Mortality Differentials in Specified Age Groups

''*Mere maleness influences unfavorably the resistance of the organism to disease at all ages*'' Allen (1934).

Not only is the sex mortality differential almost universal around the world, but males also have greater mortality at all ages, even before birth. The primary sex ratio, which is the ratio of male conceptions to female conceptions, and the fetal sex mortality ratio are not precisely known. As shown in Table 1, the ratio of males to females conceived has been estimated to be from 107 to 170 males per 100 females. Table 2 shows that the sex ratio of the fetal mortality rates has been estimated to be from 111 to 160 males per 100 females. At birth, the sex ratio is 105 males to 100 females (U.S. Bureau of the Census 1998). The sex ratio of perinatal deaths, defined as stillbirths (gestation of 28 weeks or more) and deaths during the first week of extra-uterine life, in a British study was 124 males to 100 females (Butler et al. 1963). In a study of five European countries, for the period 1901–63, the ratio was 118–129 males to 100 females (Teitelbaum 1971). Population data from the National Center for Health Statistics (1996) indicate that the male-to-female fetal mortality ratio is 1.08. Shapiro showed that sex differences in perinatal mortality cannot be explained by birth weight or gestation periods (1954). Infant mortality is greater for males than for females in all age categories, whether measured by days or months, and the infant mortality rate for every major cause of death is substantially higher among males than females. Males have greater mortality than females at every birth weight during the neonatal period, except for the highest weight group of 4,501 grams or more (Shapiro et al. 1968).

As illustrated in Figures 5 and 6, the sex mortality differential varies by age. In 1990, the U.S. ratio was 1.23 for the first year of life; it decreased to 1.14 at age 2, stayed below 1.5 until age 12, and then sharply increased to its maximum of 3.17 at age 22. Thereafter, it steadily declined to about 1.75 around age 50, plateaued until about age 75, and then steadily declined to 1 at age 112. If deaths from violence (accidents, suicide, and homicide) are excluded, the spike in the early 20s disappears completely. In Canada, as shown in Figure 6, the pattern is similar, with some small differences. The small ''hump'' from ages 2 to 6, followed by a small trough during ages 7–11 are more pronounced in Canada than in the United States. The early adult peak, which has been called the ''testosterone spike,'' occurs at exactly the same age (22)

TABLE 1
ESTIMATED NUMBER OF MALE CONCEPTIONS PER 100 FEMALE CONCEPTIONS

Number of Male Conceptions	Source
111	Tricomi, et al. 1960
115	Perls, et al. 1999
107–124	Parkes 1967
110–170	McMillen 1979
130–150	Rasmuson 1971

TABLE 2
ESTIMATED SEX RATIO OF FETAL MORTALITY RATES (MALE/FEMALE)

Ratio	Source
111	Hammoud 1965
111*	Parkes 1967, citing O. J. Miller no date
135	Parkes 1967, citing A. C. Stevenson no date
160	Tricomi, et al. 1960

*In induced abortions, presumably in the first third of pregnancy.

and amount (3.17) in Canada as in the United States. In the United States, another ''hump'' during ages 50–70 appeared in 1960, but had virtually disappeared by 1990. This hump appeared in Canada in 1991, but occurred about five years of age later.

The differential in mortality by sex has been observed among those aged 100 and older. In a study of centenarians in France that found a ratio of 7.1 female centenarians for each male centenarian, the average of the male mortality rates for ages 100–108 was .476, while the average for females was .420. Thus, the male rate averaged 13% greater than that for females (Allard et al. 1996).

Figure 7 shows the contribution by year of age to the sex differential in life expectancy at birth, based on the 1990 life table produced by the Social Security Administration (Bell et al. 1992). This bar graph shows that the contribution to the total sex differential of 7.1 years is high for infants (about 2% for the year after birth) and minimal for children (about .2% per year). It then increases during adolescence, remains stable during adult years until about age 50 (about .8% per year), then rises until about age 70 (to about 2% per year), after which it steadily declines to 0% after age 100. This type of decomposition by age is used by the Population Division of the United Nations to analyze sex mortality differentials [United Nations Population Division (Larry Heligman) 1983]. The formula used is:

$$\Delta_x = [(e_x^f - e_x^m)(l_x^f + l_x^m)/2] - [(e_{x+1}^f - e_{x+1}^m)(l_{x+1}^f + l_{x+1}^m)/2]$$

where:

- Δ_x is the contribution to the sex differential in life expectancy at birth of mortality differences within the age group (x, x + 1);
- e_x^f (e_x^m) is life expectancy at age x for females (males); and
- l_x^f (l_x^m) measures the life table survivors to age x for females (males) in a life table with radix 1.

