Far Eastern Patterns of Mortality

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INTRODUCTION

During the past few decades several demographers have developed model schedules of mortality in an attempt to describe a wide range of mortality experience by means of a small number of parameters. The most widely used model schedules include: the original United Nations set of model life tables defined by a single parameter denoting the level of mortality; the Coale and Demeny regional model life tables containing a series of mortality tables indexed by the level of mortality, for each of four regional (North, South, East, and West) patterns; and a logit system of life tables based upon a two-parameter transformation of a standard life table.[1] In this study we describe a pattern of mortality found in several Far Eastern populations during the twentieth century which differs from existing model mortality schedules. Specifically, mortality statistics from Korea, Taiwan, Hong Kong, and Singapore suggest a Far Eastern pattern of mortality characterized by excessively high death rates among older men relative to death rates among younger men and among women. This pattern appears to occur nowhere else, at least among countries with reliable mortality statistics and is characterized by the highest sex differentials in mortality at older ages to be found anywhere in the world.

In describing what appears to be a unique pattern of mortality, we must compare actual mortality schedules with some standard pattern. We have chosen the Coale and Demeny set of regional model life tables as the standard for the following reasons: these tables are based on mortality statistics from the mid 1800's until 1960 for diverse geographical areas; the schedules fit a wide variety of statistics quite closely; and the Coale and Demeny tables have previously been used to describe excess mortality among men in modern populations.[2]

Coale and Demeny developed the model life tables by examining patterns of deviations of 326 individual life tables from a set of preliminary model tables which described median world mortality experience. They subsequently found that most of the life tables could be described by four general age patterns of mortality: North, South, and East, each of which showed a relation between childhood and adult levels of mortality that was consistently different from general world experience; and a West pattern which consisted of a large residual group of life tables (mostly from Western populations) not characterized by any specific form of deviation from general experience.[3] Each of the four regional sets of tables contains a series of 24 life tables for each sex, distinguished by the expectation of life at birth.

In this analysis we compare Far Eastern mortality schedules with those in the West family for several reasons: (1) mortality figures for Korean women for the past 20 years have been

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[1] United Nations. 1955. *Age and Sex Patterns of Mortality: Model Life Tables for Underdeveloped Countries.* Population Studies, No. 22, New York; A. J. Coale and P. Demeny. *Regional Model Life Tables and Stable Populations.* Princeton. Princeton University Press, 1966; W. Brass. *Methods for Estimating Fertility and Mortality from Limited and Defective Data.* An Occasional Publication. Chapel Hill: The University of North Carolina at Chapel Hill, International Program of Laboratories for Population Statistics, 1975; N. H. Carrier and J. N. Hobcraft. *Demographic Estimation for Developing Societies.* London: Population Investigation Committee, 1975.

[2] S. H. Preston. *Older Male Mortality and Cigarette Smoking: A Demographic Analysis.* (Population Monograph 7). Institute of International Studies, University of California, Berkeley. 1970.

[3] Coale and Demeny, *op. cit.* in footnote 1.

Table 1. *Expectations of life at birth by level of West model life table for each sex*

Level	Female e_0^o	Male e_0^o
1	20	18.0
2	22.5	20.4
3	25	22.9
4	27.5	25.3
5	30	27.7
6	32.5	30.1
7	35	32.5
8	37.5	34.9
9	40	37.3
10	42.5	39.7
11	45	42.1
12	47.5	44.5
13	50	47.1
14	52.5	49.6
15	55	51.8
16	57.5	54.1
17	60	56.5
18	62.5	58.8
19	65	61.2
20	67.5	63.6
21	70	66.0
22	72.5	68.6
23	75	71.2
24	77.5	73.9

Source: A. J. Coale and P. Demeny, *Regional Model Life Tables and Stable Populations.* Princeton. 1966.

accurately described by West model patterns of mortality;[4] (2) mortality for each sex in Taiwan – the only statistics from the Far East used in constructing the Coale and Demeny tables – was best fitted by the West family of life tables; and (3) mortality schedules for the past 25 to 30 years for women in Taiwan, Hong Kong, and Singapore and very recent schedules for men in these countries conform fairly well to a West pattern of mortality. However, even had we chosen a different regional mortality pattern for a standard, our basic findings would remain unaltered.

Within the series of 24 life tables for the West family, expectations of life for women range from 20 to 77.5 years, while those for men range from 18.0 to 73.9 years. Hence, a given level of mortality already incorporates a sex difference derived from the average sex difference found in the original life tables. When comparing Far Eastern mortality rates with those in West model life tables, we generally refer to the *level* of the model table. The expectations of life of women and men for each of the 24 model West tables are shown in Table 1. It is useful to bear in mind that the lower the level of the model life table, the lower is the expectation of life.

OCCURRENCE OF PATTERN

In a recent study of trends in fertility and mortality in the Republic of Korea,[5] it was noted that women's mortality rates between 1955 and 1975 conformed to a West model pattern, whereas men's rates for these same years deviated considerably from model schedules. In particular, the death rates for older men were much higher relatively to those for women or younger men than in the model mortality schedules. The Korean mortality schedules in which these patterns were discovered were estimated from the survival rates of different cohorts during inter-censal periods (1955–60, 1960–66, 1966–70, and 1970–75) and from incomplete death registration figures for

[4] A. J. Coale, L. J. Cho and Noreen Goldman. *Estimation of Recent Trends in Fertility and Mortality in the Republic of Korea.* Report prepared for Committee on Population and Demography, National Academy of Sciences, 1979.

[5] *op. cit.,* in footnote 4.

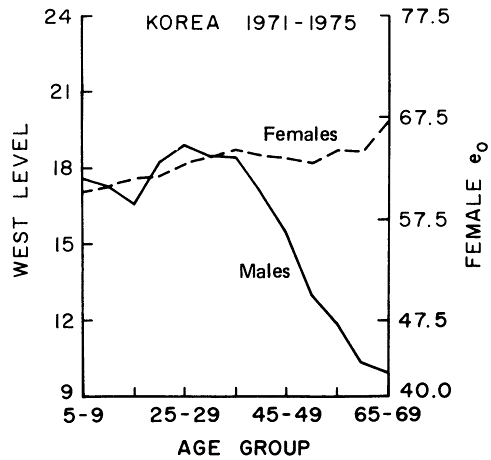


Figure 1. West levels of mortality implied by age-specific death rates for the Republic of Korea 1971–1975, males and females.

