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Research Article

Changes in Health Expectancies: A Multi State Lifetable Model

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Abstract

The study of health status of the elderly is important to project health problems in the future. Healthy life expectancy is an index of a population's state of health derived from estimates of mortality and disability, essentially addressing the question of whether observed increases in life expectancy are also accompanied by decreases in morbidity. The question is obviously important both for the understanding of changes in the state of health of a given population and for the formulation of Government policies directed at the provision of services. Therefore, this study is undertaken in order to (1) examine the prevalence of health problems in the older population and (2) to study the morbidity transition schedules on estimated life expectancy at various states of health by using multi state life table model. The data was collected from 1745 households from the three wards (one urban ward and two rural wards).

A Multi state life table technique was used to estimate rates or probabilities of transitions between health states as time or age progresses. In the study consider three states of health denoting the conditions of Healthy, Unhealthy and the absorbing state of health. Knowing the transition probabilities permits health expectancy estimates, which are the time spent in the different states of health from a given age until death. The probability of dying was much higher among the unhealthy than the healthy. For both men and women the risk ratio was almost similar at age 60. Unhealthy men at age 75 had same mortality as healthy women at age 85. It was also found that at the younger ages if a person was unhealthy there was chance of being recovering from the unhealthy state. But as age increases the chance of recovering from unhealthy was very low. The risk of having unhealthy was very high as age increases. Again the life expectancy in healthy state and the life expectancy in unhealthy state for women were higher than that of men.

Introduction

According to the *United Nations (2009)*, in 2000, the population aged 60 years or over in the World numbered 600 million, triple the number present in 1950.In2009, the number of older persons had surpassed 700 million. By 2050, 2 billion older persons are projected to be alive, implying that their number will once again triple over a span of 50 years. Globally the population of older persons is growing at a rate of 2.6 percent per year, considerably faster than the population as a whole, which is increasing at 1.2 percent annually. The pace of population ageing is faster in developing countries than in developed countries. For most nations, regardless of their geographic location or developmental stage, the oldest-old, that is, those aged 80 years and over are growing faster than any younger segment of the older population. Their numbers are currently increasing at 4.0 percent per year. Today, persons aged 80 years or over account for close to one in every seven older persons (60 or over). By 2050, this ratio is expected to increase to nearly one person aged 80 or over among every five older persons.

Increased longevity is a triumph for public health and the result of social and economic development. However, developing countries will become old before they become rich while industrialized countries became rich while they were growing old. The pace of population ageing of each country varies, owing to the difference in its stage of demographic transition, which is related to economic and social development. The world's older population-those aged 60 years and over-

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reached nearly 760 million in 2010. More than half of the total (414 million) lived in Asia, including 166 million in China and 92 million in India (United Nations, 2010). In India, the proportion of the population aged 60 years and above was 8.3 percent in 2011 and was projected to increase to 20 percent by the year 2050 (Lekha et al, 2011).

India has achieved significant gains in life expectancy in the last few decades but the overall health conditions of the population appear to have worsened as it is having very high levels of morbidity prevalence with considerable interstate differences in morbidity prevalence. Though the demographically and socially advanced states like Kerala, Punjab and West Bengal have lower infant mortality and greater life expectancy, the reported morbidity prevalence rates in these states are the highest in the country. Contrary to this, socio-economically poorer states like Bihar, Madhya Pradesh and Rajasthan have reported lowest morbidity rates.

The population of Kerala is ageing more rapidly than in other states of India. Kerala which has passed of stage of demographic transition is also experienced the health transition. The population density in this State is rather high, but its growth rate is now rapidly declining, with a high average age at marriage, a high level of family planning acceptance and fertility control, a moderate decline in mortality and a high degree of population mobility. The population is also fairly well advanced in terms of literacy and educational attainment and is moderately successful in introducing social change. According to the 2011 census, 12.5 percent of Kerala's population are 60 years or over. The projection shows that by 2051 the proportion of 60+ becomes more than 30 per cent. The increase of the population aged 60 years and above from 5 to 8 percent took 20 years (from 1961 to 1981); the same increase from 8 percent to 13 percent occurred in the next 30 years (between 1981 and 2011).

Health among the older population as measured by most dimensions has improved during the last two decades. Mortality has continued to decline, and disability and functioning loss are less common now than in the past. However, the prevalence of most diseases has increased in the older population as people survive. The longer with disease, and the reduction in incidence does not counter the effect of increased survival. On the other hand, having a disease appears to be less disabling than in the past *(Crimmins, 2004).*

As life expectancy has increased, emphasis has shifted from quantity to quality of life. Researchers and policymakers are increasingly focusing on how to extend healthy and active life. This has resulted in a growing use of measures of expected healthy life or life without disease or disability, in addition to traditional measures of life expectancy, to monitor health trends and health differences.

The idea of health expectancy had been put forward by Sanders as early as 1964 and a first method of calculation had been proposed by Sullivan in 1971. Since then, health expectancies have been increasingly used in industrialized countries to assess the evolution of the populations' health status, in particular that of older people. Health expectancies provide a means of dividing life expectancy into life spent in various states of good and bad health(Anil Chandran and Mohanachandran Nair, 2002). These measures represent the increasing focus on indicators of the quality of life lived (life spent in a healthy state) rather than the quantity (life expectancy).

The Research Problem

Health Surveys in Kerala show that the incidence of chronic and degenerative diseases is increasing very fast this has called for a shift in the technology and management of health care. Diabetes, Hypertension, cardiovascular diseases, Cancer etc. have been found to be progressively increasing in Kerala. There is, now an 'expansion of morbidity' where old age is characterized by long period of illness which may not be very serious nature. This means that the longer a person lives, the longer he/she will lives with illness. That is, we extend our life years at the cost of disability.

The main areas of concern of the aged people are the protection, health and nutrition and housing. The present situation in Kerala is that the most of the aged people are left alone which are raising various socio-economic problems. The peculiar situation of the aged is the by-product of breakup of joint families to modern nuclear families, shift of the population from the agriculture sector to industrial or service sector, migration of larger number of persons from their home villages to in and outside the state or other countries, attitude of the young generation to live independently with the spouse and children, leaving their parents, insistence on the part of aged not to leave their traditional households. Older persons must have access to adequate and appropriate food, shelter, clothing and health systems. They should be given opportunities to work or to have access to other income generating opportunities. Aged persons who are destitute and disabled need financial support also. They normally expect care and support from their own families. Unfortunately, many of them do not get family support because of various reasons.

