Health Expectancy of the Chinese Elderly: Current Trends*

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Abstract: Using the Chinese Longitudinal Healthy Longevity Survey (CLHLS), we estimate health expectancy of the Chinese elderly based on different health measurements. Our estimations use Sullivan's method combining cohort life tables with (forecasted) prevalence rates. We also calculate the corresponding confidence intervals of life and health expectancy. We find that while the Chinese elderly of both gender groups experienced an improvement in life expectancy during the sample period, health expectancy shows a mixed result at both absolute as well as relative level, depending on health measurements.

Keywords: Health Expectancy; CLHLS; Chinese Elderly;

1. Introduction

It is well known that life expectancy in China has increased substantially and more rapidly than that in the developed countries over the past five decades. For example, in China the life expectancy at birth was only about 35 years at the beginning of the 1950s (Jiang, Zhang, and Zhu, 1984), which was very low because of the prolonged and large-scale wars before the establishment of the People's Republic of China in 1949. However, the life expectancy has been extended to 71 years by 2000 (Banister and Hill, 2004), representing an increase of 8.64 months per year. In the US, the increase is from 68 years in 1949 to 75.40 years in 1990 (Lai, Lee, and Lee, 2000), representing an increase

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of only 2.17 months per year. Not surprisingly, with the extension of longevity, it is more recognized by the public that "increased longevity without quality of life is an empty prize" (WHO, 1997). Due to the mortality reduction at advanced ages, an increasing focus has been concentrated on the life quality of the rapidly growing older and oldest-old population. [1] Nevertheless, whether increases in life expectancy or declines in mortality have been accompanied by a decrease in morbidity and disability is controversial worldwide (Fries, 1980; Freedman, Martin, and Schoeni, 2002). The possibility that the population health deteriorates, even though mortality improves, is not only possible, but also likely under some circumstances. For instance, several studies find that, despite of increased life expectancy in the 1960s and 1970s, mild disability increased in this period in the U.S. (Crimmins, Satio, and Ingegneri, 1997), Canada (Wilkins and Adams, 1983), Japan (Riley, 1990), and Australia (Mathers, 1990). [2] Furthermore, it has been documented that health improvements among the elderly are not universal and that the change patterns are partly attributable to the stage of the epidemiological transition in a given country (Robine and Michel, 2004). The disabilities and impairments suffered by the older population decrease their quality of life, change the household consumption behavior,[3] and affect the national public health policies.[4]

There are several competing theories regarding the past and possible future trends in mortality and morbidity. Fries (1989) argued for a *compression of morbidity*. Under the assumptions of delayed onset of the chronic diseases and a relatively constant life span, this theory states that morbidity will be compressed into a shorter period of time before death, which increases not only the absolute value of the average time spent in an active state, but also its proportion of total life expectancy. On the other hand, *expansion of morbidity* expressed by Olshansky et al. (1991), suggests an increasing

[1] Older and oldest old population is defined as people aged 60 and over and aged 80 and over, respectively. The population of centenarians in Western Europe, Japan, and China has been doubling every decade in recent decades (Vaupel and Jeune, 1995).
[2] It should be mentioned that the disability trends, defined and measured in different ways, are rather complicated.
[3] For example, in China the proportion of household expenditure on health care and medical services to total household expenditure per capita in urban areas increased from 0.75% in 1985 to 7.14% in 2006 (China Urban Living and Price Statistical Yearbook, 2007). The population ageing, along with medical reforms and decreasing fertility, is anecdotally reported to contribute to China's increasing household saving rates.
[4] For example, it is reported by the Wall Street Journal that the population aged 65 and older in the US consumes roughly a third of all of the medical spending (*"In Medicare's Data Trove, Clues to Curing Cost Crisis"*, 25th October, 2010). In China, around a fourth of all of the retirees accounts for 60% of the pooling account of the public medical insurance (*"老龄化吞噬医保基金"* *(ageing engulfs medical fund* in English), the 21st Century Business Herald, 19th August, 2010).

prevalence of morbidity and disability and an extension of life with chronic conditions. According to this theory, therefore, the elderly spend a larger proportion of their lives in poor health. Manton (1982) proposed the *dynamic equilibrium*, which falls somewhere between these two theories. With the hypothesis that mortality and morbidity are correlated and that the same factors improving mortality also reduce the severity and rate of progression of chronic diseases, this theory indicates that the dynamics of both longevity and morbidity depend on how these factors affect the disease incidence and severity as well as the impacts of disease on disability. Given that each theory has its own explaining power, which one is more appropriate in describing the trends in mortality and morbidity finally becomes an empirical issue (Imai and Soneji, 2007).