Source: Age-specific death rates are based on death registration data for 1971–1975, corrected for omissions. A. J. Coale, L. J. Cho and Noreen Goldman, *Estimation of Recent Trends in Fertility and Mortality in the Republic of Korea.* Report prepared for the Committee on Population and Demography, National Academy of Sciences, Washington, 1979.

the period 1971–75, adjusted for omission of 21 per cent of male and 31 per cent of female deaths.[6]

In Figure 1 we show the levels of mortality that could be implied by age-specific death rates for men and women in the Republic of Korea for the period 1971–75 (derived from corrected death registration data). We note that death rates of women until age 70 conform to a West model table with a level of approximately 18 (expectation of life at birth: 62.5 years). Men's death rates for ages below 40 imply a similar level of mortality, but after this age, death rates imply lower and lower expectations of life. Death rates of men at ages between 60 and 80 imply an expectation of life as low as 40 years (i.e. level 10) in contrast to one of 60 years implied by the younger age groups. (These rates would show a departure of approximately the same amount from model mortality schedules based on any of the three other – North, South, and East – regional patterns.) Men's age-specific death rates derived from the Korean census age distributions, dating as far back as the period 1925–30 show similar deviations from model schedules, with excessive mortality of men at the older ages.[7]

After examining the pattern of excess mortality of men in the Republic of Korea, Coale recalled that, during the construction of the Coale and Demeny regional model life tables, a similar pattern of deviations had been observed for Singapore. Specifically, mortality figures for women in Singapore were consistent with the West family of life tables, while those for men showed death rates higher than expected. Thus, we conjectured that mortality schedules characterized by excess mortality of older men were more likely to be found among Far Eastern populations. A wide variety of mortality statistics from past volumes of the *United Nations Demographic Yearbook* was analyzed to determine whether such deviations occurred in other populations. In fact, mortality patterns similar to that in Korea were discovered only for Far Eastern populations: Taiwan, dating back as far as the early 1900's and continuing until recent times;[8] Hong Kong since the mid-1950's; Singapore since the mid-1940's; and, to a lesser extent, Japan between the 1940's and 1960's.

[6] *ibid.*

[7] See T. H. Kwon, *Demography of Korea: Population Change and its Components 1925–66.* Seoul. Seoul National University Press, 1977 for periods 1925–40; Coale *et al., op. cit.* in footnote 4 for periods 1955–75.

[8] Figures for the early 1900's for Taiwan were taken from the *Statistical Abstract of the Past 51 Years of Taiwan Province* (1946).

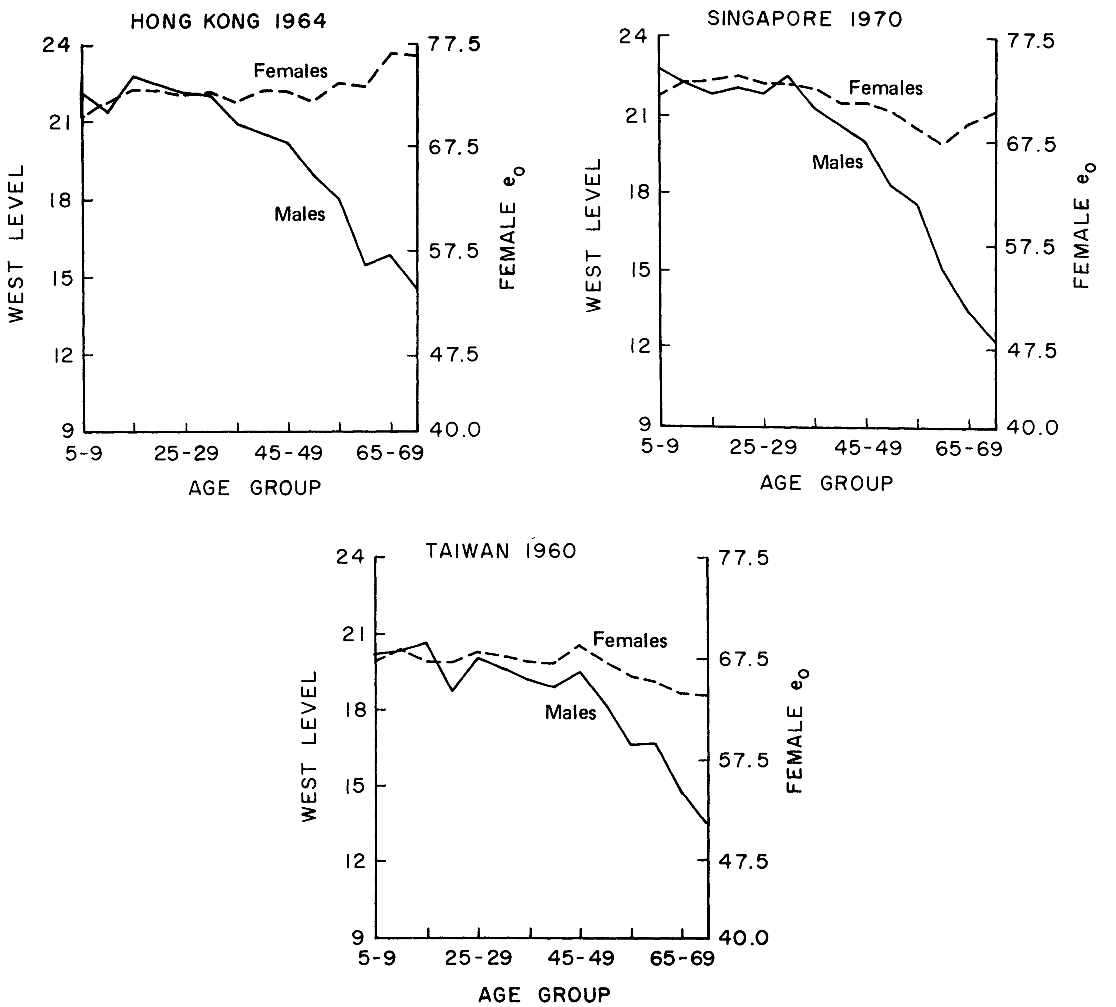


Figure 2. West levels of mortality implied by age-specific death rates for Hong Kong (1964), Singapore (1970), and Taiwan (1960), males and females.

Source: Age-specific death rates are taken from United Nations *Demographic Yearbook*, various years.

