Old-age Mortality and Its Behaviour Pattern

Mathematical Sociology of Asian Population

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ABSTRACT

Demographic approaches to modeling and forecasting mortality are often based on the observation of short-term trends in death statistics and the assumption that future mortality will exhibit patterns similar to those of the recent past. These extrapolation methods have led population scientist to establish a hypothetical link between risk factor modification and changes in death rates. Although there is probably not a genetic program for deaths, the biology of our species places inherent limits on human longevity. Nevertheless, this paper assesses the significant achievements made in the field of calculation at old age mortality since then. With this, the present provides a detailed account of classical mortality models, which involve partial mathematical relations in formal social gerontology as opposed to empirical regularities. Unfortunately the classical models have not developed the means for measuring and analyzing the old-age pattern of mortality in developing countries that equivalent in their power to methods for studying child mortality. Data issues as well as methodological one are raised. Special attention is given to new emerging Asian Gerontology where different source materials require different methods and techniques which in turn are expected to broaden the scope of the so far disproportionately old-age mortality-oriented field. Finally discussions are extended to economic, cultural, and institutional aspects of the subject, with a not to isolate social -demographic -policy analysis from other branches of historical research.

Key words: Old-age mortality, Asian population and their behaviour, mathematical model, social-gerontology, social security

Of late 1970s, a few researchers have assessed the interface between health and mortality, particularly in old age (Horiuchi and Coale, 1990) Study of the enormous amount of material published on the mortality pattern and changes during the last half a century or so leads to the inescapable conclusion that scholars have tried to convince each other through anchored sub-narratives. The classical demographic transition theory throughout this period served as the initial narratives (Brillinger, 1961). Various means and methods through historical studies have noticed it, for instance, and also through modeling aspects that were considered to be central to be models (Brass *et al.,* 1968). However qualitative work that has been undertaken with the intention of promoting the narrative form more firmly into the fundamental problems of old-age begins from their lack of positive and creative roles in a society and abrupt changes in their role status and respect in society which they have been exercising before and after retirement (Kannisto, 1988).

Needless to emphasize that the sudden and abrupt changes in their active life due to old age may generate socio-psychological stress, which may result in interpersonal relations and adjustment, which lead to various health hazards. No doubt, this is partly a reflection of the complexity of the issues involved. Unfortunately some of the studies, which specifically deal with mortality at old age or mid-old age, are indistinct. Also, the limited value of generalization can almost always be demonstrated quickly with a counter illustration drawn from a specific region (Blacker, 1977). It sometimes seems as if all efforts to gain insight into the mortality improvement in old ages is insignificant and changes have been in vain. That would, indeed, be an unfortunate state of affairs. It is sensible to try to measure the mortality at age patterns of death rates that is valid for all regions and all times.

This paper is an attempt to review the current state of affairs regarding the mortality of women at old ages and behavior patterns in Asia. It is presented against the backdrop of the anchored sub-narratives published and defended by various authors in the course of the last few decades or so. In turn, this backdrop is followed by measure denoted by k(x), indicating the proportional increase or decrease with age in the risk of death of women at given age 'x' fitting the curve by analyzing the patterns in relation to existing mathematical mechanisms which could generate the observed k(x) patterns (Horiuchi and Coale, 1990). Further, the k(x) function will be estimated to identify their similarities and differences. This paper, however, evaluates the curves defined by Horiuchi and Coale (1990).

Research Efforts

Issues of population, analyses of social and geographical mobility and the history of ideas about population have crowded mortality. The outcome has been a topic that could stand on its own, rather than be forced to enter the field through its association with population structure, growth and age-patterns. Duo, mortality rates are interesting because they are important indicators of living condition.

Throughout the period under review, the basic metric for the study of mortality has been provided by the life table, a device that has been known since 17th century (Coale and Demeny, 1966). Post-war, there had been no significant improvements in methods of life table construction in which conventional data have been used. That is, methods, which related to the number of, registered deaths in the numerator and the exposure to risk in the denomination or the mortality rate. No major advances could have been exposed because the results provided by conventional methods are quite insensitive to changes in actuarial procedures (Hill and Trussel, 1977), particularly at old age. Instead, there is a dramatic expansion in the application of life table metrics to conventional data.

Candidly, the important development in the measurement of mortality during the post-war period was Brass' technique for translating the proportion of children who died among those ever born, as reported by women in a single-round survey or census into life table measures of infant mortality (EwBank, 1982) in developing techniques.These improvements have become part of the researcher's standard repertoire. In subsequent papers the procedures have been placed on a firmer mathematical footing, and the sensitivity of the results to various forms of error has been systematically explored (James and Trusell, 1975). The success of Brass Methods for estimating childhood mortality from single-round retrospective reports by mothers spawned efforts to use inquiries about the survival of other kin to estimate mortality. Individuals were asked about the survival of their parents and old age and their responses have transpired into life-tables measures of mortality, especially that of old age or adults.

Inquires about surviving kin failed to provide reliable estimates of the mortality of adults and was also flawed. Coale and Demeny refined techniques based on inter-censual survival analysis in which life-tables have been used in UN manual – IV (UN, 1967), but the results proved to be highly sensitive to errors in the data. The incidence of adult deaths implied by comparison of cohort counts in successive census or surveys are strongly influenced by migration, by differences in survey or census completeness, and by age misreporting. Authors who attempted to refine these methods did not consider their fundamental problems, but proposed new mathematical equations or procedures that did not require the use of life tables at all (Jeremiah and Sullivan, 1972). However, these techniques were hastened by the cost of matching and comparing with its original applications. During recent years more attention has been paid to the mortality of adults, and especially that of the old. This shift in emphasis from childhood mortality coincided with a shift in the age distribution of deaths. In the first article to appear in the *Population Studies* that dealt specifically with the mortality of adults, Preston suggested that the stubbornness in the death rates of adult men, then in evidence in each of Western world, was a result of cigarette smoking, rather than the fact that biological limits to life expectancy had been attained (Preston, 1970). Using a variety of clever indirect methods, Coale and Kishker demonstrated conclusively that most of the instances of very low mortality at old ages were bogus products of data error (Coale *et al.,* 1986). Three recent articles have chronicled the rapid progress of mortality at advanced ages in countries with good data. This stage is likely to be the scene of a very lively new production of nature/nurture debate, with very important implications for social policy. Several mathematical equations describing the mortality increase with age among middle-aged and old persons have been developed over the period of more than a century by Gompertz, Makenam, Perks and Beard.

