights being the proportions of the population at each age. If the weights used in the calculation are instead taken from the age distribution of some different population, chosen as the standard, the resulting weighted average is the standardized (or strictly, the age-standardized) death rate.

For comparisons of death rates among populations, standardization (with the same standard used throughout) removes the effects of the different actual age distributions on the rates. In the example in Table 1, standardization is used to compare the mortality of Egypt and the United States in 1995, using the U.S. age distribution as the standard. In 1995 the United States had 2.311 million deaths in a population of 262.755 million, giving a crude death rate of 8.8 per 1000. The corresponding crude death rate for Egypt was 6.5. The lower level of mortality in Egypt by this measure, however, is an artifact of the age distribution: Egypt's life expectancy at birth, about 65, is some twelve years less than that of the United States. Since reported age-specific death rates of reasonable quality for Egypt are available, it is possible to calculate the number of deaths the United States would have if it had the reported age-specific death rates of Egypt. Table 1 compares the number of deaths at each age using ASDRs of both Egypt and the United States applied to the U.S. age distribution. The deaths that would have occurred in the United States if it experienced Egypt's mortality at each age are about 4.4 million, compared to the 2.3 million deaths that did occur. The resulting death rate for Egypt in 1995, standardized on the U.S. population, is 16.9 per 1,000 population rather than 6.5. (See Item 4 in the Formula Table.)

The technique of standardization is much more general than this example may suggest. Death rates can be standardized by other characteristics than age, or by other characteristics as well as age, the choice depending on the intended comparison.

Pros: Standardization by age allows comparison of death rates abstracting from influences of differences in age distributions.

Cons: It requires data on deaths or death rates by age for both countries and the age distribution of one country. The comparison depends to some degree on the choice of the standard.

Life Expectancy

Life expectancy at any given age is the average number of additional years persons of that age would live under the mortality conditions prevailing at the time. Most frequently, life expectancy is quoted in terms of life expectancy at birth: the number of years a newborn infant can be expected to live under mortality rates at each age existing at the time of its birth.

Life expectancy at age x is calculated in a life table by summing the number of survivors at each single year of age above x (which gives the total person-years lived beyond x in the life table population) and dividing by the number at age x. It is most commonly calculated from age 0, giving the expectation of life at birth.

Pros: Life expectancy at birth is the single best summary measure of the mortality pattern of a population. It translates a schedule of age-specific deaths rates into a result expressed in the everyday metric of years, the average "length of life."

Cons: It requires a full schedule of age-specific death rates. Since mortality typically declines over time, a calculated life expectancy, derived from cross-sectional mortality data, understates the true expected length of life. Subtracting actual age from life expectancy at birth is often erroneously interpreted as giving average remaining years to live.

See also: *Actuarial Analysis; Fertility Measurement; Life Tables; Maternal Mortality; Mortality, Age Patterns of; Population Dynamics.*

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