Figure 2 shows the levels of West model life tables implied by male and female age-specific death rates for these populations at selected dates between 1960 and 1970. For all of these countries, patterns of women's mortality conform approximately to a West model pattern, while those of men's mortality show greater departures from model life tables with increasing age. In Taiwan, Hong Kong, and Singapore, during most of the past few decades, men's and women's death rates at the younger ages imply approximately the same level of mortality; but, starting at some point in middle age, men's death rates begin a steady and steep departure from this implied level. The sex differences at adult ages in these schedules are among the largest to be found in any of the reliably recorded mortality schedules in the world.

Because of cultural and possibly ethnic similarities among the populations characterized by this singular mortality pattern, differences in mortality patterns within a Far Eastern population consisting of distinct ethnic groups might be expected. Statistics from Singapore provide an opportunity for exploring this question: 76 per cent of the population is Chinese and 15 per cent is Malaysian (1970 Census). Figure 3 shows implied West levels for Chinese and Malay death rates by sex for Singapore for the years 1968–72.

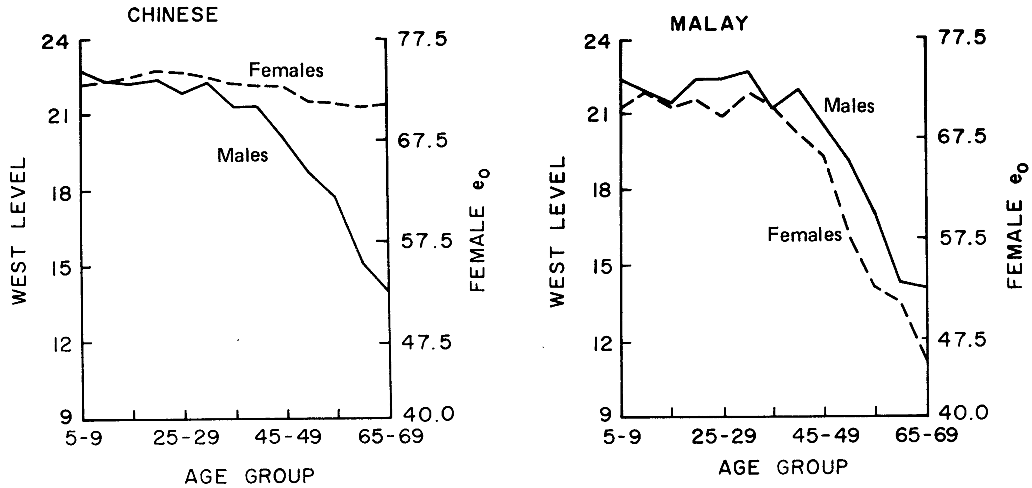


Figure 3. West levels of mortality implied by age-specific death rates for Chinese and Malays in Singapore (1968–1972), males and females.

Source: Number of deaths, by sex and ethnic group, are taken from the *Report on the Registrations of Births and Deaths and Marriages*, Singapore, 1968–1972. Age distributions, by sex and ethnic group, are based on the 1970 Census (Department of Statistics, *Yearbook of Statistics*, 1972/73).

The result is somewhat surprising. As might have been anticipated, a large sex differential in mortality in the older ages exists for the Chinese but *not* for the Malays within Singapore. But, the mortality rates of neither Malay men nor Malay women follow a West pattern. (However, in Malaysia, recent age-specific rates for all races combined can be approximately described by West model tables for either sex.)

A COMPARISON WITH WESTERN POPULATIONS

A departure from model patterns in mortality rates for older men has frequently been noted for modern Western populations, in particular for the years since World War II.[9] These populations include the United States, England, Australia, and Germany, all modern countries with a high expectation of life. In a comprehensive analysis of recent patterns of the mortality of older men in North America and Europe, Preston[10] has shown that these unexpectedly high death rates for older men are associated with cardiovascular and respiratory causes of death and are highly correlated with increased cigarette consumption in these populations. To what extent are these 'modern' mortality patterns in Western populations similar to those just described for Far Eastern populations?

Figure 4 shows the implied levels of West mortality for age-specific death rates of men and women in the United Kingdom, 1971, and in the United States, 1970. A comparison of Figures 2 and 4 reveals that the deviations of men's death rates in modern Western populations are much smaller than those noted for Far Eastern populations. For example, death rates of men in the United States (1970) imply a drop of four levels from ages in the twenties to ages in the sixties, while those in Singapore and Hong Kong imply drops of almost ten levels. A further distinction between the mortality patterns in Western and in Far Eastern nations should be noted: whereas the excess mortality of men in Western populations has generally been increasing with time since about 1940, excess mortality for Far Eastern men has decreased in Taiwan, Hong Kong, and Singapore as will be described in the following section.

[9] Cf. for example Preston, *op. cit.* in footnote 2.
[10] *ibid.*

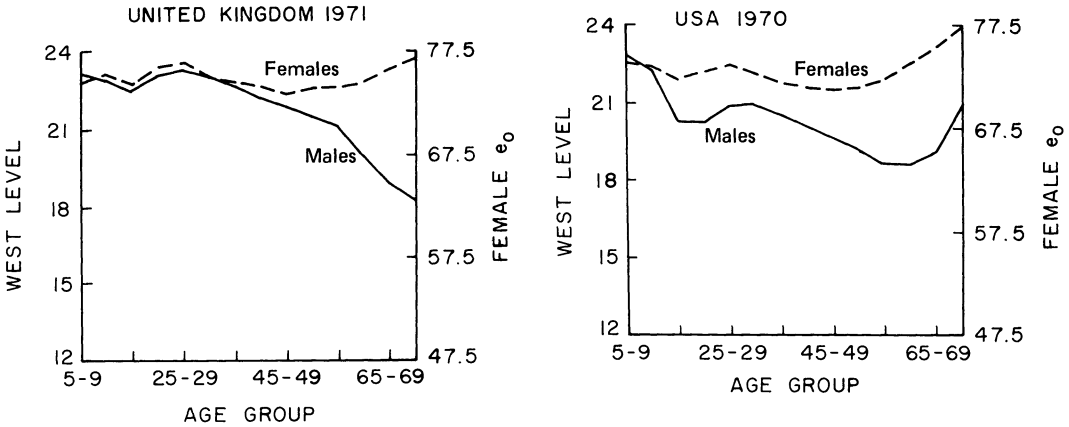


Figure 4. West levels of mortality implied by age-specific death rates for United Kingdom (1971) and United States (1970), males and females.
Source: Age-specific death rates are taken from United Nations *Demographic Yearbook*, 1974.