Gompertz (1825) attributed the exponential increase of death rates in his equations to physiological deterioration that proceeds with age i.e., $u(x)=Be^{ux}$. He indicated that chance and degeneration were the basic two causes of death. Deaths by chance seem to include deaths by accident, suicide and homicide. Since, Gompertz did not include the chance factor in his equation, Makenam (1860) added an age-independent term for the risk of death by chance, that is, A to the Gompertz equation, $u(x)=A+Be^{ux}$. In some population, however, observed death rates tends to be higher at young ages and lower at late old ages than the death rates estimated by fitting the Gompertz or Makenam equation to data. To overcome this problem, Perks (Horiuchi, S. and Coale, 1990) proposed a logistic equation, that is $u(x)=A+Be^{ux}/\ 1+Ce^{ux}$. Beard (1963) derived another logistic equation by modeling the physiological process of aging, which excluded the parameter A from the Perks equation because the term was for approximating the child mortality i.e., $u(x)=Be^{ux}/1+Ce^{ux}$. Gompertz, Makenam, Beard and Perk developed methods that permitted the assumption of stability. In addition, the results have also been sensitive to the same types of data error as intercensual method, although their sensitivity appears to be less.

The new methods were one of the greatest achievements of demography during the post-war period. However, these methods worked more for measuring childhood mortality than that of adults. Improved methods for the assessment of mortality of adults have different k(x) functions and the deficiencies of existing methods will become more apparent as epidemiological transition directs more attention to the issues of adult's health in less developed countries (Jeremiah Male Sullivan and Godwin, A. Udofia, 1979). However, these models have different k(x) functions, as shown below:

Gompertz	$k(x) = u$
Makeham	$k(x) = u/1+De^{-ux}$
Perks	$k(x) = (u/1+De^{-ux}) / (u/1+Ee^{-ux})$
Beard	$k(x) = u/1+Ce^{ux}$

Where D=A/B AND E=1/C

The constancy of k(x) is implied by the Gompertz model. Both the Makeham and the Perks model imply that k(x) follows logistic curves. A significant difference between the two logistic functions is that the Makeham logistic curve rises monotonically from zero to u, whereas the Perk's logistic curves declines monotonically from u to zero.

It is not a very simple task, however, to evaluate and compare the validity of these models. All of these models usually fit observed death rates and their logarithms well; making it difficult to determine which model fits the data well. In general, models with more parameters tend to fit data better, introducing additional difficulties in comparative assessment of these models. These mathematical models, however, can be straight forwardly evaluated using k(x), because age patterns of k(x) implied by these models are significantly different.

Research Orientations

Significant shifts have occurred during the last decade concerning the main orientations of research into the changes in mortality levels. These can be interpreted as shifts from one sub-narrative of the initial demographic transition theory to another, generated by the limited success obtained in testing the validity of competing sub-narrative. The paradigms of different disciplines had their chance. It is quite obvious that changes in the amount and character of the demographic information available and the trends in demographic measures were also influential. It is also easily overlooked that considerable pressure and efforts have been exerted in the direction of research. Meetings, assessments and major collection efforts made towards policy consideration played an important role, even though policy-makers will normally have sought the advice of experienced scholars to improve the living conditions. In recent years many of the studies have been focused on cross-sectional variations at the individual or family level within a specific country. The major emphasis during the last-half century, however, has been on explaining movements in aggregate level indices of mortality by reference to economic factors.

However, the distribution between description and analysis is in any event imprecise. Anomalous age patterns of mortality and their possible epidemiological roots have been outlets for synthetic overviews of the pattern and programs of mortality, particularly the old age. As a consequence, those drawn into the same orbit have usually had easy access to data sources and exerted a direct influence on research design. Coupled with a competitive academic tradition, this had led to a strong presence scholarly in the forefront of methodological innovation and substantive discussions. This is particularly true of research into the old age patterns of mortality, and around the politically highly relevant idea of demographic transition. In fact, its obscurity and its wartime effort scene and subsequent mutation would seem to have had as much to do with these wider influences as with purely cognitive and intellectual considerations.

Overview of Mortality Models for Old Ages Emanating from Major Research Efforts

YEAR	AUTHORS (S)	TITLE
1960	Strechler:, B.L. and and Mildvan, A.S.,	*General Theory Of Mortality And Aging. Science*
1970	Samuel H. Preston	*An International Comparison Of Excessive Adult Mortality Population Studies*
1971	Brass, W.,	*On The Scale Of Mortality, Biological Aspects Of Demography: London; Taylor and Francis.*
1973	Jermiah M. Sullivan	*The Influence Of Cause Specific Mortality Conditions Of The Age Pattern Of Mortality With Special Reference To Taiwan. Population Studies.*
1974	Brown, K.S, and Forbes, W.F,	*A Mathematical Model Of Aging Process. Journal Of Gerontology*
1979	Manton, K.G., Poss. S. S., and Wings, S	*The Black/White Mortality Crossover: Investigation From Their Perspective Of The Components Of Aging. The Gerontologist.*
1981	Manton, K.G., and Stallard, E.	*Methods For Evaluating The Heterogeneity Of Aging Process The Human Populations Using Vital Statistics Data: Explaining The Black/ White Mortality Crossover By A Model Of Mortality Selection. Human Biology.*
1981	Buorbeau, R., and Legare, J	*Introduction Of A Process Of Deterioration In The Study Of Adult Mortality: Applications Of A Simultaneous Model To Norwegian Generations 1866-1916. Genus*
1982	Horiuchi, S and Coale, A.J.,	*A Simple Equation For Estimating The Expectation Of Life At Old Ages. Population Studies*
1983	Weatherby, N.L., Nam C.B., and	*Development, Inequality, Health Care, And Mortality At The Old Ages.*

	Issac L. W.	*Demography.*
1983	Horiuchi, S.,	*The Long-Term Impact Of War On Mortality; Old Age Mortality Of World War I Survivors In The Federal Republic Of Germany. Population Bulletin Of United Nations.*
1983	Nam, C.B., Weatherby N.J., and Ockay, K.A	*Causes Of Death, Which Contribute To The Mortality Crossover Effect. Social Biology.*
1983	Preston, S.H., and N. G. Bennett	*A Census – Based Model For Estimating Adult Mortality. Population Studies.*
1986	Coale A.J., and Kisker, E.E.,	*Mortality Crossovers: Reality Or Bad Data. Population Studies.*
1988	Vatno Kannisto	*On Survival Of Centenarians And The Span Of Life. Population Studies.*
1988	Vauperl, J.W., Yashing, A.J., and Manton, K.G.,	*Debilitation's Aftermath: Stochastic Process Models Of Mortality. Mathematical Population Studies.*
1989	Preston, S.H., Himes, C and Eggers, M.,	*Demographic Conditions Responsible For Population Aging. Demography.*
1990	Horichi, S., and, A.J.,	*Age Patterns Of Mortality For Older Women: An Analysis Using The Age Specific Rates Of Mortality Change With Age. Mathematical Population Studies.*
1992	Thatcher, A.R.,	*Trends In Numbers And Mortality At High Ages In England And Wales. Population Studies*
1994	Christina, L Himes, Preston, S.H., and Condran, G.A.,	*A Relational Model Of Mortality At Older Ages In Low Mortality Countries. Population Studies.*