Health expectancies extend the concept of life expectancy to morbidity and disability. Health expectancies, in particular disability-free life expectancy, were first developed to address whether or not the lengthening in life expectancy is being accompanied with an increase in time lived in bad health. Less is known about recent morbidity changes in the aged population and most of the studies reported increase in the prevalence of disabilities, particularly functioning problems among the older population. It is necessary to get a clear understanding of the dynamic changes in both population health and health experiences pertaining to an individual life. It is better to know how many life years are spending in healthy state rather than the total life years. Again no study, especially in the Indian context has successfully analysed the effect of changes in the mortality and health transition rates on the length of expected life in various states of health. This study is an attempt in that perspective.

Objectives

The main objectives of the study are as follows:

(1) To examine the prevalence of health problems in the older population.

(2) To study the morbidity transition schedules on estimated life expectancy at various states of health by using multi state life table model.

Data and Methodology

As secondary data is not available for a study like this, it was decided to collect information from elderly persons directly. It was decided to collect information from around one Thousand elderly persons from the selected sample. As rural panchayat ward would have lesser number of households compared to Municipal ward it was decided to collect data from two rural wards of a panchayat and one ward from the Trivandrum Municipal Corporation. Two wards from Sreekaryam Panchayat were selected randomly, the wards are Chempazhanthy and Aniyoor and Pattom ward from the Trivandrum corporation. The data were collected from 1745 householdsfrom the three wards. The wards were selected using simple random sampling.

The period prevalence and period health expectancies are not dependent on the past history of each cohort surveyed and therefore are better indices to monitor actual changes in health policy. Period life expectancies are computed from official vital statistics, which are a collection of certificates concerning people dying within a time period, usually one year. Period health expectancies can only be measured from a longitudinal health survey, which is the only way to record the changes occurring in health status.

A cross –longitudinal survey consists of a first survey (“cross”) where individuals of different ages are interviewed about their health status or degree of disability. A second wave of interviews (“longitudinal”) should measure each individual’s new health status after one year of the first survey and third wave of interviews again after one year of the second wave survey (Fig: 1). Heath expectancies are computed from the transition observed between waves(interviews) and are computed for each degree of severity of disability (number of health states). The more degree of severity considered, the more time is necessary to reach the maximum likelihood of the parameters involved in the model. Considering only two states of health transition due to morbidity (healthy and unhealthy) is generally enough (Fig: 5).

Multi State Life Table Method

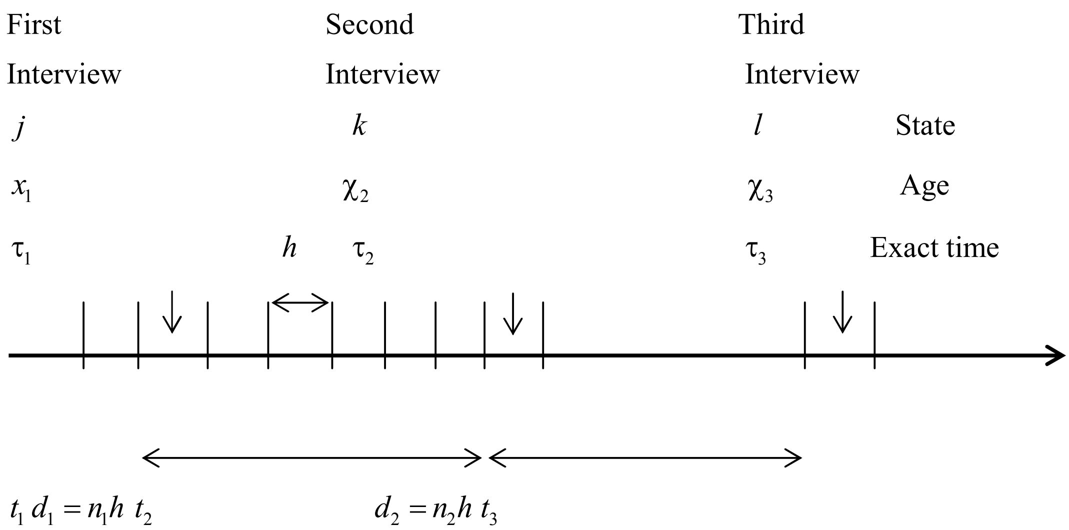
The multistate life table method has been proposed by Rogers et. al. (1989) in order to take into account the recovery of lost functions and return to a state of good health. Data comes from longitudinal surveys which provide requested probabilities over a couple of years

- onset of disability or other health problems
- recovery from disability or other health problems
- probability of dying for people who had initially disability and for people who were initially healthy

Based on this set of probabilities, multistate life tables can be computed by simulating from age to age the risks of entering disability, recovering and dying and deriving from it the person-years with and without disability.(Fig: 1)

The advantage of this method - based on transitions between states of health - is that it gives a period indicator that takes into account the reversibility of disability. As there are Different methods to compute multistate life tables (Crimmins E.M*et al,*1994,1996 and 2009), Crimmins (2004),Fries J F(1989), Saito *et al* (1999) and Cruz (2007). In this study, IMaCh program has been used to compute the morbidity transition on estimated life expectancy. This programme computes Healthy Life Expectancies from cross – longitudinal data using the methodology pioneered by Laditka and Wolf (1998).

Figure 1: Follow-up of an Individual i in State j aged x_1 at the First Interview



The first step is the estimation of the set of the parameters of a model for the transition probabilities between an initial state and a final state. From there, the computer program produces indicators such as the observed and stationary prevalence, life expectancies and their variances both numerically and graphically. The transition model consists of absorbing and non-absorbing states assuming the possibility of return across the non-absorbing states.

The program is dependent upon a set of parameters inputted by the user: selection of a sub-sample, number of absorbing and non-absorbing states, number of waves to be taken in account, a tolerance level for the maximization function, the periodicity of the transitions, covariates in the model.