Since Sanders (1964) proposed the concept of health expectancy,[1] interest in estimating it and in investigating its determinants has been increasingly becoming a new focus among policymakers and members of the academic community. Unlike life expectancy, health expectancy takes into account both mortality and morbidity, measuring the average time that individuals live in varying health statuses. Even though life expectancy still has been widely used as an important indicator of population health, the increasing recognition of the multidimensionality of health has focused attention of governments and academia on health expectancy when assessing the dynamics of population health, since a decline in mortality does not necessarily represent an improvement in other dimensions of health (Crimmins, 2004). For conceptual studies of health expectancy, see Robine, Michel, and Branch (1992).

However, the literature on health expectancy by far is still unsatisfactory and incomplete. First, with few exceptions addressing this topic in developing countries or regions,[2] most prior studies have focused on the developed world.[3] Given that the developing world accounts for the bulk of the world population, identifying the trends in health expectancy in developing countries is therefore important for the world population health. Second, the measures of health status used for estimating the health expectancy often differ across studies. As a result, the evidence demonstrating the trend in one

[1] The terms *health expectancy* and *healthy life expectancy* are often used interchangeably in the literature.
[2] For example, ASEAN countries (Chen and Jones, 1989), Asian countries (Lamb, 1999), and Latin American countries (Ham-Chande, 2003).
[3] For example, the United States (Cai and Lubitz, 2007), the United Kingdom (Breakwell and Bajekal, 2006), the Netherlands (Nusselder and Looman, 2004), Germany (Shkolnikov et al., 2007), France (Cambois, Robine, and Hayward, 2001), Canada (Belanger et al., 2002), Japan (Schoeni et al., 2005), Belgium (Bossuyt et al., 2004), Austria (Doblhammer and Krtir, 2001), and Denmark (Bronnum-Hansen, Davidsen, and Kjoller, 2003).

dimension of health may not accurately reflect the changes in other dimensions of health (Crimmins, 2004), both within and across nations. Moreover, due to the differences in sampling, survey methods, questionnaire wording, and analytic strategies, even studies using data of the same country also get different results (Freedman et al., 2004). Third, most of these studies only report health expectancy for single time points, without examining the differences over time. Few studies take into account the trends into the future. Finally, Sullivan's (1971) method, given its primary methodological importance in the exploration of morbidity, has been extensively used to estimate the health expectancy. Under stationarity assumptions, Imai and Soneji (2007) show that this method combining the period life table with the disability prevalence yields a consistent estimator of health expectancy. In reality, however, stationarity assumptions might not be appropriate. For example, age-specific death rates at all ages have declined exponentially at a constant rate in most developed countries. Therefore, an alternative method estimating health expectancy without the stationarity assumptions might be of interest. Imai and Soneji (2007) demonstrate that, by combining a cohort life table with the disability prevalence (from a longitudinal survey or consecutive cross-sectional surveys), Sullivan's method can be extended to estimate the health expectancy without stationarity assumptions. As a result, we apply their method in this paper.

Using the Chinese Longitudinal Healthy Longevity Survey (CLHLS), the purpose of this paper is to fill in the gap in the existing literature by estimating and extrapolating the trends in health expectancy of the elderly in China. China provides an interesting setting for a number of reasons. Firstly, as the largest country in terms of population with more than 20 percent of the world's inhabitants, China has over 21 percent and 16 percent of the world's older and oldest old population in 2000, respectively (Poston and Zeng, 2008), and is a significant factor in the development of the world population health. To our knowledge, few studies have focused on the oldest-old, particularly in developing countries, due to a lack of data. Secondly, as a transition economy, China is experiencing more unique factors making it complicated to understand the trends in health expectancy. On the one hand, for example, the rapid economic growth and epidemiological transition might result in comparable trends in health improvement in China as in the developed world, since the younger cohorts with better conditions at their early life and healthier lifestyles are replacing the older generations (Zhu and Xie, 2007). On the other hand, however, health care reforms, implemented in the mid 1980s, caused Chinese, especially those living in rural areas, difficulty in accessing their limited health insurance established in the 1960s and 1970s (Lai, 2009). The changing family structure resulting from the family planning policy initiated from the late 1970s also makes it difficult for the younger generation to undertake the traditional duties of family care (Li, 2005). It is documented that the Chinese elders who receive respect from family members are reported to have better rated mental and physical health than those not having a sense of filial piety from their children (Yu et al., 1997). These social and institutional changes might result in negative effects on the Chinese population health. Therefore, estimating health expectancy, especially its future trends, is of high importance for providing the relevant demographic background for appropriate socio-economic policy decisions. Finally, with indications of changing trends in morbidity and mortality[1] and new data available, it is reasonable to estimate the health expectancy in China.