From the policy perspective, the introduction of sanitation technique and imparted medical technology and the supply of contraceptives (means necessary to practices contraception) would prove to be the central factor in triggering the mortality transition. The results of family planning campaigns did not come up to these expectations. Interest in demand for contraception and reducing mortality by improving health conditions started to sustain. Apart from its adequacy as an explanation of development is the question whether advances in nutrition and standards of living have played a dominant role in mortality reductions elsewhere. No one denies that standards of living and nutrition affect rates of mortality; the issue is whether observed changes in one are capable of explaining observed changes in the order. The efforts on the likely mortality in the regime effects of changes in age patterns, population structure and functions are certainly sustained. The significance of technological arrangements and the path-dependency of development are stressed on ideational changes. More generally it would appear that sustained mortality below the marked level in much of Europe, for instance and the extreme rapidity of mortality change with a high level of fertility in Asia stimulated the search for explanations where much of the developments have not been viewed. However, the factors responsible for improvements in mortality can perhaps best be demonstrated by individual-case studies. The value of individual-case studies and Table representation are not those that provide fresh insight into the content of the scientific debates that have been taking place. It is rather a demonstration that significant changes in orientation have occurred, and that so far, *no single approach has proved workable*. It suggests further a plausible association between technical progress in demography as a discipline, the availability of richer data base as a result to major data collection efforts, analyses in which the new techniques are used, and the range of explanations offered for the amazingly rapid changes in mortality at old ages in some parts of the world and within the regions, and the very limited changes elsewhere. Additional methods of estimating mortality of adults when data are incomplete involve attempts to estimate the degree of their incompleteness. In several papers dealing with mortality, attempts have been made to identify the factors associated with variations in mortality levels. The major emphasis during the last half-century, however, has been on explaining movements in aggregate level indices of mortality for old ages with reference to socio-economic and psychological factors.

TheUse of Mortality Models and the Advantages of k (x)

The methods of life table, given a set of age-specific rates, are straightforward statistical procedures. The basis for model–life tables is the existence of a regional pattern of mortality rates at different ages. Model tables that incorporate such patterns derived from population with a reliable check on recorded rates and make it possible to estimate mortality schedules for population projections and other purposes. In 1962, Graunt described in his life table that survival function is approximately linear between ages. In 1825, Gompertz introduced that the rate of mortality increases exponentially with age at a constant rate or following a rising exponential path. Though Makeham modified Gompertz's law by adding 'A' term that does not change with age, Makeham's and Gompertz's functions do not apply before age 30 or so, but with some modifications they play a useful part in actuarial work and research on model life table. However, an obstacle to constructing estimates of the future mortality is the obvious understatement of mortality as recorded at older ages in the European countries. Despite much higher death rates in childhood and early to middle-adult ages of that in Western Europe, the reported mortality at older ages were lower than the lowest in the West. It became clear that old age mortality has been understood because of its under-registration (of deaths) of older people and overstatement of age in Census. In 1971, Brass employed a new approach in constructing model life tables. He used the logit transformation of the probability of surviving to age x(l_x/l_0) in a given population and stated that it is linearly related to the logit of the probability of surveying to the same age in a standard population. The constant in the linear equation determines the level of mortality, and the slope governs the relation between infant and adults mortality. An extension of the model allows for two additional parameters that determine the shape of the mortality scheduled within the younger and within the older ages respectively (Coale and Guo, 1990).

In general, application of mortality models at old age extends from the conventional life table, through "stable population based on strong ergodicity and the composition of any population on weak ergodicity", to mathematical models of conception to characteristic age patterns of mortality as building blocks. These models have been the basis of better understanding of interrelations within population. The empirical models of mortality reviewed here share several features that "in large samples, although the fit of the model to the data is visually generally quite to good, formal statistical tests would nearly always reject the null hypothesis that the restricted model fits as well as an unrestricted model with a separate parameter for each (or duration)". These models are valuable because they can be used to make broad inferences about behaviour, more commonly.

However, very little attention has been given to the measurement of k(x) partly due to the common exercise in mortality research to calculate the logarithms of age specific death rates and plot them against age. There are three main advantages of k(x) as defined by Coale and Horiuchi in 1990.

First, k(x) is expected to provide some clues about the heterogeneity of a population with respect to mortality. A population may be considered to consist of subgroups that follow different mortality schedules. The proportions of these subgroups in the population vary with age because the groups exposed to higher risk tend to be reduced faster. Therefore, the age pattern of k(x) for the entire population may be significantly different from those of its subgroups, giving some clues about the distribution in the population of vulnerability to the risk of death. It is shown that the introduction of a heterogeneity model helps explain observed k(x).

Second, k(x) seems useful in studying physiological aging the risk if death increases as the human body degenerates, so that k(x) may reflect age variation in the 'pace of aging.

Third, k(x) is useful in detecting cohort mortality variation. For example, if a low mortality cohort is followed by a high mortality cohort, mortality increases with age from the younger group at a relatively low rate, so that k(x) tends to become small. If the order is reversed, k(x) tends to be large. Therefore, if a cohort experiences a relatively higher mortality schedule than its adjacent one, low values of k(x) at older ages tend to be followed by high values k(x) at younger age, and the high mortality cohort is likely to be located between these unexpectedly high and low values of k(x).

METHODS AND MATERIALS

Given a modicum of domestic and international peace, mortality has fallen in every country and has been a part of socioeconomic progress. The mortality transition has spread through most of the world. Life expectancy in industrial high-income countries is now between 75 and 80 years and may be approaching a ceiling, but at best any further increases will be slow. On the other hand, it is true that mortality reduction in less developed countries and the consequent rapid growth of population may impede capital formation and other aspects of development. The results would differ in each individual case and within the case, but are at least as likely to be positive as negative. Certainly, reduced mortality and morbidity in a healthier population are major contributors to a rise in living standards, which are often regarded as major factor in fertility decline. But, it would be fatuous to consider a single cause, and focus on it as the only cause. Socioeconomic, cultural, psychological and ideational factors are much too closely intertwined to be isolated.

Nevertheless, mortality reduction should be given greater attention as one cause of fertility decline, notably by promoting economic productivity, especially in a more productive labor force. The major focus of the World Bank's World Development Report for 1993 is 'Investing in Health' which includes an exhaustive study of the burden of disease. The concept of the 'disability life year' has been used as a measure that combines health life years lost because of premature mortality with those lost because of disability. The figures range which from 17 per 1000 population is established in the market economies to 344 in India. However, views of life have changed and people believe that it is possible to influence one's fate, an attitude that fosters individualism.

On the other hand, the empirical analysis of old-age mortality is complicated by four defects often found in recorded data.

First, the small number of persons and deaths at very old ages, introducing an unavoidable large stochastic variation in death rates.

Second, old age mortality data has a strong tendency toward age misreporting for old persons, both in the ages of the living as well as the dead.

Third, given heterogeneity in population, the process of aging and mortality and morbidity condition of old ages is generally wrongly recorded and misinterpreted.