(a) Estimating Transition Probabilities

The Markov chain was used to model transitions between health states, which have two non-absorbing states, coded 1 for Healthy(able to provide independent living) and 2 for Unhealthy (unable to provide independent living), and one absorbing state of Death which is coded 3. Let $X(x)$ denote the state of an individual aged x.

After time h this individual is in state $X(x+h)$, assume that $X(x)$ is a non-homogeneous discrete parameter. Markov chain on these three states with transition probabilities:

$$ {}_h p_x^{jk} = \Pr(X(x+h) = k \mid X(x) = j), \tag{1} $$

And one step transition matrix:

$$ {}_h P_x = ({}_h p_x^{jk}) = \begin{pmatrix} {}_h p_x^{11} & {}_h p_x^{12} & {}_h p_x^{13} \\ {}_h p_x^{21} & {}_h p_x^{22} & {}_h p_x^{23} \\ 0 & 0 & 1 \end{pmatrix} \tag{2} $$

A natural parameterization for the transition probabilities is the multinomial logit. This parameterization implies that the dependence on age x is of the relatively simple form of linear log(partial odds). If we assume that h is fixed (e.g. a month or trimester or a year) the model is

$$ \ln \frac{{}_h p_x^{jk}}{{}_h p_x^{jj}} = \alpha_{jk}(h) + \beta_{jk}(h)x, j \neq k \tag{3} $$

A more detailed treatment with a commensurate increase in computational effort would involve the examination of a more complex dependence on age, or on cohort, and the introduction of covariates. Let $\tau_1, \tau_2, \ldots$ be the exact times of scheduled follow-up of the study as shown in figure 1. Suppose that individual i, aged x_1 at first examination at exact time τ_1 is observed to be in state j. τ_1 is usually rounded to integer times: a month, trimester or year; t_1 is the corresponding rounded time. Suppose that individual i at a second interview, aged $\chi_2 = x_1 + \tau_2 - \tau_1$, is classified in state k at time τ_2.

It is not necessary to round x_1 but for confidentiality reasons, age is often given in integer years. The duration between two interviews is expressed in terms of elementary time units, that is, $d_1 = n_1 h$. Age at the second interview is rounded to $x_2 = x_1 + d_1$. Then the contribution at time t_2 of individual i to the likelihood is:

$$ L_{t_1 - t_2}^{(i)} = {}_{d_1} p_{x_1}^{jk} \tag{4} $$

where the probability on the right hand side is the $(j,k)^{th}$ element of the matrix product:

$$ \prod_{u=1}^{n_1} {}_h P_{x_1+(u-1)h} = \left({}_{d_1} p_{x_1}^{jk}\right) \tag{5} $$

If this individual is observed only once more at time $t_3 = t_2 + d_2, (d_2 = n_2 h)$ and noted to be stat 1, then a further contribution to the likelihood is ${}_{d_2}p_{x_2}^{kl}$ $(x_2 = x_1 + d_1)$. In this case the component of the total likelihood due to individual i is

$$L^{(i)} = \left({}_{d_1}p_{x_1}^{jk}\right) * \left({}_{d_2}p_{x_2}^{kl}\right) \qquad (6)$$

One observes that the formation of the likelihood is no trivial matter since there is no simple analytical expression for the higher order transition probabilities in (5).If the individual is dead at the time of the interview, the date of death must be known in order to calculate the contribution to the likelihood. If this date is unknown, we assumed that the individual died at the mid interval. In this way, the log-likelihood of a sample of N individuals can be formed:

$$l = \sum_{i=1}^{N} \log L^{(i)} \qquad (7)$$

The parameters $\alpha_{ij}(h)$ and $\beta_{ij}(h)$ of (3) are estimated by maximizing this quantity.

If θ denotes the vector of parameters and $\hat{\theta}$ its maximum likelihood estimator, then standard theory tells that for a large sample of size N the MLE $\hat{\theta}$ is approximately normally distributed with mean θ and covariance matrix $V(\hat{\theta})$:

$$\lim_{N\to\infty} E(\hat{\theta}) = \theta \text{ , } V(\hat{\theta}) = \frac{1}{N} I^{-1}(\theta) \qquad (8)$$

Where $I(\theta)$ is the information matrix computed at the true value θ. This implies the asymptotic normality of the estimates of the transition probabilities and health expectancies.

(b) Estimation of Health Expectancies and their Variances

For convenience take the time/age unit h = 1 so that the temporal unit is now suppressed in the notation. Recall, however, different values of h will give different numerical estimates of the parameters.

Let e_x^{ij} be the expected subsequent time spent in state j by an individual who was in state i at age x. For such individuals, e_x^{ij} is the health expectancy of state j.

If

$${}_yI_x^{ij} = \begin{cases} 1 & if\ X(x+y) = j\ given\ X(x) = i, \\ 0 & otherwise \end{cases} \qquad (9)$$

then $O_x^{ij} = \sum_{y=1}^{\infty} {}_yI_x^{ij}$ (10)

is the subsequent time spent in state j by individuals in state i at age x. Now the mean of ${}_yI_x^{ij}$ is

$$E\left({}_yI_x^{ij}\right) = \Pr\left(X(x+y) = j \mid X(x) = i\right) = {}_yp_x^{ij} \qquad (11)$$

and hence $e_x^{ij} = E\left(O_x^{ij}\right) = \sum_{y=1}^{\infty} {}_yp_x^{ij}$ (12)

Thus the transition probabilities ${}_{y}p_{x}^{ij}$ permit calculation of the health expectancies e_{x}^{ij}. In fact the probabilities ${}_{y}p_{x}^{ij}(\theta)$ are estimated by ${}_{y}p_{x}^{ij}(\hat{\theta})$ where $\hat{\theta}$ is the maximum likelihood estimator of the previous section. Hence e_{x}^{ij} is estimated by

$$\hat{e}_{x}^{ij} = e_{x}^{ij}(\hat{\theta}) = \sum_{y=1}^{\infty} {}_{y}p_{x}^{ij}(\hat{\theta}) \tag{13}$$