In an attempt to measure the size of sex differentials in mortality for 165 national populations, Preston has compared actual death rates of men with those predicted from a simple regression equation.[11] Using an orthogonal regression equation with women's age-standardized death rates as the independent variable, Preston obtained deviations between expected and actual death rates of men for these 165 populations. By a considerable margin, the largest deviation (with actual rate higher than predicted) occurred for Taiwan (1920), with five out of the six largest values occurring for Taiwan (1920, 1930, 1936) and Hong Kong (1961, 1964). (The remaining high value occurred for Spain, 1940.) These five Far Eastern mortality schedules for Taiwan and Hong Kong were the only Far Eastern mortality schedules included in the analysis. Preston noted what seemed to be a Far Eastern phenomenon of high sex differentials in mortality and attributed the sex differences in Hong Kong to the complete urbanization of the population.

The present analysis identifies a Far Eastern mortality phenomenon which appears in Korea and Singapore in addition to Taiwan and Hong Kong. The mortality rates of older men in these Far Eastern populations are excessive not only relatively to those of women, but also to death rates of younger men (based on patterns of mortality existing elsewhere in the world). These patterns of mortality are undoubtedly due to a complex interaction among environmental and genetic factors within Far Eastern populations.

DISAPPEARANCE OF PATTERN

Figure 5 shows implied West levels of mortality for age-specific death rates of men for Taiwan, Hong Kong and Singapore, for periods of 20 or 30 years (i.e. as far back as reliable statistics are available). In all three countries, the excess mortality of men (as measured by deviations from model life tables) has decreased with time. For example, whereas men's death rates in Taiwan for the years 1950–52 imply a drop of seven levels from the age group 15–19 to the age group 60–64, those for 1971–73 imply a drop of less than one level over the same ages. In general, the more recent the figures, the smaller are the departures from model patterns; the trend is somewhat less pronounced in Hong Kong than in Taiwan and Singapore. For all three countries, women's death rates during these periods generally conform to West model life tables.[12]

[11] S. H. Preston, *Mortality Patterns in National Populations*, Academic Press, New York, 1976.

[12] Mortality rates of women in Singapore before 1960 and in Taiwan before the mid 1950's show deviations from West model tables of the order of a drop of three levels from childhood to old age.

Continuing to look at Figure 5, we note that more recently, men's mortality rates begin to deviate from model schedules at increasingly older ages. In particular, the time series of West levels for Taiwan and Singapore suggest a generally monotonic relation between time and the age group at which death rates begin to differ from expected rates in model tables. For the most recent years, age-specific death rates for Taiwanese men can be fairly well fitted by a West model life table, and, extrapolating roughly from the curves in Figure 5, we note that within the next decade or so, death rates for men in Singapore and Hong Kong should also conform generally to a West model table.

The progressive disappearance of excess mortality of men suggests some type of 'cohort phenomen.' Observing the trends in Figure 5, we originally conjectured (1) that members of past birth cohorts had experienced additional mortality risks (perhaps as a result of childhood disease or a generally poor childhood environment) which they carried with them throughout their lifetimes; and (2) that members of the most recent birth cohorts have been subject to little, if any, extra risk. Neil Bennett analyzed the time series of mortality for Taiwan, Hong Kong, and Singapore in order to quantify the rate of erosion of excess mortality and test the hypothesis that it was experienced on a cohort basis. Unfortunately, the separation of cohort and period declines in mortality is a complex task, and the application of several techniques failed to yield a firm conclusion (see Appendix). At present, it appears that the reduction of mortality of men over the past few decades in the Far East is both a cohort and a period decline. In the next section, we propose an explanation for excess mortality of men in the Far East and its progressive disappearance.

CAUSES OF DEATH

Having isolated a unique pattern of mortality in the Far East, we have attempted to analyze it in terms of the specific diseases responsible for excess death rates of men. In order to account for the Far Eastern mortality pattern one searches for causes of death with the following four characteristics in Far Eastern countries:

1. A large sex difference in age-specific death rates at older ages;
2. A gradual disappearance over the past several decades;
3. A high prevalence rate;
4. A pattern of occurrence differing from those prevailing in other regions.

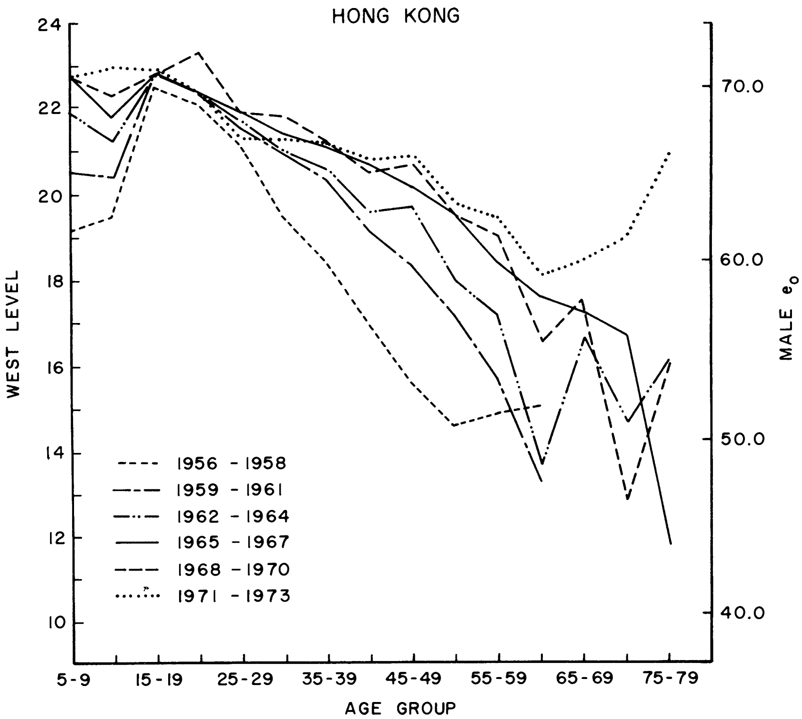
Tuberculosis mortality appears to satisfy most of the conditions listed above.[13] Rates of morbidity and mortality from tuberculosis have been (and in some cases still are) extremely high in Far Eastern populations. For example, in the early 1950's in Hong Kong tuberculosis was the single largest cause of death from infectious disease, accounting for nearly 20 per cent of all deaths; in the 1950's and 1960's, tuberculosis was the colony's major health problem with an incidence rate among the highest in the world (Hong Kong, Department of Medical and Health Services).