Fourth, the exaggeration of old age is, perhaps, natural in a population, which matures early and has a short expectation of life; there is also a tendency to under-report ages. Old age in traditional societies are a matter of prestige but beyond a limit the relationship valuable because they can be used to make broad inferences about behaviour, more commonly.

However, very little attention has been given to the measurement of k(x) partly due to the common exercise in mortality research to calculate the logarithms of age specific death rates and plot them against age. There are three main advantages of k(x) as defined by Coale and Horiuchi in 1990.

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Taking all these into consideration, the study populations are selected in order to obtain relatively accurate single-year data on age at death of old persons. For that Asia, which has 'unity in diversity' concept and has low levels of literacy and poor health with rich cultural backgrounds were selected as study population and further, these have been divided into three categories as to investigate the k(x) function in selected population to identify their similarities and differences, to examine the validity of those findings and to analyze the observed k[x] pattern in relation to existing mathematical model. That is, population with high levels of literacy and education and also with the replacement level of fertility as which have good records of vital registration system like Japan and on the other hand, the study also observed few population with relatively high level of infant mortality, old-age mortality, low levels of literacy and education, but with high level of fertility as compared with westernized thoughts, for instance India, Bangladesh, Pakistan and Sri Lanka are included for the present study. This shows that population in unusual circumstances can shed valuable light on much broader development. However, the categorization of these countries by the quality of vital registration has been made through the Census index (Ravichandran, 1994).

The data were collected mainly from the sample registration system during 1980-81 to 1995-96. This has been hoped that the long-term data would minimize the error that lies in the vital registration system. Also, this would help in investigating the cohort effect of the observed age patterns.

The force of mortality at exact age x is given by

$$u(x) = d\ln(l(x))/dx \qquad \text{[1]}$$

Where l(x) is the life table function representing the proportion surviving from birth to age x. the rate of mortality change at age x is then defined by

$$k(x) = d\ln(u(x)) / dx \qquad \text{[2]}$$

If data are available for single year age groups, k(x) may be estimated by

$k(x)=\ln(m(x,1)) - \ln(m(x,1))$ .... [3]

Where m(x,a) is the central death rate from age x to x+a. Note that, in equation [3], mortality data from exact age x-1 to x+1 are used for estimating k(x).

The empirical analysis of old-age mortality is complicated by above said defects. There is a need to smoothen as the available data. The sequence of ln(m(x,1)) first by taking moving averages of five successive values using equation [3], k(x) values are computed from gradual ln(m(x,1)) the sequence of k(x) again smoothed by taking weighted averages of nine successive values, the weight being distributed triangularly over nine values. Namely, k(x) is estimated by

k(x) S [5 - |n| *k(x+n) / 25 .... [4]

Although this method consists of two steps, i.e., smoothing of ln (m(x,l)) and that of k(x), the second step is more crucial than the first step.

RESULTS

Logarithms of death rate, from age x to x+1, ln(m(x,l)) are plotted for ages 50 and over for women and men for the selected population. m(x,l) is calculated by dividing the number of death between age x to x+1 by mid-year population. m(x,l) is accepted as an approximation of u(x+0.05). Horichi and Coale had shown that if morality increases exponentially at a rate 'k' over the interval from x to x+l then the population is stationary. This is expressed by the following equation

$m(x,l) = u(x+0.05) * (1 + k^2 / 24)$ .... [5]

For the study population it has been selected value of k as 0.1

$m(x,l) + u(x+0.05) * (1 + 0.0004)$ ....[6]

As illustrated in Figure-1 (i.e., the force of mortality u(x) plotted against age followed fairly straight lines. In all women population u(x) changes systematically. For example, in Japan both rural and urban women show two parallel lines but urban have higher death rates at early ages 50 (-5, 7) than rural women at the age of 52 [-5,2]. In the case of Pakistan, the difference between rural and urban women at age 50 shows broad variation [-3.8, -4.8] but for the same population, there is little difference between rural [-1,1] and urban [-1,3] at 65 and above. Contrarily, the pattern is reverse in case of India women during the same year. In case of Sri Lanka curves of both the rural and urban women mortality cross before and after age 72. This pattern is different from that observed for all other study populations.