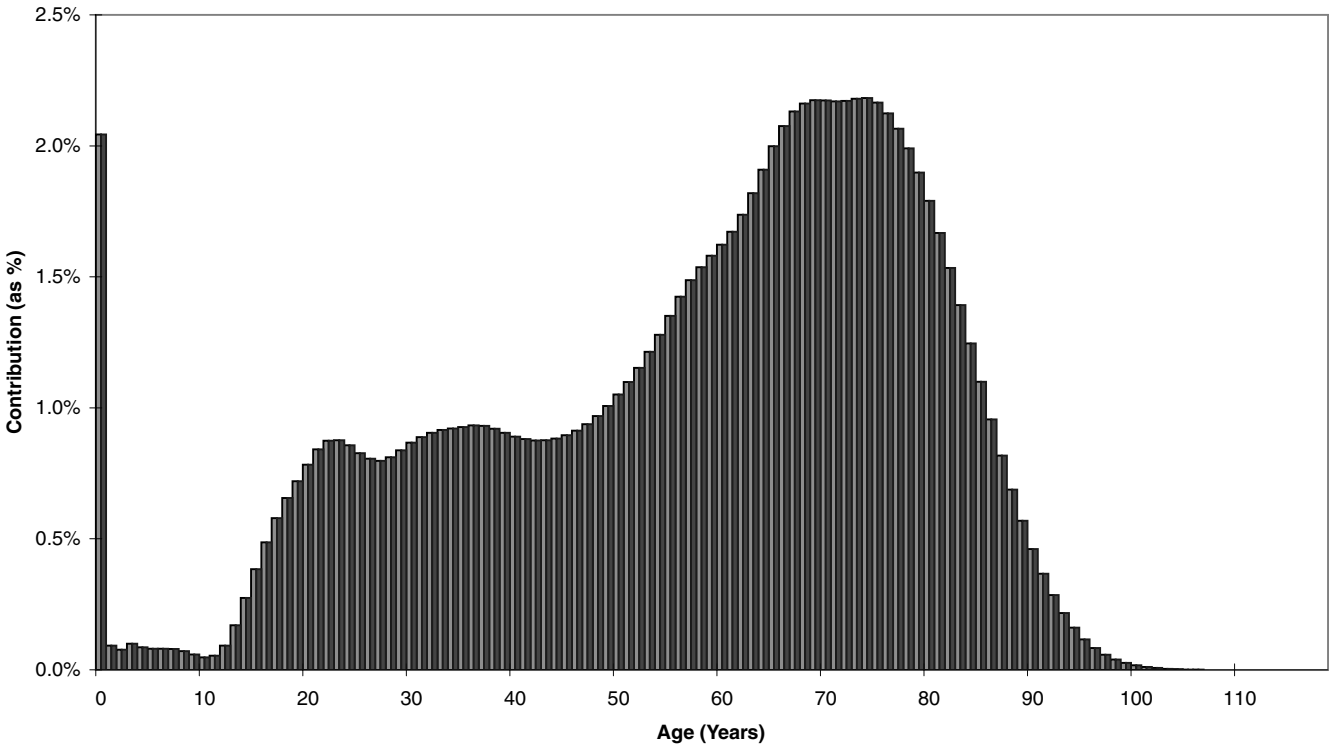
The differences in mortality by sex can be illustrated by a mathematical expression of the age pattern of mortality. A formula that considers all ages, proposed by Heligman and Pollard (1980), is:

$$\frac{q_x}{p_x} = A^{(x+B)^C} + De^{-E(\ln x - \ln F)^2} + GH^x$$

where q_x is the probability of dying within one year

FIGURE 7

CONTRIBUTION BY YEAR OF AGE (AS %) TO SEX DIFFERENTIAL IN LIFE EXPECTANCY AT BIRTH IN 1990



Source of data: Social Security Administration in Bell, et al. 1992, as shown in Society of Actuaries Mortality Tables Library [online database].