The contributions of this paper are threefold. First of all, using updated data we examine the latest trends in health expectancy based on different measures for the Chinese elderly. Secondly, we use Sullivan's approach, combining the cohort life table derived from the Lee-Carter model rather than the period life table with the disability prevalence, to estimate the healthy expectancy. In this way, we can use Sullivan's method without stationarity and other assumptions. Thirdly, by constructing a bad health index, we attempt to predict the future trends in health status using a logit model in Lee-Carter format, taking into account uncertainties in the health improvement. We hence project the health expectancy by combining the cohort life table with the projected health status trends.

Our paper presents several main findings: first, while the Chinese elderly of both sex groups experienced an improvement in life expectancy for all ages during the sample period, health expectancy shows a mixed result. On the one hand, the Healthy Life Expectancy (HLE), based on self-evaluated health, and regardless of the widely or the narrowly defined healthy status, followed an Increase-Decrease-Increase pattern across age as well as sex groups. On the other, the trends in the Disability-Free Life Expectancy (DFLE) were mixed, depending on health measurements and age as well as sex groups. However, both the HLE and DFLE were better off in 2005 than in 1998. At the relative level, the HLE shows the increasing proportion of lives in poor health over time, whereas the DFLE presents a mixed result again. Second, though females

[1] For example, over the 20th century, mortality rate for the oldest ages have declined. Furthermore, the prevalence of activities of daily living (ADL) disability for the Chinese elderly declines around 1% annually between 1992 and 2002 (Gu and Zeng, 2006).

generally could expect to live longer than males in terms of life as well as health expectancy, it is males who could expect to live a larger of their remaining lifetime in good health.

The remainder of this paper is organized as follows. In the second section, we introduce the data on mortality and health status, health expectancy measurements, and definitions of health/disability. Section three introduces how to construct cohort life tables using the Lee-Carter model as well as Sullivan's method combining cohort life tables with the prevalence of morbidity, and reports estimations results. Finally, section four offers some concluding remarks.

2. Data and Health Measures

In this section we introduce the data on health status and mortality, both of which we need to estimate the health expectancy. Additionally, we describe the definitions of health status used in this paper and the corresponding measurements of health expectancy based on these definitions.

2.1 Mortality Data

Our data include 16 yearly age-specific observations of death and population counts by sex groups from age 0 to 84 inclusive during the period of 1994-2009.[1] Using these death and population counts, we can obtain raw age-specific central mortality rates. Nevertheless, as the mortality data at older ages are missing, we need to use the available data to extrapolate death rates at older ages for accurate estimations of life expectancy as well as health expectancy.

Similar to Zhend and Melenberg (2012), we use the Kannisto model to fit the mortality data from the age of 60 and 65 for males and females, respectively, to the maximum age available in each year and extrapolate the central death rates up to age 120 for each sample year during the period of 1994-2009. Following Roli (2008), we replace the observed death rates for all ages at or above $\bar{x}$, where $\bar{x}$ is the lowest age at which there are fewer death counts than 100 but should satisfy $80 \leq \bar{x} \leq 95$. In this way, we obtain an extended data covering age-specific mortality rates from age 0 to 120 for the period of 1994-2009. With this extended data, we use the Lee-Carter model to project future mortality rates, by which cohort life tables can be constructed. An

[1] These data are obtained from the China Population Statistics Yearbook and China Statistical Yearbook, respectively, which are compiled by the National Bureau of Statistics of China (NBSC).

alternative approach to construct the cohort life table is to firstly project future mortality rates with the Lee-Carter model using the raw unextended data (namely only from age 0 to 84) and hence to extrapolate mortality rates at older ages with these projected results. In Melenberg and Zheng (2012), cohort life tables constructed by both approaches yield similar results.