Figure - 1 Plot of u(x) for women in the age group 50-82 of Selected Countries

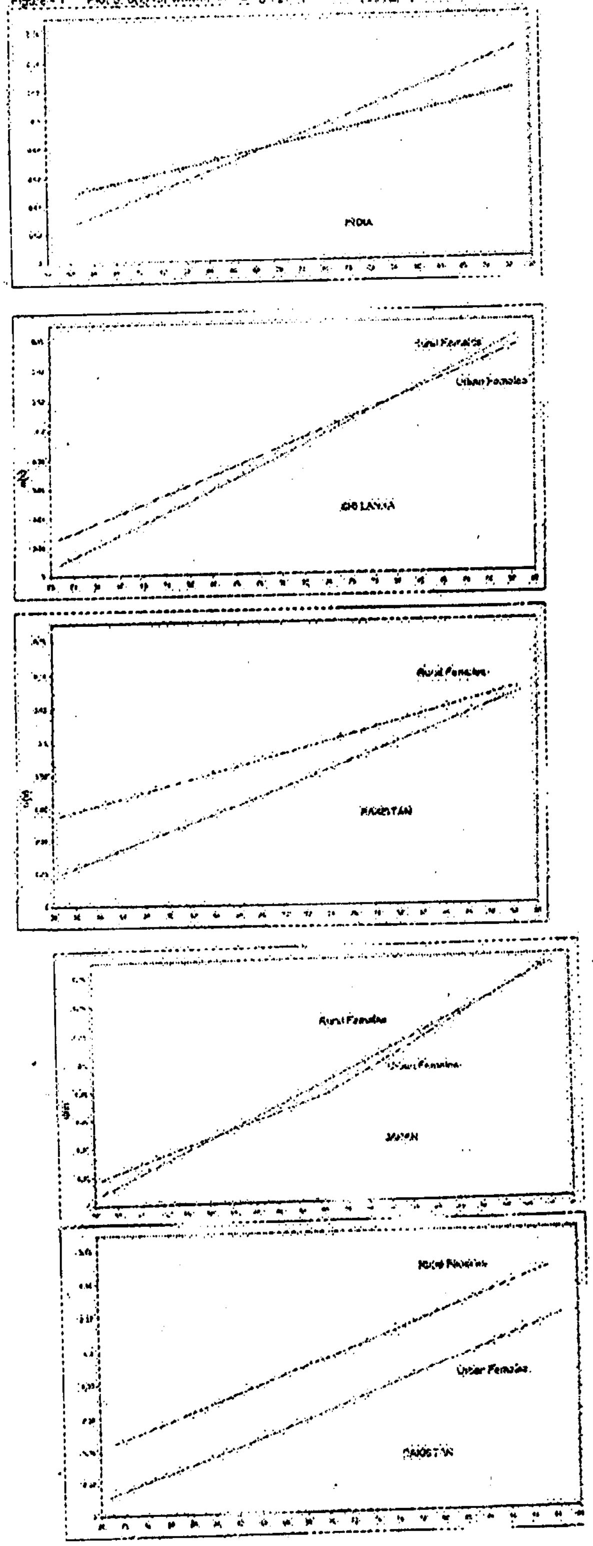


Figure-2 Plot of k(x) for women in the age group 50-82 of Selected Countries

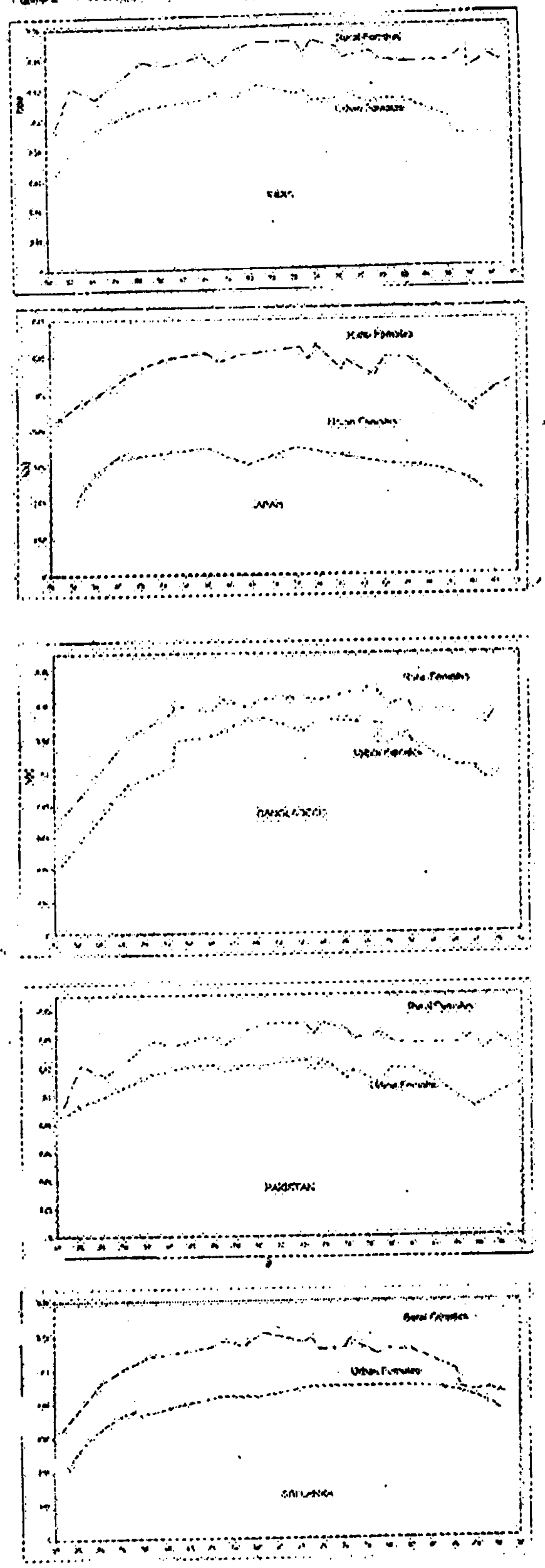


Figure-3 Values of k(x) calculated using three different procedures

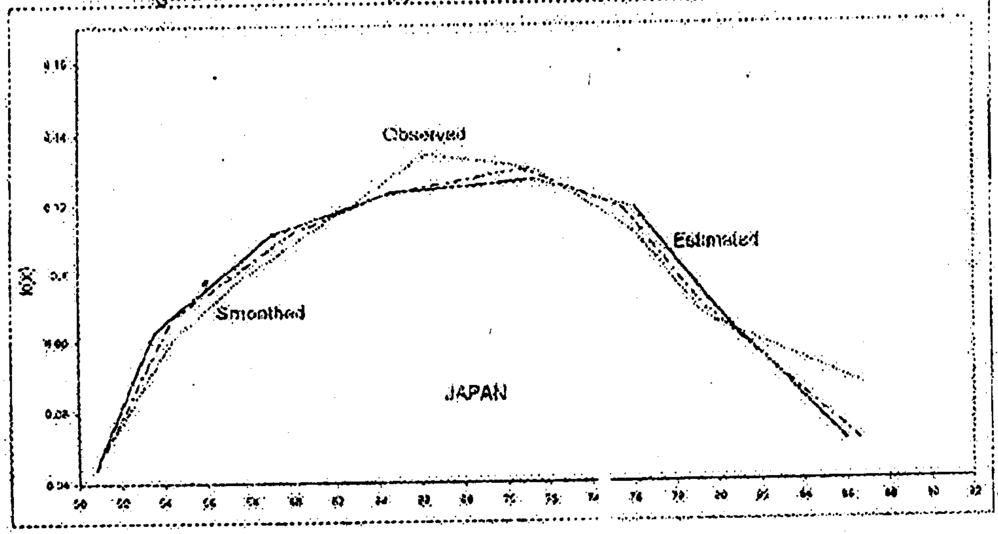
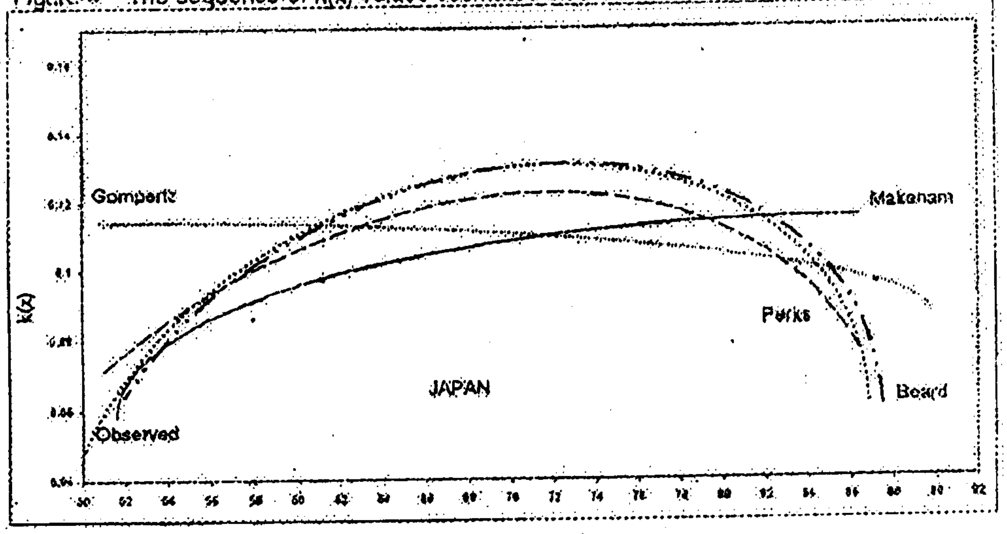
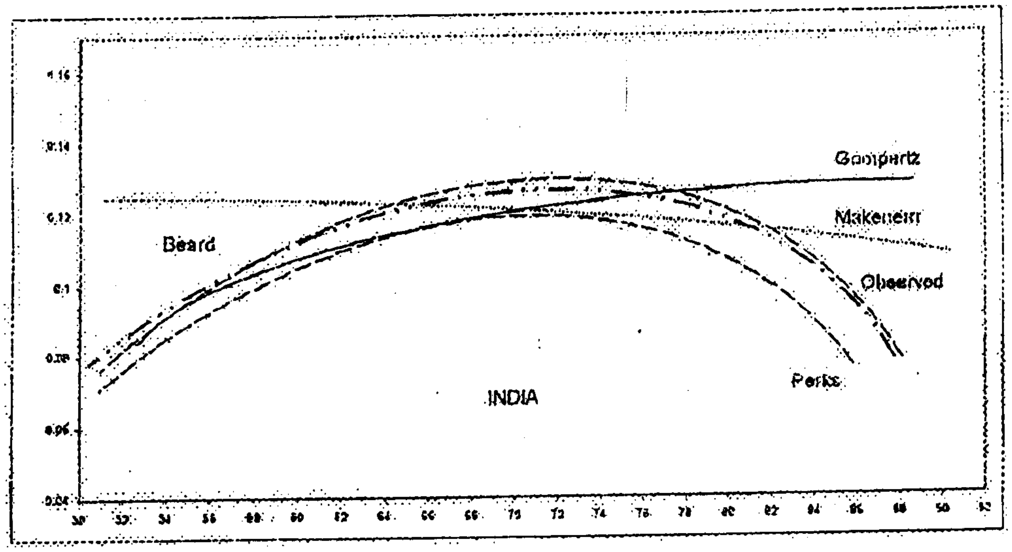