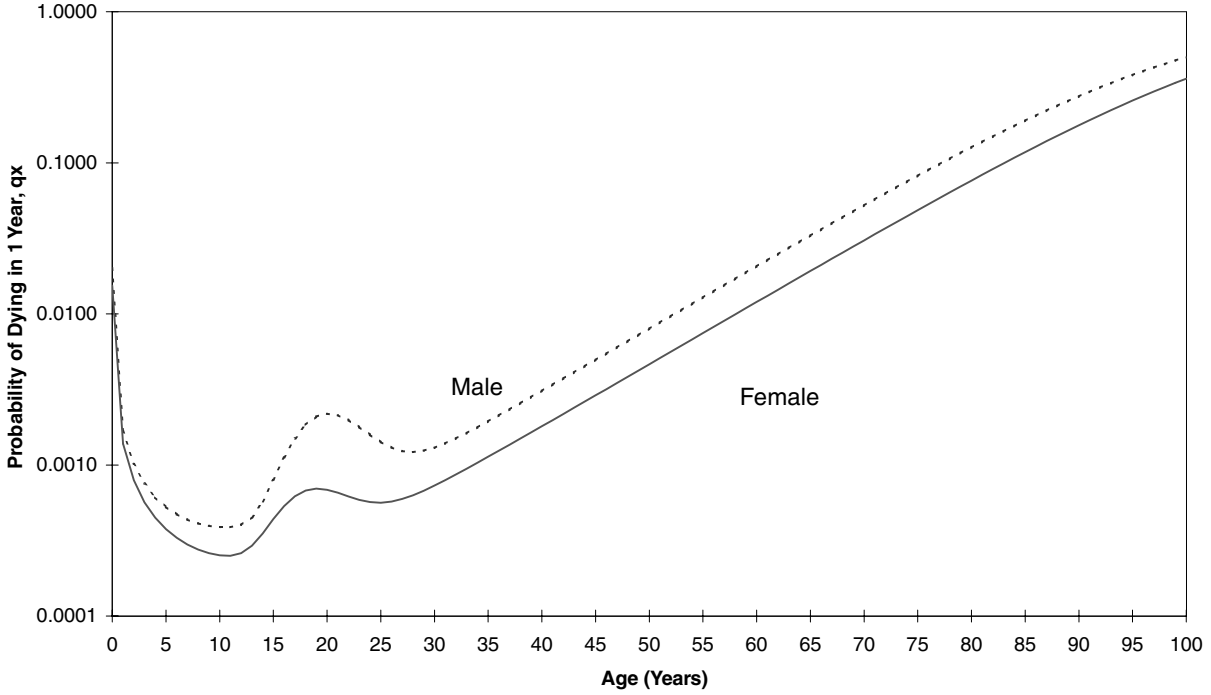
TABLE 3
Parameter Values for Heligman-Pollard Formula of Australian Mortality during 1970–72

Parameter	Representation	Male	Female	Difference (Female–Male)
A	Nearly equal to q_1	0.00163	0.00137	0.00026
B	Measures location of infant mortality from q_1 to .5	0.0144	0.0251	−0.0107
C	Rate of mortality decline in childhood (the greater C, the faster mortality declines as age increases)	0.1182	0.1249	−0.0067
D	Severity of 'accident hump'	0.00164	0.00039	0.00125
E	Spread of 'accident hump'	18.49	16.8	1.69
F	Location of 'accident hump'	19.88	18.58	1.30
G	Base level of senescent mortality	0.0000643	0.0000383	0.0000260
H	Rate of increase of senescent mortality	1.1013	1.1007	0.0006

Source of data: Heligman & Pollard 1980.

for a person aged x exactly, and $p_x = (1 - q_x)$. The first term of this expression, a rapidly declining exponential with parameters *A*, *B*, and *C*, represents mortality during early childhood. The second term, which is a function similar to the lognormal with parameters D, E, and F, represents the ''accident hump'' in early adulthood reflecting accident mortality in males and accident plus maternal mortality for females. The third term, the Gompertz exponential with parameters G and H, represents the near geometric rise in mortality at the adult ages. This mortality is usually considered to represent the aging or deterioration of the body, so it is often called senescent mortality. The parameter values representing the Aus-

FIGURE 8
Probability of Dying within One Year for a Person Aged x Exactly, of Australian Mortality during 1970–72 using Heligman-Pollard Formula (using log scale)



Source: Derived from formula and parameter values in Heligman & Pollard 1980.

tralian national mortality during 1970–72 for males and females, and the differences, are shown in Table 3.

Thus, for this population, mortality at age 1 is about 20% greater for males than for females and mortality declines faster in childhood for females than for males. The ''accident hump'' is over four times more severe and slightly more spread out in males than in females, and it occurs a year later in males. The base level of senescent mortality is about 70% greater in males than in females and has a slightly greater rate of increase in males than in females. The values of q_x, the probability of dying within one year for a person aged x exactly, determined by this formula and the above parameter values for males and females, are shown in graphical log form in Figure 8 and tabular form in Appendix C. These mortality rates yield an expectation of life at birth of 68.0 years for males and 74.7 years for females.