$e_{x}^{ij}(\hat{\theta})$ is a consistent asymptotically normally distributed estimator of e_{x}^{ij}. The Taylor approximation

$${}_{y}p_{x}^{ij}(\hat{\theta}) \simeq {}_{y}p_{x}^{ij}(\theta) + (\hat{\theta}-\theta)' \frac{\partial}{\partial\theta} {}_{y}p_{x}^{ij}(\theta) \tag{14}$$

implies the large sample variances and covariances:

$$Var\left({}_{y}p_{x}^{ij}(\hat{\theta})\right) = \left(\frac{\partial}{\partial\theta} {}_{y}p_{x}^{ij}(\theta)\right)' V(\theta) \frac{\partial}{\partial\theta} {}_{y}p_{x}^{ij}(\theta), \tag{15}$$

$$Cov\left({}_{y}p_{x}^{ij}(\hat{\theta}), {}_{y}p_{x}^{kh}(\hat{\theta})\right) = \left(\frac{\partial}{\partial\theta} {}_{y}p_{x}^{ij}(\theta)\right)' V(\theta) \frac{\partial}{\partial\theta} {}_{y}p_{x}^{kh}(\theta) \ ,$$

$$Var\left(e_{x}^{ij}(\hat{\theta})\right) = \sum_{y}\sum_{u} \left(\frac{\partial}{\partial\theta} {}_{y}p_{x}^{ij}(\theta)\right)' V(\theta) \frac{\partial}{\partial\theta} {}_{u}p_{x}^{ij}(\theta),$$

$$Cov\left(e_{x}^{ij}(\hat{\theta}), e_{x}^{ik}(\hat{\theta})\right) = \sum_{y}\sum_{u} \left(\frac{\partial}{\partial\theta} {}_{y}p_{x}^{ij}(\theta)\right)' V(\theta) \frac{\partial}{\partial\theta} {}_{u}p_{x}^{ik}(\theta) \ ,$$

where $V(\theta)$ is the covariance matrix (8).

Formulae (14) and (15) hold true for the health expectancy

$${}_{y}e_{x}^{ij} = \sum_{u=1}^{y} {}_{u}p_{x}^{ij} \tag{16}$$

over the interval $(x, x+y)$, given the initial state i at age x, with y as the upper limit in the sums.

Total life expectancies respective of the initial state are

$$e_{x}^{i\cdot} = e_{x}^{i1} + e_{x}^{i2} \tag{17}$$

Health expectancies irrespective of the initial state are weighted averages of e_{x}^{1j} and e_{x}^{2j}. The weights are the proportions $\pi_{x}^{1}, \pi_{x}^{2} (= 1-\pi_{x}^{1})$ of the population aged x in states 1 and 2 respectively. Thus

$$e_{x}^{\cdot j} = \pi_{x}^{1} e_{x}^{1j} + \pi_{x}^{2} e_{x}^{2j} \tag{18}$$

is the (marginal) health expectancy of state j at age x . Its estimator $e_x^{\cdot j}\left(\hat{\theta}\right)$ is the same linear combination of $e_x^{ij}\left(\hat{\theta}\right), i=1,2,$ and as such is asymptotically normally distributed with mean $e_x^{\cdot j}$ and variance

$$Var\left(e_x^{\cdot j}\left(\hat{\theta}\right)\right)=\sum_{i=1}^{2}(\pi_x^i)^2 Var\left(e_x^{ij}\left(\hat{\theta}\right)\right)+2\pi_x^1\pi_x^2 Cov\left(e_x^{1j}\left(\hat{\theta}\right),e_x^{2j}\left(\hat{\theta}\right)\right) \quad (19)$$

Total life expectancy is $e_x^{\cdot\cdot}=e_x^{\cdot 1}+e_x^{\cdot 2}$. Also $e_x^{\cdot 1}\left(\hat{\theta}\right)$ and $e_x^{\cdot 2}\left(\hat{\theta}\right)$ are asymptotically normally distributed with covariance

$$Cov\left(e_x^{\cdot 1}\left(\hat{\theta}\right),e_x^{\cdot 2}\left(\hat{\theta}\right)\right)=(\pi_x^1)^2 Cov\left(e_x^{11}\left(\hat{\theta}\right),e_x^{12}\left(\hat{\theta}\right)\right)+2\pi_x^1\pi_x^2\left[Cov\left(e_x^{11}\left(\hat{\theta}\right),e_x^{22}\left(\hat{\theta}\right)\right)+Cov\left(e_x^{12}\left(\hat{\theta}\right),e_x^{21}\left(\hat{\theta}\right)\right)\right]+ (\pi_x^2)^2 Cov\left(e_x^{21}\left(\hat{\theta}\right),e_x^{22}\left(\hat{\theta}\right)\right). \quad (20)$$

Formulae (19) and (20) apply if π_x^1 and π_x^2 are known. However, this is generally not the case and the probabilities have to be estimated from the sample.

One procedure is to use age- specific proportions of people observed in each state during the survey. It can work well if the survey is a single cross-sectional survey at a precise date, but if the survey is a multiple round survey with a wide range of the dates of interviews, it is better to compute the initial probabilities from the model itself. Our approach is similar to the *period* life table calculation where the total number of survivors at age x is calculated from the mortality rates before age x (and usually starting from birth).

Analysis

Data on the age of the population were obtained by asking the completed age in years of an individual at the time of the household visit. 1745 households were covered for this study, there were 7188 people of this total population 1131 were aged 60 and above, that is, about 16 percent of the populations were elderly people(Table 1). The share of elderly of the total population was nearly 20 percent in urban area and 11.5 percent in rural area. The average household size was 4.12 for the whole sample, in urban area it was 3.86 and 4.43 in rural area. Again it can be seen that about 65 percent of the household have an elderly person. The corresponding figure for urban area was 76 percent and only 51 percent in rural area. This clearly indicates the rapid growth of older people in the state.

The age and sex distribution of the aged population is given in Table 1. Out of the 1131 respondents around 33 percent were in the age group 60-64 and nearly 90 percent were in 60-80 age group. Only 10 percent were in '80 years or above'. The overall sex ratio was 1071 and females were more in number in all age group except the 75-79 age group and among the old-old group the sex ratio was very high.