2.2 Health Data

We draw the data on health status from the first four waves of the Chinese Longitudinal Healthy Longevity Survey (hereafter CLHLS). The CLHLS was conducted in 631 randomly selected counties and cities in 22 of China's 31 provinces, which account for about 85 percent of the total Chinese population. Moreover, the CLHLS was the first large nationally representative and longitudinal survey on health and longevity for extremely old (i.e., 100 years and older) and oldest old population in China (Zeng et al., 2001).[1] The first wave including 8,959 respondents aged 80 years and older was conducted in 1998 as a baseline, with the follow-up surveys conducted in 2000, 2002, and 2005. Since the CLHLS contains detailed information regarding demographic and health characteristics, for example, self-rated health status and Activities of Daily Living (ADLs), this makes it possible to obtain the prevalence data among people at the oldest ages. Table 1 provides the (percentage) sample distribution by sex and age of the CLHLS. In each sample year, respondents aged 80 and over account for, on average, 80 percent of total respondents. This makes it possible for us to better understand the health status of the oldest-old Chinese population. For the detailed description of the sampling design and data quality, see Zeng et al. (2001).

[Insert Table 1 here]

In response to the question on quality of life, several measurements of health expectancy have been reported, including the Disability-Free Life Expectancy (hereafter DFLE), the Healthy Life Expectancy (hereafter HLE), and the (Specific) Diseases-Free Life Expectancy (hereafter SDFLE). For example, 23 OECD member states firstly reported their estimations on health expectancy in 1997; the World Health Organization (WHO) reported the 1999 health expectancy for 191 countries worldwide in 2000.

[1] To our knowledge, three other national surveys on the population aged 60 and older in China were conducted in 1987, 1992, and 2000, respectively, namely, The Aged Population over 60 Years Sampling Survey (1987), The Survey on Old Age Support System (1992), and The Survey on Urban and Rural Elderly in China (2000). But none of these surveys are longitudinal.

The DFLE[1] is an objective measurement and the most commonly used form of health expectancy (Lièvre, Alley, and Crimmins, 2008). Since 1985, the DFLE has been used as one of the indicators measuring the achievement of regional 'Health for All' objectives in Europe. Based on limitations in Activities of Daily Living (hereafter ADLs) or in Instrumental Activities of Daily Living (hereafter IADLs), the DFLE is the average number of years an individual is expected to live free of disability if current patterns of mortality and disability continue to apply. On the other hand, the HLE is more or less a subjective measurement of health expectancy. Based on the subjective self-rated health[2] questions, the HLE is the average number of years that an individual is expected to live in a given health status if current patterns of mortality and health states continue to apply.

Both measures have their advantages and disadvantages. For example, when examining the social-economic status gradient in health, the HLE might not be a good indicator, given that different standards may be used in evaluating health among social classes (Thorslund and Lundberg, 1994). Albeit being a subjective indicator of health, the self-rated health is a good predictor of disability (Ferraro and Su, 2000) and of mortality (Schwarze, Andersen, and Anger, 2000). For example, it is reported that the risk of early and late mortality for individuals with poor self-rated health is 2.92 and 2.77 times that of those with excellent self-rated health, respectively, controlling for objective physical conditons and sociodemographic factors (Mossey and Shapiro, 1982). On the other hand, the HLE is a much better indicator due to the aging population, taking into account both the changes in living with a disability and in mortality that are responsible for the increase in life expectancy. In China, for example, the proportion of disabled increased from 4.9% in 1987 to 6.4% in 2006 with the population ageing (Qiao, 2009). Due to its correlation with the physician- rated health, the self-rated health as a proxy indicator of the objective health status is therefore commonly accepted. Moreover, it might be an appropriate indicator in the context of China. During the rapid transition from the agricultural society to the industrial society and from a planned economy to a market

[1] It is also called healthy life years (HLY) or active life expectancy (ALE) in literature. The differences between them are not clear since many studies do not distinguish between these concepts (Crimmins and Saito, 2001). According to Verbrugge and Jette (1994), this confusion might result from the definitions and usage of terms, for example, handicap, functional limitations, or disability. Nevertheless, since they are usually computed using the prevalence of activities of daily living (ADL) limitations, they are essentially a disability life expectancy corresponding to the life expectancy without ADL limitations.

[2] Self-rated health and other terms are often interchangeably used. For example, self-assessed health, self-rating of health, perceived health, and global health status (Liu and Zhang, 2004).

economy, it is anecdotally reported that the Chinese are more mentally unhealthy, even though they are physically disability free. Therefore, self-rated health might be better for calculating the health expectancy. In this paper, both the HLE and the DFLE are estimated, since showing several health expectancy indicators together can help to clarify the situation in a country and improve understanding of the trends over time.