In addition, sex differences in mortality from tuberculosis in Hong Kong, Singapore, Taiwan, and Korea[14] have been extremely large. For example, men's death rates from respiratory tuberculosis[15] in middle age have been approximately three times as high as those of women, for Hong Kong and Singapore during the 1950's and 1960's; sex differences in the oldest age groups have

[13] Noreen Goldman, 'Tuberculosis Mortality in Far Eastern Populations'. Unpublished Manuscript. 1979.

[14] Although statistics on causes of death in the Republic of Korea are scarce and generally unreliable, the few figures available indicate a large sex difference in death rates from tuberculosis. Cf. C. B. Park, 'Statistical Observations on Death Rates and Causes of Death in Korea'. *Bulletin of the World Health Organization* **13**, 1955, pp. 69–108; I. S. Kim and D. W. Lee. 'Recent Mortality Trends in Korea' *The Korean Journal of Preventive Medicine* **2**, 1969.

[15] Deaths from respiratory (or pulmonary) tuberculosis comprise the majority of tuberculosis deaths in the Far East. For example, 92 per cent of tuberculosis deaths in Hong Kong during the late 1950's and 94 per cent of those in Singapore in 1960 were due to pulmonary disease.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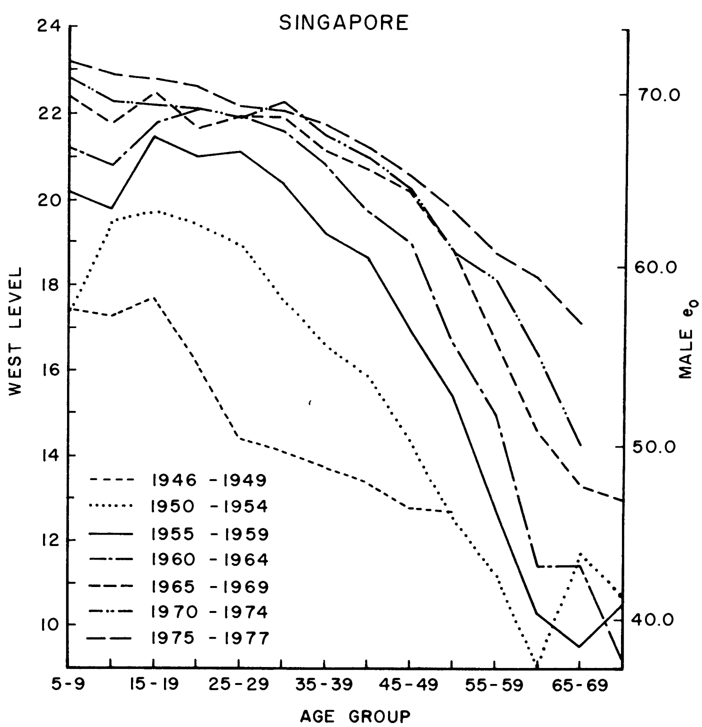
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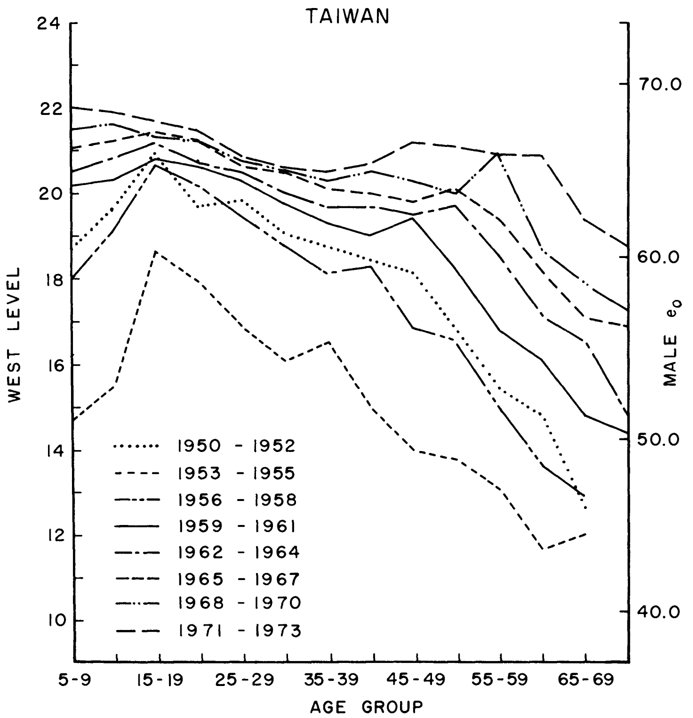

Figure 5. West levels of mortality* implied by male age-specific death rates in successive periods for Hong Kong (1956–1973), Singapore (1946–1977) and Taiwan (1950–1973).

Source: Age-specific death rates for Hong Kong and Taiwan are taken from: Hong Kong: United Nations *Demographic Yearbook*, various years. Taiwan: *Taiwan Demographic Fact Book*, 1964, 1974. Numbers of deaths for Singapore are taken from the *Report on the Registration of Births and Deaths and Marriages*, various years. Age distributions for Singapore are taken from United Nations *Demographic Yearbook*, various years.

*Age-specific death rates (and implied West levels) for Singapore were obtained from aggregated deaths and population for each period. Age-specific death rates (and implied West levels) for Hong Kong and Taiwan were initially obtained for single calendar years. West levels for each period were subsequently obtained by using the median of the West levels for the single years within the corresponding period.

been even higher (see Figure 6). Extremely high sex differences for tuberculosis mortality in the Far East have previously been noted.[16]

These very large sex differences in the adult ages, as depicted in Figure 6, do not seem to exist in other countries with a high incidence of tuberculosis.[17] For example, the typical pattern of tuberculosis mortality prevalent in Western populations during the early twentieth century (e.g., Scandinavia, England and Wales, and the United States) was one of increasing risk from childhood through early adult life and a subsequent decline through the older ages; sex differences were small, with women's rates frequently higher than those for men. As tuberculosis death rates declined, the age of maximum mortality shifted toward older ages[18] but a pattern of monotonic increase with age, particularly notable for men, did not occur.