The distribution of respondents by their marital status is given in table2. In the sample about 65 percent were currently married, among the males 89 percent were currently married but in the case of females it was only 43 per cent. 32 percent of the elderly were either widows or widower. Here the widows come around 53.8 percent and widower only 8.6 per cent. As the life expectancy of the females are higher than males (on average six years difference) in Kerala the proportion of widows are on increasing over the years. Further among women 3.6 percent were either single or divorced or separated the corresponding figure for males was only 2.6 per cent. This finding clearly shows the seriousness of the elderly problem particularly that of elderly women.

Table 1: Percentage Distribution of Respondents by Age and Sex

Age	Sex		Total	Sex Ratio
	Male	Female		
60 - 64	196 (35.90%)	180 (30.80%)	376 (33.20%)	918
65 - 69	135 (24.7%)	141 (24.1%)	276 (24.40%)	1044
70 - 74	107 (19.60%)	132 (22.60%)	239 (21.10%)	1234
75 - 79	63 (11.50%)	63 (10.80%)	126 (11.10%)	1000
80 - 84	31 (5.70%)	33 (5.60%)	64 (5.70%)	1065
85 - 89	10 (1.80%)	27 (4.60%)	37 (3.30%)	2250
90+	4 (0.70%)	9 (1.50%)	13 (1.10%)	1071
Total	546 (48.30%) 100.00%	585 (51.70%) 100.00%	1131(100.00%) 100.00%	

Table 2: Percentage Distribution of Respondent by Marital Status

Marital Status	Sex		Total
	Male	**Female**	
Married	485	249	734
	88.80%	42.60%	64.90%
Widow/ Widower	47	315	362
	8.60%	53.80%	32.00%
Single/ Divorced/ Separated	14	21	35
	2.60%	3.60%	3.10%
Total	**546**	**585**	**1131**
	48.30%	**51.70%**	**100.00%**
	100.00%	**100.00%**	**100.00%**

Type of Family

The type of family of the respondents and where they live are given in figure 2. Nearly half of the respondents live in nuclear families, about 47 percent in joint families and three percent live as single. In the case of males, 55 percent live in nuclear families, 44 percent in joint families and about one percent in single member household. Among women, 44 percent live in nuclear families, 51 percent in joint families and five percent live in single member household.

Health Status

The self-rated health status of the elderly with others in the same age is given in figure 3. In this study it was found that about 5.5 percent of the respondent reported that their health condition were very poor compared to others, 29 percent reported it as poor and another 30 percent respondents' health condition were satisfactory. 36 percent of the elderly reported their health status as good compared to their friends.

Figure 2: Percentage Distribution of Respondent by Type of Family and Sex

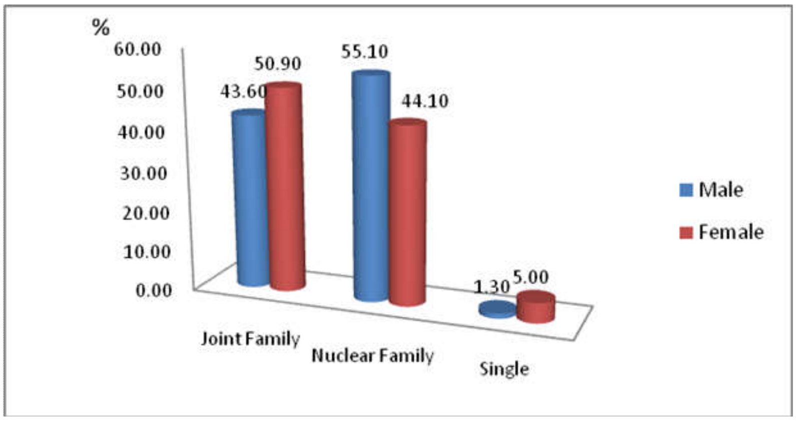


Figure 3: Health Condition of the Elderly

Chronic Disease

The distribution of respondents having any chronic disease is given in the table 3. Of the total sample population 66.6 percent (753) reported to have one or more chronic diseases. Among males, the corresponding figure was 62 per cent, while for females it was around 71 per cent. Of the total respondents who reported to have a chronic ailment, 55 percent were women and the remaining 45 percent were men. The distribution of respondents according to the various types of chronic diseases is also given in the table. The major chronic problems are diabetes and blood pressure. Of the 753 people who reported to have a chronic ailment, 59 percent have blood pressure and about 40 percent have diabetes. It was also noted that 10 percent have cardiac problem. The sex difference in the prevalence of illness was also observed and the number of females afflicted with diseases was found to be more than men. It was also found that nearly 240 elderly have more than one disease, of which 60 percent were women and 40 percent men.

Table 3: Percentage Distribution of Respondent by Chronic Ailment

Chronic Ailment	Sex		Total
	Male	Female	
No	207	171	378
	54.80%	45.20%	100.00%
	37.90%	29.20%	33.40%
Yes	339	414	753
	45.00%	55.00%	100.00%
	62.10%	70.80%	66.60%
Total	546	585	1131
	48.30%	**51.70%**	**100.00%**
	100.00%	**100.00%**	**100.00%**

Functional Disability

Functional disability has numerous implications for public health, including increased demand for health care, reduced quality of life, increased cost of care and higher mortality. In this study, we define functional disability in terms of four non absorbing states that separate the population in to two dependent and independent states. The dependent states are (i) being unable to independently provide personal care and (ii) being able to provide personal care but not able to manage life in the whole independently. The independent states are (iii) being able to provide both personal care and independent living but having some difficulty in performing these tasks outside home and (iv) having no functioning difficulties.

The number of elderly having functional disability is given in the table 4. It can be seen that about 10 percent of the respondents have severe functional disabilities. Here functional disability means bed ridden, paralysis and other type of disabilities which affect daily activities. This does not include physical disabilities (old age problems) like poor vision, sleeping problem, hearing problem etc. Of total 111 elderly those who have functional disability 78 were women and 33 men.