Figure-4 The sequence of k(x) values estimated on the basis of different Models





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Usually, plotted points are narrowly scattered around a straight line over a wide range of middle and old ages. However, as shown in the figures 1 and 2, the logarithms of death rates plotted against age tend to appear to fall on a straight line, even when the value of k(x) changes substantially with age. Therefore, age variation in the proportional increment of death rate should be detected not by looking at graphs of the logarithms of death rates plotted against age but by calculating k(x) directly. In all study population (Figure-2), k(x) changes systematically. It rises in early old age, reaches a peak, then declines, in the late old age, resulting in a bell shaped curve.

The curve in the study population follow similar trajectories at which k(x) starts to rise around 56 and the peak is about age 72, except for India. Rural women of Pakistan have lowest value of peak [0,1] whereas rural women of Japan have highest value of peak [0.13]. All the selected population of urban women population depict broad bell shaped curve. These curves have lower peaks at earlier ages and spread over which wide age ranges. The rural-urban differences in k(x) show large difference in all study population except for Japan. Both the curves of urban and rural women for all countries (including Japan) show small fluctuation at early old ages (Figure-3).

DISCUSSION

In general, we know very well that the model with more parameters tends to fit data better. But in the present study it has arrived contradictorily. That is, Perks model with more parameters is not consistent with Asian data. Because age variations in mortality due to physiological degeneration are considerably greater than the period variation. Because the large period variation might be determinant as of improved public health programs, increased the standard of living and reduced environmental contamination. However, such debilitation effects are not taken into consideration in Perks model. This reflects that there is a need to evolve cultural specific model rather proposing more parameters may not fulfill the needs of the population characteristics.

The Gompertz constant 'u' is high for Japan rural women (0.0931387) compared to Pakistan rural women (0.08113142). Thus women show lower initial mortality in Pakistan than in Japan. Interestingly, the second parameters B shows low values for Japan rural women (0.0000328) compared to Pakistan rural women (0.00045699). The ratio of mortality at old ages from Gompertz equation is found to be simply e^u for small values. For example, among Japan urban women, the estimated value 0.9970 is interpreted as approximately (1+u) 2.23 per cent increases in the age specific mortality per single years of age. The actual value computed using the ratio e^u is only slightly higher 2.69 per cent.

The value of R^2, for Japan women, for u(x) is 0.99992 and k(x) 0.02828. In case of Pakistan rural women, the value u(x) is 0.99970 and k(x) is 0.029622. It shows that Pakistan value is higher than Japan for u(x) and k(x) (see Figure-2). If we plot the figure for Japan women age specific mortality range from 50 to 92 years, it formed a straight line with small fluctuations and it also shows rapid decline in the old ages. In the case of Gompertz, he did not include the chance factor in his equation. Makeham added an age independent term for risk of death by chance i.e., A to the Gompertz equation. If we look at the value of chance factor (A), it appears to be very small for all the study population. Thus, there is a positive relation between for B and A. The existence of positive relation was anticipated from the result of the Makeham function to the mortality at ages, if we look at the value of R^2. In case of Japan the difference between these two mortality was 0.02828 whereas Pakistan was found to be slightly higher (0.02841).

According to Beard model k(x) curve rises form 0 to u, and their distance along the x-axis is always ln(B/C). It should be noted that k(x) fits curve fairly well except for departures at both ends (i.e., early old ages and late old ages). Therefore, among the four models, Beard model is consistent with bell shaped k(x) patterns found for older women in the selected population. This is illustrated for Japan women in Figure-4. Table-1 present values of parameters for four models that are estimated by fitting death rates for India/Japan of rural women. A non-linear square was employed for regression of ln(u(x)) and k(x) for ages between 50 to 92 years. As shown in the table R^2 of ln(u(x)) for each model is very close to one or more. But for k(x) only Makeham and Beard value of R^2 is close to one. But in the case of Beard model, assumption of Gamma distributed individual frailty; this has several advantages in modeling frailty. It is very flexible, taking on a variety of shapes, if the individual's risk is expressed as the sum of two age dependent terms. It gives the selective survival in a heterogeneous population and makes the population composition less frail at older ages there by slowing down the mortality increases with age.

Table 1 : Results of non-linear least squares regression analysis for Japan and India aged 50-92

Parameters	Model			
	Gompertz	Makeham	Perks	Beard
JAPAN :				
A		0.000713	6.907 (e-06)	
B	0.0000291	0.0000277	0.0000254	0.0000175
C			0.0000090	0.0000111
u	0.09813	0.08965	0.09313	0.09561
R^2 of ln (u(x))	0.8725	0.9143	0.9997	1.0000
R^2 of k(x)	0.3769	0.09658	0.5104	0.4173
INDIA :				
A		0.00201	0.00668	
B	0.000125	0.0000162	0.0001011	0.0000175
C			0.000443	0.0004981
u	0.08023	0.03955	0.08647	0.08891
R^2 of ln (u(x))	0.8633	0.8907	0.9844	1.0000
R^2 of k(x)	0.3383	0.04180	0.6615	0.3916

Thus, the sequence of k(x) derived by fitting the Beard model to the logarithms of age specific death rate agrees fairly well with smoothed sequence of observed k(x) values except for some departure at both ends. However, k(x) values derived from the other models deviate substantially from observed values, in spite of the fact those models fit the logarithms of observed death rates remarkably well. Here the bell-shaped pattern reflects age variations rather than the cohort variations of mortality.