2.3 Definitions of Health Status

In this paper, we estimate the HLE according to the self-rated health status based on the answer to the following question: "How do you rate your health at present?" The answer to this question is coded on a 1-6 scale, with 1 being "very good", 2 as "good", 3 as "so-so", 4 as "poor", 5 as "very poor", and 6 as "not able to answer"[1]. In order for a consistent comparison with other studies, we define individuals as bad health using a narrow and wide definition, respectively. In the wide definition, bad health consists of self-rated ratings "so-so", "poor", and "very poor", whereas in the narrow one bad health consists only of "poor" and "very poor". Table 2 provides the descriptive information about the prevalence rates of self-rated bad health by sex and age groups. In each sample year, no matter what definition of bad health is used, the prevalence rates across age groups follow somewhat inverted-U patterns, though variations among age groups are minor. Nevertheless, the prevalence rates at each age group increase over time for both gender groups, indicating the self-rated health deterioration across sample years. For example, in terms of the narrow definition of bad health, about 7 percent of males and 9 percent of females self-reported bad health in 1998; in 2005, the same indicator increased to 13.76 percent for males and 16.16 percent for females, respectively. Additionally, table 3 shows that females are more subjectively pessimistic about their health status than males.

[Insert Table 2 here]

We also estimate the DFLE according to the ADLs disability, which is defined as the self-reported limitations in performing any ADLs items, namely bathing, dressing, eating, indoor transferring, toileting, and continence. Furthermore, we categorize the individuals with no ADLs limitations as ADLs active, with one or two limitations as mild disability, and with three or more limitations as severe disability. Table 3 shows the prevalence rates of ADLs limitation among the Chinese elderly by sex in sample years. Though the

[1] The proportion of respondents with "not able to answer" is small. For example, in 1998 only about 3 percent of males chose this answer.

functional limitations in ADLs also increase with advancing age in each year, especially after age 85, Chinese elderly generally experienced an improvement in terms of functional limitations over time. Take the ADLs active as an example: the overall prevalence rates of ADLs active, namely with no ADLs limitations, increased from about 72 percent in 1998 to about 82 percent for males and from about 56 percent in 1998 to about 70 percent in 2005 for females. Moreover, females are generally worse than males regarding the ADLs status at all age groups, no matter what measurements are used.

[Insert Table 3 here]

Table 2 and 3 shows the health differentials resulting from different definitions of health status. This quantitatively confirms our hypothesis that, even though the Chinese elderly may actually experience an improvement in physical health based on ADLs, they are more mentally unhealthy according to the self-rated health status.

3. Estimation of the Health Expectancy

In this section, we use Sullivan's method based on cohort life tables to estimate the health expectancy of the Chinese elderly. Before doing so, we introduce the Lee-Carter model (1992), through which we project the age-specific mortality rates and thus construct cohort life tables.

3.1 Sullivan's Method

Sullivan's Method (1971) combines mortality data with cross sectional health status data to generate estimates of expected years of life in various health states. Given a (period) life table and starting with n people (at a particular age) one can calculate how many people will survive x years, for x=0,1,2,…, from which one can calculate the life expectancy (for the given age). From the cross sectional health status data, one can calculate for each age the fraction of people in a particular health status. Combining this with the survival data, one can calculate for every year how many people will survive in that particular health status. This allows one to calculate the health expectancy (for each age). Details are provided by Imai and Soneji (2007). In our calculations, we shall follow closely EHEMU's (2007) technical guide.

Sullivan's Method has been one of the most widely used methods for estimating health expectancy over the past four decades. It has been proved to be a useful instrument, especially when longitudinal data on transition between functional statuses and differences in mortality among people with different functional statuses are unavailable (Zeng, Gu, and Land, 2004). Moreover, under stationarity assumptions of the period life table[1] and the age-specific disability prevalence, Imai and Soneji (2007) prove that Sullivan's estimator of health expectancy is "unbiased and consistent". For a review on the quality of Sullivan's method, see Mathers and Robine (1997).

In reality, however, the stationarity assumptions might not be appropriate. Take the age-specific death rates as an example: neither are they constant over time, nor do they change in the same direction and in the same magnitudes across cohorts. Figure 2 presents the mortality rates of selected age groups for several time periods, normalized to one for the year 1981. Obviously, figure 2 shows the non-stationary dynamics of the age-specific death rates.