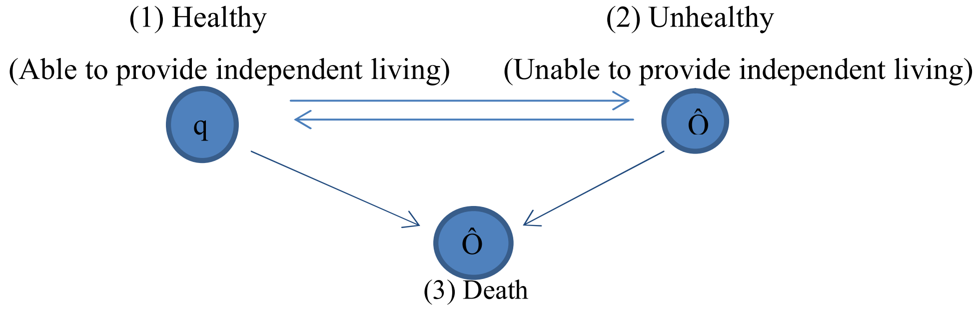
Table 4: Distribution of Elderly Having Functional Disability (Need help for daily routine)

Functional Disability	Male	Female	Total	Percent
Yes	33	78	111	9.8
No	511	502	1013	89.6
Total	**546**	**585**	**1131**	**100**

Multistate Life Table Analysis

Multistate life table techniques have been widely applied in the social sciences, in particular to the analysis of life histories using data from longitudinal surveys. Such methods make it possible to estimate rates or probabilities of transitions between states as time or age progresses. We consider three states of health denoting the conditions of Healthy, Unhealthy and the Absorbing state of death (Fig: 4). Time is taken as discrete and the central problem is to determine estimates and their standard errors of the transition probabilities over time intervals. Knowing the transition probabilities permits health expectancy estimates, which are the times spent in the different states of health from a given age until death.

Figure 4: Health States and Possible Transitions across States



This paper is focused on period age-specific prevalence of disability instead of cross-sectional prevalence widely used under Sullivan's method *(Sullivan, 1971)*. The period prevalence is analogous to the survival function in a period life table.

A period life table is the sequence of survivors which would be observed in a fictitious cohort using the actual age specific mortality rates. It differs from the proportions of survivors in each actual surviving cohort. Analogously, the period prevalence of disability is the proportion of disabled among the survivors of a fictitious cohort subject to the actual age-specific conditions of entering and exiting the disability state.

Period prevalence and period health expectancies are not dependent on the past history of each cohort surveyed and therefore are better indices to monitor actual changes in health policy.Period life expectancies are computed from official vital statistics, which are a collection of certificates concerning people dying within a time period, usually one year.Period health expectancies can only be measured from a longitudinal health survey, which is the only way to record the changes occurring in health status.

Definition of Health States

The non-absorbing health states are classified into two (1) Healthy (able to provide independent living) and (2) Unhealthy (unable to provide independent living). Here, we defined an individual as unhealthy if help is required in performing at least one of the following activities (because of health) such as eating, bathing, dressing, getting in and out of bed, toileting, preparing own meals, shopping for personal items, managing money, using the telephone, doing light housework. Figure 4 shows the health transitions.

The survey was designed to study the process of ageing, in particular the evolution of functional health, through a questionnaire on daily activities. The sample consisted of 1131 persons aged 60 and over (546 men and 585 women) living in both the urban and rural areas. The same people were interviewed in a cross-longitudinal survey of 3 waves (2004, 2005 and 2006) using the same questionnaire.

Table 5 shows the transition numbers for 2004 – 2005, 2005 – 2006 and 2004 – 2006. In this study, we have taken the health transition between the period 2004 and 2006 which is having relevant number of transition between the health states. Hence the study is mainly focused between 2004 and 2006.

Table 5: Total Number of Transitions from 2004 -2006

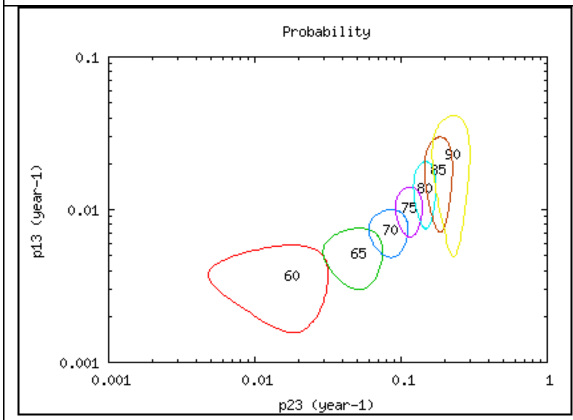
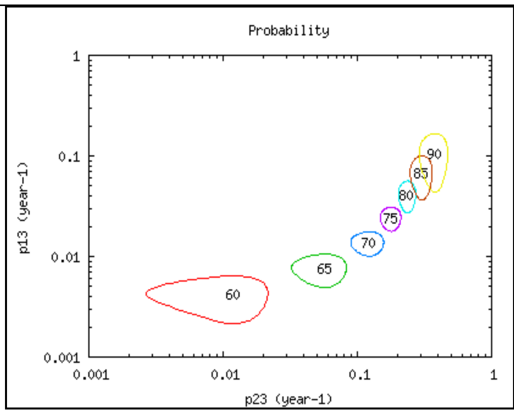
Transition			2004 - 2005	2005 - 2006	2004 - 2006
Healthy (1)	→	Healthy (1)	910	891	879
Healthy (1)	→	Unhealthy (2)	44	29	68
Healthy (1)	→	Death (3)	10	6	16
Unhealthy (2)	→	Healthy (1)	16	4	16
Unhealthy (2)	→	Unhealthy (2)	125	138	99
Unhealthy (2)	→	Death (3)	26	27	53
Total			**1131**	**1095**	**1131**

Sex Differential in Incidence of Unhealthy, Recovery and Mortality

As expected, the probability of dying is much higher among the unhealthy than the healthy (figure 5). For both men and women, the risk ratio was almost similar at age 60. Unhealthy men at age 75 have same mortality as healthy women at age 85. The confidence regions that have been drawn on figures indicate the fragility of the mortality estimates at the youngest ages when deaths are scarce.

At age 85 and 90 the probability of incidence of unhealthy is significantly higher for women than men but at younger ages the confidence regions are small. That is, at younger ages the chance of

Figure 5: Incidence of Mortality from Unhealthy State versus Incidence of Mortality from Healthy State at Age 60, 65, 70, 75, 80, 85 and 90 for Women and Men

Women	Men
	

recovery from unhealthy to healthy is high. At higher ages the recovery rate is very low (figure 6). This proves the hypothesis that the chance of transition from unhealthy to healthy state is comparatively low at older ages compared to younger ages.