Social Interpretation

Ageing is an unavoidable issue for two reasons. First, it is inevitable and will affect people in all societies sooner or later. Consequently population growth and ageing are the two dimensions of one and the same phenomenon, a sudden decline in population growth causing ageing to accelerate (Chuan Beyens Wu, 1986). Second, ageing presents each country with particular challenges. In the West, the challenge is one of inter-generated relationships (human relationships but also social security system) and the choice between endeavoring to prolong life as much as possible and ensuring an old age of quality for the vast majority of people. In the countries in Asia, the challenges relate particularly to global strategies for example, rapid fertility reduction due to a voluntary based policy leads to more rapid population ageing. An alternative strategy might be a better spread of efforts over time so as to retain greater attitude for finding suitable institutional human and economic solutions.

Despite the success of social policy in the study population, gaps in coverage remain. At the same time, social policy does not deal with all groups equally well. Social security benefits and supplementary security income fail to provide for a decent standard of living. Countries like India and Pakistan where there is no old age policies or any social security schemes benefits can seldom rely on private savings or pension benefits. Those with the most serious health problems often have no spouse or family member who can care for them. These old age problems most vulnerable in one way are likely to be vulnerable in other ways. Although a high-income nation – Japan - with a democratic political system, low fertility and mortality rates, and an advanced industrial economy, Japan differs from European nations in the treatment of its elderly. On the one hand, government support for the elderly has remained low relative to European nations. On the other hand, a tradition of respect for elders in Japan provides high levels of family support for older people because of the special nature of public and private support. In addition, public pension benefits differ greatly for low and high-income workers. Besides this, Japan does not offer other comprehensive social services for the elderly or provide for retirement housing and nursing home care (Louise, 1997).

Moreover, in general all these countries, as long as the retires do not develop major health problems, disabilities or physical / mental impairment or as long as they do not retire from work even after specified age: They can enjoy a satisfying old age. Countries like India where the old age policy or where social security policy was introduced later eighties work less well for those who do not fit this model. Those who do not work continuously during adulthood or do not have jobs that participate in the social security system receive limited benefits that barely keep recipients above the poverty line (Helpard, 1998). Those with health problems of disability health or mental impairment face huge expenses that can push them into destitution before they die. The risk of a person faces during old age of becoming one of the unfortunate elderly with health and disability problems compounds the normal financial difficulties associated with retirement the risks faced by older women stem from the nature of social security, particularly countries like India, Pakistan and Bangladesh suffer more than their share of poverty. Thus, the decline in poverty rates seems less impressive than it first appeared and remains vulnerable to expensive health problems. Despite progress in the past several decades, old age security has not come without cost. Recognizing changing future demographics in India with 6.66 per cent of elderly population in 2001, ranks fourth in terms of total elderly population, but by 2001 AD it will be second to China. Where as Japan with 12 per cent as compared to Sweden with 18 per cent. Though the proportion of the aged population in India appears small, in terms of absolute numbers they will reach staggering dimensions. These figures in terms of planning and maintaining an appropriate quality of life are expected to pose problems. It requires steady ascending proportions are expected to modify savings, consumption and investment patterns of families, and alter the regions economies.

Cross-sectional data reveal poor health, greater social disability and higher death rates among people over age 65 compared to those under age 65. Furthermore, people and 75 and over face higher risks of health problems and death than do people in mid-old ages. It is evident in India and Pakistan. Older people generally remain in good health and serious problem affects only a minority. Still compared to younger age groups, health risks increases in old age including Japan. Time series data demonstrate declining mortality and higher life expectancy in recent decades, but they give mixed evidence on health and other related issues. According to some, healthier life styles and improved medical procedures have reduced the prevalence of both health risks and morbidity. This is true in India, Pakistan, Sri Lanka and Bangladesh. However, the declining death rate among the elderly is viewed by nearly everyone as a positive development in the study population (for instance India). Although, longitudinal data describes changes in health during old age similar to those described by cross-sectional and time-series data, they also identify more precisely how differences in social classes affect changes in health. Healthy people obviously experience a more satisfying old age than those in poor health, and in turn out that those from higher classes and backgrounds enjoy better health.

Findings come from even older women in India (see Figure-2) that social class difference exemplify at mid-old ages. That is, those belonging to social class experienced lower death rates in old age, and those who lived in poverty before old age experience higher death rates at mid-old age. This is found in all the study population in the Indian Sub-continent. Besides the social class differences in mortality in old age may relate to class differences in mortality in old age may relate to class differences in smoking, alcohol, and other high-risk behaviors. Despite the social class and behavioral differences, the study population strongly illustrates the consequences of social inequality. As a result, differences in class in mortality remained stable over time and continue to create diverse experiences in old age.

In general, the leveling differences in health in old age results in part from higher rates of mortality before old age, which leaves a harder subset of old age. Still, all the study population in Asia suffers from fewer resources and poorer medical care than do extreme old ages. Also consistent with leveling arguments, mortality statistics by country reveal the some of the cross over phenomenon. Mortality rates for Pakistan study population exceed those for India population. After 73, however, death rates for Japan exceed those for India. Drawing lines representing the death rates of all study population at all ages thus show a higher line for the ages 56-73. In contrast, smaller differences exist in mortality across the late old age groups. Although mortality declines in the old age, it falls in a way that maintains the size of the pre-existing gap.

Another problem in supporting the elderly may become more serious in the future and contribute to greater inequality – the high cost of medical care for an increasingly larger elderly population. Current costs of medical care greatly exceed. Projections, and costs will certainly grow in the future as the population of people qualifying for Medicare increases. As with public pensions, funding problems may well increase the gap between social disadvantaged and advantaged groups particularly the aged population. If Medicare benefits are reduced, rates of deaths and sickness for high-status and low-status groups in the aged population could diverge more, and health inequalities may rise along with economic inequalities in the case of Japan.

Public health care spending on the elderly may increase for another reason. If life expectancy continues to rise, but those last years are plagued by disease and disability, costs for health care may likewise increase. To support an increasing number of people, public health programs must deal with the costs of treating people at increasingly older ages with increasingly more difficult health problems. These trends may, in fact, erode some of the progress made in the financial support of older people.

Changing patterns of mortality make the risk of serious and expensive health problems more likely that a few decades ago. In the past, sickness and death came primarily form infectious viral or bacterial diseases such as influenza, pneumonia or gastroenteritis. These acute diseases potentially affect people of all ages and do not have long-lasting physical consequences. Better nutrition, community sanitation, personal hygiene, medical treatment and drug therapy reduce their incidence and their severity. Today, the threat comes not so much from these acute diseases as from chronic degenerative diseases involving the wearing out of the body rather than invasion by outside organism. Heart diseases, stroke and cancer are now the major sources of death and they strike more often as people age (Weathjerby *et al.*, 1983). As a result, death and diseases have become more closely associated with old age than in the past. And, changing composition of the elderly population may increase the prevalence of disability and serious chronic diseases (Antonovsky, 1989).