In further support of our hypothesis, we note that in the Far East mortality from tuberculosis has been declining because of the introduction of the BCG vaccine, antibiotics, chemotherapy

[16] *op. cit.* in footnote 11.

[17] S. H. Preston, N. Keyfitz and R. Schoen. *Causes of Death: Life Tables for National Populations.* New York: Seminar Press, 1972.

[18] V. M. Springett. A Comparative Study of Tuberculosis Mortality Rates. *Journal of Hygiene* 48, 1960, pp. 361–395; W. H. Frost. The Age Selection for Mortality from Tuberculosis in Successive Decades. *Milbank Memorial Fund Quarterly* 18, (1) 1940, pp. 61–66.

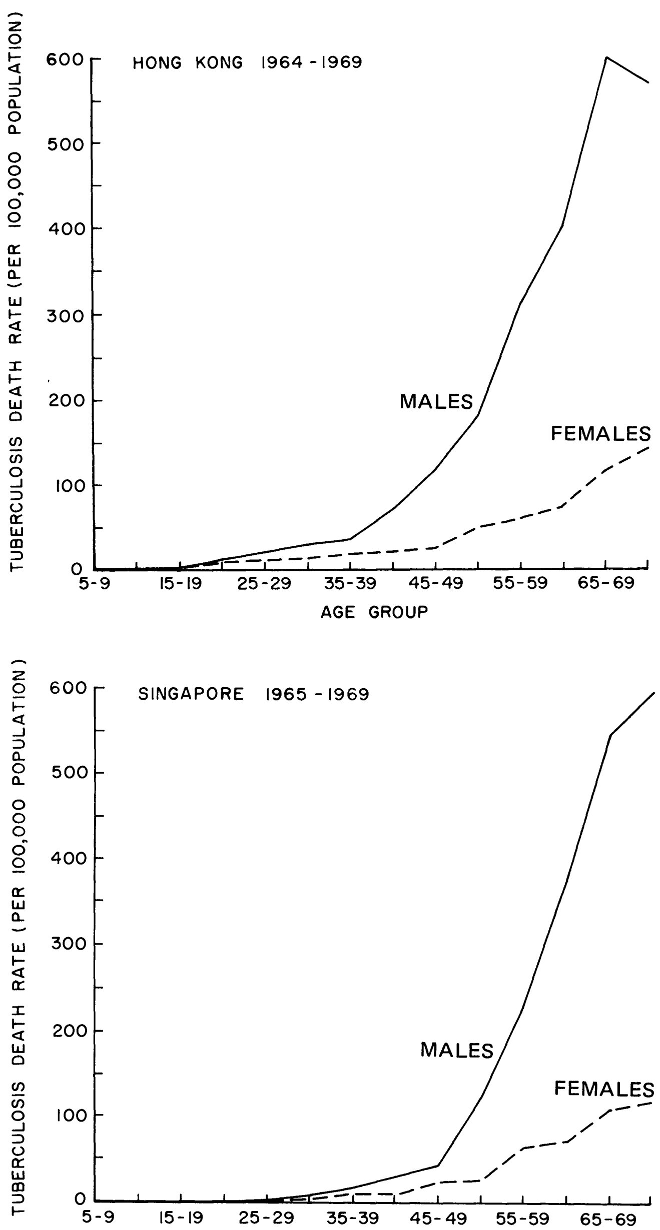

Figure 6. Age-specific death rates from respiratory tuberculosis by sex, Hong Kong (1964–1969) and Singapore (1965–1969).

Source: Numbers of deaths from respiratory tuberculosis are taken from: Singapore: *Report on the Registration of Births and Deaths and Marriages*, 1965–1969. Hong Kong: *Departmental Report by the Director of Medical and Health Services*, 1964–1969. Age distributions are taken from: Singapore (1967): N. Keyfitz and W. Flieger, *Population: Facts and Methods of Demography*, San Francisco, W. H. Freeman, 1971. Hong Kong (1967): United Nations *Demographic Yearbook*, 1967.

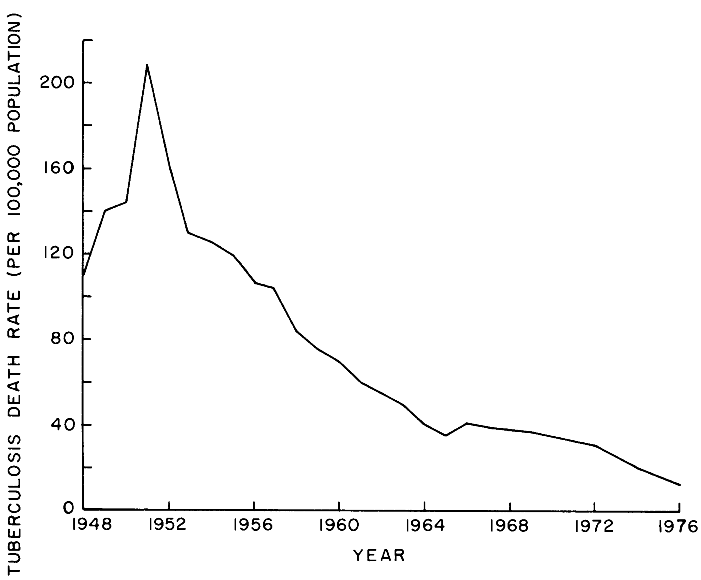

Figure 7. Death rates from tuberculosis (all forms), Hong Kong, 1948–1975.

Source: United Nations *Demographic Yearbook*, various years; Hong Kong, *Departmental Report by the Director of Medical and Health Services*, various years.

and improved hospital and sanitary facilities. Figure 7 shows the drastic reduction in tuberculosis death rates in Hong Kong since the early 1950's. The eradication of tuberculosis over the past 20 years or so is consistent with the progressive disappearance of excess mortality of men.

Although these characteristics of tuberculosis mortality make tuberculosis a suitable 'culprit' for excess mortality of men, the number of deaths from tuberculosis alone has not been sufficiently large to account for the existing pattern. That is, the elimination of excess deaths of men from tuberculosis would not eliminate the deviations of men's overall mortality rates from West model patterns nor would it sufficiently reduce sex differences in death rates from all causes combined. Instead, one would have to posit an interaction between tuberculosis and several other causes of death. For example, it might be conjectured that widespread early exposure to tubercle bacilli and subsequent latent infection predispose Far Eastern men to respiratory and cardiovascular diseases. In support of this hypothesis, we note that the majority of Far Easterners have been exposed to tubercle bacilli as measured by positive reactions to the tuberculin test;[19] large sex differences in death rates are present for respiratory and cardiovascular diseases in Far Eastern populations;[20] and, the elimination of excess mortality of men from several of these causes of death would be sufficient to yield a West pattern of mortality for Far Eastern men.