Figure 6: Incidence of Unhealthy versus Incidence of Recovery with Confidence Intervals for Some Round Ages for Women and Men

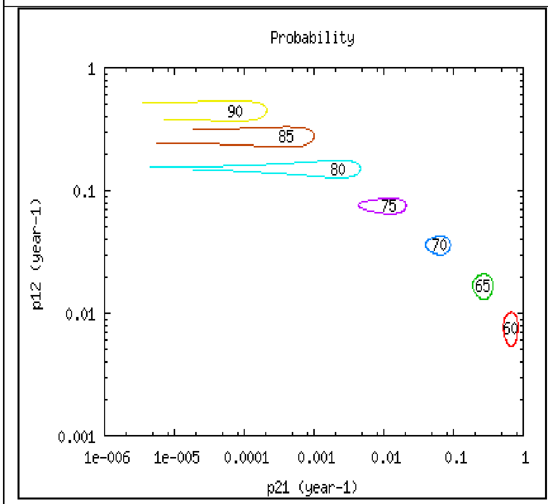
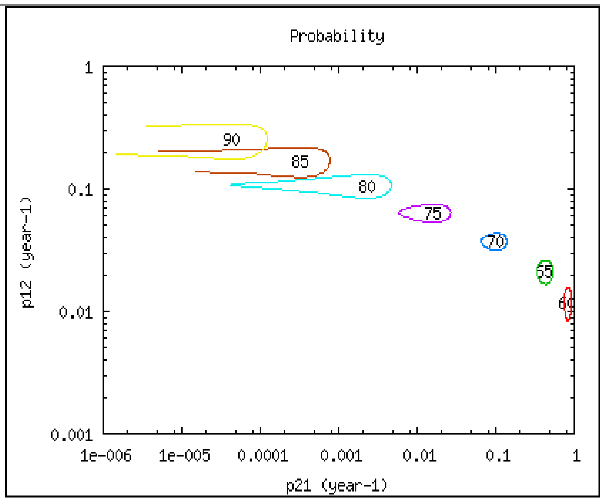
Women	Men
	

Table 6 summarizes the average correlation between incidences from age 60 to 90. The highest correlation concerns the incidence of unhealthy and incidence of recovery (0.15). It simply means that a higher estimate of unhealthy requires a higher estimate for recovery in order to get the fixed number of individuals in each health state.

Table 6: Correlation between Incidences (average from age 60 to 90)

Transition			Healthy (1) ↓ Unhealthy (2)	Healthy (1) ↓ Death (3)	Unhealthy (2) ↓ Healthy (1)
Healthy (1)	→	Death (3)	-0.17		
Unhealthy (2)	→	Healthy (1)	0.15	0.02	
Unhealthy (2)	→	Death (3)	0.12	-0.14	-0.04

A higher incidence of unhealthy, even if partly compensated by the incidence of recovery leaves fewer candidates in the healthy state to die, explaining a lower mortality risk (-0.17). But the estimate of recovery is no longer related to a higher mortality from the disability state (-0.04), probably because mortality is high and recovery is low.

Gender Differential in Health Expectancies

Age-specific mortality differentials between men and women are well-known and important enough to be measures from a longitudinal survey even at a single age level. The total health expectancy and Gender differentials in health expectancies are shown in tables, 7,8 and 9 respectively.

Men aged 60 can expect to live 16.5 years in the healthy state, given that they were in that state initially, but the expectation is reduced to 15.9 years if they were in the unhealthy state at age 60. The corresponding health expectancies for the unhealthy state are 3.2 and 3.8, respectively. Women have longer health expectancies. A woman aged 60 can expect to live 18.3 years in the healthy state, given that she was in that state initially, but the expectancy decreases to17 years if she was in the unhealthy state. The corresponding health expectancies for the unhealthy state are 5.4 and 6.2 years respectively. But we can see from the tables for both sexes, the chance of recovery from the unhealthy state is nominal if they cross the age of 70 years. Further, as age increases the years spend in unhealthy state also increases for both the sexes.

If we consider the population as a whole, a person attaining the age 60 can expect to live 17.7 years in the healthy state, given the initial condition, but the expectation is reduced to 16.7 years if unhealthy at the age of 60. The corresponding health expectancies for the unhealthy state are 4.2 and 4.9 respectively.

The classical calculation of a life table relies on the assumption that at each age the survivors are at the same risk of dying (the homogeneity hypothesis). A multistate model takes into account the heterogeneity due to health states being entered episodically in the course of life history. If the actual prevalence of disability in the whole population is higher than the stable prevalence computed from the transition rates, the total life expectancy computed from the multistate model will be higher than the life expectancy deduced from vital statistics. Taking into account the future decline of the prevalence of disability gives a better index of future mortality. A prevalence ratio observed at a given age cannot be constant over time because new cohorts will reach the same age but with different health histories. From the above tables it can be seen that as age increases the life expectancy in state 2 is higher than the life expectancy in state one. Further, we can see that the life expectancy in state one for women is higher than the life expectancy in state two for women. Similarly, the life expectancy in state 2 for women is also higher than men in state 2. Form this it is clear that the years spend with unhealthy state was higher for women. Further it was also observed that the Life

Expectancy in Unhealthy state for Women was higher than that of men and they were spending more years in the Unhealthy State than men.

Table 7: Total Life Expectancy (TLE), Healthy Life Expectancy (HLE) and Unhealthy Life Expectancy (UHLE) and Health Expectancies e_{ij} from State (i) to State (j) at Selected Ages for the Total Population

Age	TLE $(e_{..})$	SE	HLE $(e_{.1})$	SE	UHLE $(e_{.2})$	SE	(e_{11})	(e_{12})	(e_{21})	(e_{22})
60	21.96	0.36	17.74	0.32	4.22	0.21	17.75	4.22	16.65	4.86
65	17.13	0.34	12.90	0.31	4.23	0.22	13.05	4.18	7.91	6.06
70	12.91	0.32	8.75	0.29	4.16	0.22	9.59	3.93	0.98	6.32
75	9.33	0.30	5.42	0.27	3.91	0.22	6.94	3.56	0.07	5.15
80	6.56	0.29	3.06	0.24	3.50	0.24	4.88	3.16	0.00	4.06
85	4.53	0.27	1.54	0.21	2.99	0.26	3.36	2.76	0.00	3.18
90	3.13	0.24	0.65	0.17	2.47	0.27	2.29	2.39	0.00	2.50