Not only that, the reducing importance of disability and chronic diseases has serious implications for health care. The costs of medical care for chronic degenerative diseases greatly exceed costs for infectious diseases. Surgery and critical care for heart and cancer patients; dialysis for kidney failure; eye surgery for older people with cataracts, cornea problems, or other vision difficulties; rehabilitation for broken bones; arthritis; osteoporosis; and full-time nursing care for dementia use substantial resources. The more common these diseases become among the elderly, the greater the private and public costs. If the probability of physical diseases and mental incapacity increases with old age, and more and more people live to old age than in the past, then we can expect more people to suffer from these expensive chronic health problems.

As the average length of life increases, people become more vulnerable to disability. People may live longer than in the past, but the quality of life for those added years may worsen. However, differences in social background shape the experiences of old age and contribute to advantages for some and disadvantages for others. The physical changes of aging create the potential for high levels of inequality between the socially advantaged and disadvantaged, the health and the middle old age groups and late old age groups. That is, differences in health across the subgroups within the aged population define a central dimension of inequality. The growth of the early old, mid-old and the older relative to the mid-old may worsen health problems and inequality within the aged population (Shepard and Zeckhauser, 1982).

Not all the trends in health and mortality appear negative. A more optimistic view notes the connection between improved mortality and improved health. That is, efforts to encourage diseases prevention and healthy life styles may contribute substantially to a longer and more active life. Those people raised since youth to value exercise and good nutrition can reap the benefits of a healthier old age. Improvements in medicine and lifestyles would postpone serious health problems until the last few years or months of life (Thompson, 1992). Nearly all people healthy and independent until near the maximum limit of the human life span, then experience a quick decline and death. Although, current evidence provides little support for these claims, such compression would reduce the cost of treating the elderly.

REFERENCES

Antonovsky, A. Unraveling the Mystery of Health: How People Manage Stress and Stay Well. Sanfrancisco: Jossey-Bass, 1989

Beard, R.E. A Theory of Mortality Based on Actuarial, Biological and Medical Considerations. In *Proceedings of International Population Conference.* New York: No. 1. pp. 611-625. Liege: IUSSP, 1963.

Blacker, G.C. The Estimation of Adult Mortality in Africa from Data on Orphanhood. *Population Studies.* No.31. pp.107-128; 1977.

Brass, W. *et. al.* The Demography of Tropical Africa. 1968. Princeton: Princeton University Press; 1968.

Brillinger, D.R. A Justification of Some Common Laws of Mortality. *Transactions of the Society of Actuaries.* No. 13. pp. 116-119, 1961.

Chuan Beyens Wu. Aging in a Changing Population. China in the 21st Century. Chaire: Auetelet. pp. 177-189, 1986.

Coale, A.J. and Ellen, Eliason Kisker. Mortality Cross-Overs: Reality or Bad Data. *Population Studies.* No.40. pp.389-401, 1986.

Coale, A.J. and Guo, G. Revised Regional Model Life Tables at Very Low Levels of Mortality. *Population Index* . No. 55 (4). pp. 613-643, 1990.

Coale, A.J. and Demeny, P. Regional Model Life Table and Stable Population. Princeton: Princeton University Press, 1966.

EwBank, D.C. The Sources of Error in Brass's Method for Estimating Child Survival. The Case of Bangladesh. *Population Studies*, No. 36. pp.459-474, 1982.

Gompertz, B. On the Nature of the Function Expressive of the Law of the Human Mortality and on a New Mode of Determining the Value of Life Contingencies. *Philosophical Transactions* of *Royal* Society. No.115. Part – II. pp. 513-585, 1825.

Helpard. The Kaleidoscope Experience for Elderly Women Living with Caronary Artery Disease. *Candian Journal of Caradiovasular Nursing.* No.19. pp. 11-23, 1998.

Hill,K. and Trussel,T.J. Further Developments in Indirect Mortality Estimation. *Population Studies.* No. 31. pp. 313-334, 1977.

Horiuchi, S. and Coale, A.J. Age Patterns of Mortality for Older Women: An Analysis Using the Age-Specific Rate of Mortality Change with Age. *Mathematical Population Studies.* Vol. No. 2 (4). pp. 245-267, 1990.

Horiuchi, S. and Coale, A.J. Age Patterns of Mortality for Older Women: An Analysis Using the Age-Specific Rate of Mortality Change with Age. *Mathematical Population Studies.* Vol. 2 (4). pp. 245-267; 1990.

James,T. Trusell. A Re-estimation of the Multiplying Factors for the Brass Technique for Determining Survivorship Rates. *Population Studies.* No. 29. pp. 97-108, 1975.

Jeremiah Male Sullivan and Godwin, A. Udofia. On the Interpretation of Survivorship Statistics. The Case of Non-Stationary Mortality. *Population Studies.* No. 33. pp. 364-374, 1979.

Jeremiah, M.Sullivan. Models for the Estimation of the Probability of Dying between Birth and Exact Ages of Early Childhood. *Population Studies*. No. 26. pp. 71-97, 1972.

Kannisto, V. On the Survival of Centenarians and the Span of Life. *Population Studies*. No.46. pp 389-406; 1988.

Louise, Lassonde. Coping with Population Challenges. London: Earthscan Publication Limited, 1997.

Makeham, W.M. On the Law of Mortality and the Construction of Annuity Tables. *Journal of the Institute of Actuaries*. No. 13. pp. 325-367, 1860.

Preston, S.H. 1970. An International Comparison of Excessive Adult Mortality. *Population Studies*. No.24. pp. 5-20.

Ravichandran N. Age Pattern of Mortality for Older Women in Selected States of India. Paper Presented in MPS Seminar at International Institute of Population Sciences, Mumbai on April 23-26, 1994, 1994.

Shanfield, S. Return to Work after an Actue Myocardial Infarction: A Review. Hearty and Lung; *Journal of Critical Care*. No. 19. Pp. 109-117, 1990.

Shepard, D.S. and Zeckhauser, R.J. The Choice of Health Policies with Heterogeneous Populations. In V.R. Fuchs, (ed.) Economic Aspects of Health. Chicago: The University of Chicago Press, 1982.

Thompson, P. I Don't Feel Old: Subjective Aging and the Search for Meaning in Later Life. *Aging and Society*. No. 12. pp. 23-47, 1992.

United Nations. Methods of Estimating Basic Demographic Measures from Incomplete Data. *Population Studies. No.* 42, 1967.

Weatherby, N.L. Nam, C.B. Issac, L.W. Development, Inequality, Health Care and Mortality at the Old Ages. A Cross National Analysis. *Demography*. No. 20. pp. 27-44, 1983.