With regard to the last point, Figure 8 shows implied West levels for Hong Kong men (1961) as reported and under the assumption that men are subject to age-specific death rates of women for the following sets of causes: (1) respiratory tuberculosis, (2) respiratory tuberculosis and other respiratory diseases, and (3) respiratory tuberculosis, other respiratory diseases and cardiovascular diseases. The figures show that the elimination of excess tuberculosis mortality by itself would not sufficiently reduce men's mortality at the older ages. However, the additional elimination of excess

[19] For example, according to survey estimates, 95 per cent of the population aged over 14 in Hong Kong (1952), 77 per cent of the population aged over 15 in Korea (1965) and 79 per cent of men aged over 20 in Taiwan (1952) reacted positively to the tuberculin test. In addition, abnormal lung shadows were found in 92 per cent of the survey population, and X-ray evidence of tuberculosis in 39 per cent. (Hong Kong Department of Medical and Health Services: *Department Report by the Director of Medical and Health Services 1952–53;* Republic of Korea, Ministry of Health and Social Affairs, *Yearbook of Public Health and Social Statistics* 1977, Chen *et al., Epidemiology of Tuberculosis in Taiwan.* Provincial Tuberculosis Centre, Taipei, 1961.)

[20] Preston, *op. cit.* in footnote 11, p. 143.

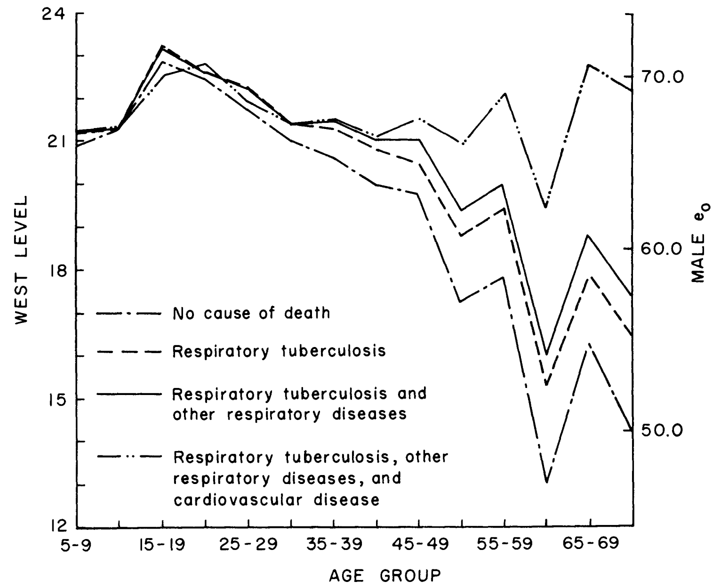

Figure 8. West levels of mortality implied by age-specific death rates of Hong Kong men (1961), assuming women's death rates for men for specified causes of death.*

*Disease classification is in accordance with the Seventh Revision of the International Lists of Diseases, Injuries and Causes of Death (Abridged list) as follows:

Respiratory tuberculosis	B1
Other respiratory diseases (Influenza, pneumonia, bronchitis)	B30–32
Cardiovascular diseases	B22, 24–29 A85, 86

Age-specific death rates, by causes of death, are taken from S. H. Preston, N. Keyfitz and R. Schoen, *Causes of Death: Life Tables for National Populations*. New York, Seminar Press, 1972.

mortality from other respiratory diseases (pneumonia, influenza, and bronchitis) yields a pattern of West levels similar to that found in modern Western populations (Figure 8); the further elimination of excess deaths of men from cardiovascular disease completely eliminates the deviant mortality pattern.

The preceding discussion suggests that tuberculosis and other diseases associated with tubercular infection may account for men's excess mortality. However, the question remains why Far Eastern men have been subject to a higher risk of death than Far Eastern women. Several explanations are possible, but all are highly speculative at present.

Various studies have shown that increased cigarette consumption in Western populations has been strongly correlated with increased risks of dying from cardiovascular diseases, respiratory diseases, and lung cancer. Similarly, smoking of tobacco or opium in Far Eastern nations may have been responsible for high rates of tubercular and other respiratory infections among older men. Although statistics on the prevalence of smoking are scarce, according to the 1905 Census nearly one-fifth of Taiwanese men over age 30 were known users of opium.[21]

Drug addiction and alcohol consumption may also explain high mortality risks of men. Death rates from tuberculosis in Hong Kong among drug addicts have been found to be approximately four times as high as the rates among the general population.[22] Alcohol consumption is known to aggravate liver disorders and may be partly responsible for the high masculinity of

[21] G. W. Barclay, *Colonial Development and Population in Taiwan*. Princeton, Princeton University Press, 1954.

[22] W. G. L. Allan, 'Tuberculosis in Hong Kong Ten Years Later'. *Tubercle*, 54, 1973, pp. 234–246.

deaths from cirrhosis of the liver in the Far East.[23] For example, in Taiwan, Hong Kong, and Singapore during the mid 1960's, age-specific death rates of men from cirrhosis of the liver were approximately three to four times as large as those of women at the older ages, a sex ratio greater than that found in most other populations.[24] Since cirrhosis of the liver results in fewer overall deaths than does tuberculosis, one would again have to posit interactions between liver problems and other diseases (e.g., tuberculosis, cardiovascular disease) to account for the excess mortality of men depicted in Figure 5.

CONCLUSION

This study has identified a pattern of mortality which seems to occur only in Far Eastern populations and which has not been previously described by model mortality schedules. As compared with either model life tables or actual mortality schedules in other parts of the world, mortality schedules in Taiwan, Hong Kong, Singapore, and Korea have been characterized by:

1. much higher than expected death rates of men at adult ages, compared with mortality of men at younger ages, and
2. large sex differences in death rates for adult ages.