Table 8: Total Life Expectancy (TLE), Healthy Life Expectancy (HLE) and Unhealthy Life Expectancy (UHLE) and Health Expectancies e_{ij} from State (i) to State (j) at Selected Ages for Males

Age	TLE $(e_{..})$	SE	HLE $(e_{.1})$	SE	UHLE $(e_{.2})$	SE	(e_{11})	(e_{12})	(e_{21})	(e_{22})
60	19.77	0.46	16.54	0.44	3.24	0.24	16.54	3.23	15.99	3.78
65	15.27	0.43	12.03	0.42	3.24	0.24	12.14	3.20	7.85	4.88
70	11.17	0.41	7.98	0.40	3.18	0.24	8.78	2.94	0.57	5.43
75	7.85	0.38	4.88	0.38	2.97	0.25	6.24	2.59	0.02	4.30
80	5.38	0.36	2.75	0.35	2.62	0.26	4.31	2.23	0.00	3.31
85	3.64	0.32	1.40	0.32	2.24	0.29	2.91	1.90	0.00	2.55
90	2.48	0.27	0.62	0.27	1.86	0.31	1.96	1.60	0.00	1.98

Table 9: Total Life Expectancy (TLE), Healthy Life Expectancy (HLE) and Unhealthy Life Expectancy (UHLE) and Health Expectancies e_{ij} from State (i) to State (j) at Selected Ages for Females

Age	TLE $(e_{..})$	SE	HLE $(e_{.1})$	SE	UHLE $(e_{.2})$	SE	(e_{11})	(e_{12})	(e_{21})	(e_{22})
60	23.72	0.55	18.28	0.47	5.44	0.39	18.30	5.43	17.04	6.26
65	19.08	0.53	13.66	0.45	5.43	0.39	13.87	5.35	7.82	7.53
70	14.67	0.51	9.37	0.42	5.30	0.40	10.27	5.05	1.38	7.49
75	10.78	0.49	5.82	0.38	4.96	0.41	7.46	4.61	0.16	6.18
80	7.65	0.48	3.23	0.33	4.42	0.43	5.27	4.10	0.02	4.91
85	5.31	0.46	1.56	0.27	3.75	0.46	3.62	3.58	0.00	3.87
90	3.68	0.43	0.62	0.21	3.06	0.47	2.46	3.08	0.00	3.05

Conclusion

The state of Kerala, which achieved the below replacement level fertility much ahead of other Indian states, has the highest proportion of elderly. This proportion would increases from 12.5 percent in 2001 to 18.3 percent in 2026 (India, Registrar General, 2006). This increasing number of aged persons will be a serious problem in the near future. The intensity of the old age problems is greater for females. High life expectancy of women over men will raise the proportion of the aged women. It is a fact that when people grow old, they are at greater risk of deterioration in their structural functioning and capacity. Consequently, the elderly are more vulnerable to the unhealthy state and this eventually leads in functional disability. Thus, the increase in the proportion of the elderly leads to the rise in the elderly suffering from functional disability. This causes formidable tasks for families, health personnel, and policymakers.

The additional years spent in good health or in a prolonged state of illness and dependency is a question obviously important both for the understanding of changes in the state of health of a given population and for the formulation of government policies directed at the provision of services. Therefore, this study is undertaken in order to examine the morbidity transition schedules on estimated life expectancy in various states of health by using multi state life table model. A multistate life table technique was used to estimate rates or probabilities of transitions between health states as time or age progresses. Here, we consider three states of health denoting the conditions of Healthy, Unhealthy and the absorbing state of death. Knowing the transition probabilities permits health expectancy estimates, which are the times spent in the different states of health from a given age until death. The probability of dying is much higher among the unhealthy than the healthy. For both men and women, the risk ratio is almost similar at age 60. Unhealthy men at age 75 have same mortality as healthy women at age 85. The confidence regions indicate the fragility of the mortality estimates at the youngest ages when deaths are scarce. It was also found that at the younger ages if a person is unhealthy there was change of being recovering from the unhealthy state. But as age increases the chance of recovering from unhealthy is very low. The risk of having unhealthy is very high as age increases.

Recommendations

The finding that elderly women had a lower proportion of years lived without disability compared to men, reflected the poorer quality of life in elderly women. There is a chance of recovery from unhealthy for the elderly at younger ages. But the chance of recovery is fewer as age increases. We conclude, therefore, that people may be living longer, but the extra years are largely lived in poor health. Effective health promotion strategies throughout life have the potential to enable people to take control over the risks in early years of life and improve their health, which will contribute to active and healthy ageing. Thus, promoting good habits for consuming healthy foods and carrying out regular physical activity would reduce hypertension, heart diseases, stroke and diabetes in later years. In addition to increasing longevity, the ultimate goal of promoting health throughout the life-course should be to improve the quality of life and increase happiness, productivity and satisfaction. Government should frame policies that have the potential to provide economic relief to older people who face the burden of increased medical costs at a time when their earning capacity has diminished and there are no social safety nets other than the family to shoulder the cost of health care, as it fails to conceive the issue of elderly health as more than just a medical one.

Majority of the elderly people, are less educated and a large number of them, particularly females are single. Further a great majority of these would not be able to work and would be economically dependents. In the absence of family support it is true that the aged people would expect help from the Government. Fortunately, Kerala is far ahead than any other states in India, providing social security or assistance or financial security for the aged persons. An ideal system of social security is meant for helping the people in need. There are more than 40 social security and assistant schemes have been implemented in Kerala. Of these, state Government finance 16; among these 16 state supported schemes seven scheme directly provide pensions to the elderly. In addition to this, there are a number of health insurance schemes were introduced in the state by both Central and State Governments. Again the functioning of the Palliative care is on strengthening in the State, which is a great support to bedridden patients. Further, along with the social and economic security schemes, a long term plan should be introduced, to utilize the rich experience, wide knowledge and capacity of the elderly for the welfare of the society and the nation. To achieve this, if necessary, the Government should provide essential legislature and administrative support.

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