In general, the excess mortality of men has been more pronounced in the past (1950's and 1960's) than in recent years. An analysis of statistics of causes of death available for Taiwan, Hong Kong, and Singapore as well as for Far Easterners residing in the United States[25] supports the hypothesis that a high level of exposure to tuberculosis in the past has produced excess mortality risks for men at the adult ages. Whether men are more susceptible than women to tuberculosis and related diseases because of a different life style (e.g., stressful physical labour or smoking) or because of their genetic composition remains difficult to determine.

[23] According to Preston's analysis, the categories 'certain chronic diseases' and 'other unknown causes' (defined by Preston, *op. cit.* in footnote 11, p. 5) show much larger sex differences in the Far East than elsewhere. Diabetes, nephritis, ulcers of the stomach and cirrhosis of the liver are included in the first category.

[24] United Nations, *Demographic Yearbook*, 1967.

[25] Goldman, *op. cit.* in footnote 13.

Appendix: The Measurement of Period- and Cohort-Specific Reduction in Mortality

Neil G. Bennett*

Having observed the sequence of West levels of mortality for successive periods in Taiwan, Hong Kong, and Singapore (Figure 5), we noted that, for each period, the mortality of men up to a certain age approximately followed a West model pattern but that after that age their death rates increasingly diverged from that model pattern. The age at which this divergence first occurs (the 'cut-off age') appears to be monotonically increasing with time. This suggests the hypothesis that the gradual disappearance of the excess mortality of men is cohort-based.

In attempting to confirm the existence of a cohort-specific reduction in mortality, we used three methods of analysis. A brief description of each is given below.

Method 1: Suppose excess mortality were due to the pervasive presence of a childhood disease or poor environmental conditions, which increased mortality risks for certain cohorts throughout their lives. We assume that the presence of this disease or these conditions explains the divergence between period death rates and a West pattern of mortality. We posit that at some point in time the childhood disease is eradicated or the environment improved through the introduction of better public health measures, and that subsequently, period death rates conform to West patterns of mortality. Hence, we expect the cut-off ages for consecutive periods to relate to a single cohort, i.e., the last of the birth cohorts the members of which exhibit excess mortality with respect to the West model schedules. Therefore, in theory the slope of the line fit to a scatter plot of cut-off age against time would be equal to unity. The criterion by which we judge genuine departure from the West model may be based on either statistical tests or more robust empirically grounded procedures.[26]

Method 2: On the assumption that men's mortality rates have been reduced by a fixed percentage across all age groups we compare proportionate reductions in mortality by period and cohort. We take the male ${}_5m_x$ values of a given period as our reference. For each subsequent period (generally every five years) we compute the ratio of the corresponding ${}_5m_x$ values to those of the reference period.

Let $R_x(t)$ be the ratio of ${}^5m_x(t)$ (death rate for age group $[x, x + 5]$ during period $[t, t + 5]$) to the reference ${}_5m_x(0)$ (the reference period is arbitrarily set equal to $t = 0$). If mortality improvements were period-based, we might expect the series of values $\{R_x(t)\}, x = 0, 5, \ldots,$ within any specified period $[t, t + 5]$ to be approximately constant. On the other hand, if such improvements were cohort-specific in nature, we might expect the series $\{R_{x+t}(t)\}, t = 0, 5, \ldots,$ to be constant for any cohort aged $[x, x + 5]$ at the reference period.[27]

Method 3: We assume that in the absence of excess mortality risks men's age-specific death rates in all periods would conform to a West model schedule. It has been found empirically that for Taiwan, Hong Kong, and Singapore, age-specific death rates for men between ages 5 and 29 (and those for women of all ages) follow the West pattern. For each period $[t, t + 5]$, we generate expected age-specific death rates for men based on the model life tables with level equal to the

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[26] For maximum likelihood estimation cf. R. E. Quandt, 'The Estimation of the Parameters of a Linear Regression System Obeying Two Separate Regimes'. *Journal of the American Statistical Association*, 53, 1958, pp. 873–880. See also N. G. Bennett, 'Measurement of Cohort-Specific Reductions in Mortality'. Unpublished Manuscript, 1979.

[27] For previous applications of this method cf. W. O. Kermack, A. G. McKendrick and P. L. McKinlay, 'Death Rates in Great Britain and Sweden: Some General Regularities and their Significance.' *The Lancet.* 1934, pp. 698–703; S. H. Preston and E. van de Walle, 'Urban French Mortality in the Nineteenth Century'. Population Studies, 32, 1978 pp. 275–297.

median of five West levels implied by the values of male ${}_5m_x(t), x = 5, 10, 15, 20, 25$. Using the sets of actual and expected age-specific death rates, we determine proportionate deviations ([actual − expected] /expected) by cohort and period. If mortality improvement were cohort-based, we might expect an approximately constant proportionate deviation (in general, excess of actual over expected) across age groups for a given cohort. On the other hand, if reductions in mortality were period-specific, we might expect constant deviations along period lines.

None of these methods yielded results consistent with a cohort-specific reduction in mortality. Although the correlation between time and cut-off age in the first method was very high, the corresponding slope was usually well above unity. Ratios derived from the last two methods showed as much variation along cohort lines as along period lines.

Distinguishing period- and cohort-based effects remains methodologically difficult. Our failure to confirm the hypothesis that mortality reductions occurred largely on a cohort basis, may be due to the failure to find an appropriate measure of mortality change. For example, it is not clear whether proportionate reductions in death rates or increases in the implied expectation of life at birth (i.e., level of model life table) constitute a more suitable measure in a dimensional (period versus cohort) analysis of mortality. These two measures reflect very different notions of mortality change. Over the range of mortality experience on which the study is focused, mortality improvements are associated more with the older ages as time progresses. As expectation of life rises, it becomes increasingly difficult to make additional improvements in mortality at the younger ages. We can see this point clearly within the West model life tables. For example, a 42 per cent reduction in male ${}_5m_5$ is required to imply a jump in level from 23 to 24 ($e_0 = 71.2$ to $e_0 = 73.9$), whereas only an 11 per cent reduction in male ${}_5m_{70}$ is necessary to imply the same improvement in the expectation of life at birth. Thus, even if mortality reductions were cohort-specific, we could not have found both a slope of unity using the first method and constant proportionate differences in m_x values using the last two methods.

In summary, our inability to support the original hypothesis may be due to either of two factors: (1) the hypothesis was false (i.e., period-specific reductions in mortality were substantial), or (2) we have not developed an appropriate model by which we can measure mortality reduction.