[Insert Figure 1 here]

An alternative method for estimating health expectancy without stationarity assumptions is the multi-state method, a life table method based on a division of the population by age and sex into any a number of health states and taking into account transition rates between these health states. For example, Majer (2011) applies a multi-state life table model to the Dutch population aged 55 and older and estimates health expectancies between 1989 and 2030. Not only does he show the life expectancy and the proportion of the original birth cohorts still alive at different ages, but also the remaining life expectancy and proportion of people alive in a given state. Therefore, the multi-state life table, providing valuable information about transitions among different states, allows researchers to conduct a richer analysis of mortality and morbidity than Sullivan's method. However, this method also requires a number of assumptions about transition probabilities and the functional form of the hazard functions, none of which is necessary for Sullivan's method. Furthermore, the multi-state method requires a large-scale longitudinal data, which usually is unavailable, especially in developing countries.

In this paper we follow Imai and Soneji (2007) to estimate the health expectancy of the Chinese elderly by Sullivan's method based on cohort life tables, which has several advantages over the methods mentioned above. On the one hand, with cohort life tables available, Sullivan's method can be extended to estimate the health expectancy without stationarity assumptions. On the other hand, even if the consecutive cross-sectional health surveys are used, this method can be applied to get an unbiased estimation of the health expectancy. This is particularly an attractive advantage, because the cross-

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[1] A period life table relies on the following stationarity assumptions of the population: 1) the age-specific hazard rate is constant over time; 2) the birth rate is constant over time; 3) the net migration rates are 0 at all ages (Preston, Heuveline, and Guillot, 2001).

sectional surveys are usually easier to obtain than longitudinal data. For a detailed description of Sullivan's method based on a cohort life table, see Imai and Soneji (2007).

3.2 Cohort Life Table and the Lee-Carter Model

In order to use Sullivan's method based on cohort life tables, we need to construct cohort life tables, which describe the mortality experience of a real cohort of individuals from birth of the first to the death of the last member of this group. In this paper, we use the Lee-Carter model (1992) to fulfill this projection, because it has become the "leading statistical model of mortality in the demographic literature" (Deaton and Paxson, 2004) and, along with its extensions, has been widely applied for many countries for its simplicity and robustness in the context of linear trends in age-specific death rates.

According to Lee and Carter (1992), $\ln(m_{x,t})$, the log central death rate of the x-year-old persons in year t, is determined by a common latent factor κ_t, with an age-specific level parameter, α_x, and an age-specific sensitivity parameter, β_x.

Mathematically, the model can be expressed as follows:

$$\ln(m_{x,t}) = \alpha_x + \beta_x \kappa_t + \varepsilon_{x,t}, \ \sum_x \beta_x = 1 \text{ and} \sum_\kappa \kappa_t = 0 \quad (5)$$

where the white noise error terms, $\varepsilon_{x,t}$, represent the transitory non-systematic shocks.

Here κ_t is assumed to be an ARIMA process. Lee and Carter (1992) originally find that, for the mortality data of the US, κ_t satisfies a random walk with drift process as:

$$\kappa_t = \kappa_{t-1} + c + \xi_t, \quad (6)$$

where the white noise terms, ξ_t, representing permanent shocks, are assumed to be independent of $\varepsilon_{x,t}$ and to follow a (normal) distribution with mean zero and variance of σ_ζ^2.

With standard statistical or econometric time-series techniques, the parameters in (5) and (6) can be estimated. However, the resulting ARIMA process of κ_t for other countries rather than the USA might be different from a random walk with drift. Thus, standard statistical procedures should be applied to find an appropriate ARIMA model for the time series of κ_t (Liu, 2008).

The systematic path of the central mortality rate of the x-year-old persons in year t satisfies:

$$m_{x,t} = \exp(\alpha_x + \beta_x \kappa_t), \qquad (7)$$

In order for the projection of future mortality, we firstly need to forecast the future values of $\tilde{\kappa}_{T+\tau}$ (T is the final year of the sample) and then the systematic path of future central mortality rate by

$$m_{x,t+T} = \exp(\alpha_x + \beta_x \tilde{\kappa}_{T+\tau}), \qquad (8)$$

Melenberg and Zheng (2012) estimate the Lee-Carter model using the same mortality data and find that the κ_t processes for both Chinese males and females follow a random walk. They also project the future age-specific mortality rates. We directly use their projection results to construct the cohort life table.

3.3 Estimation Results

In this section we follow EHEMU's (2007) technical guide to calculate the health expectancy and present estimation results. While age-specific mortality rates in the period life table are assumed to be time-independent, they are time-dependent in the cohort life table. Therefore, in addition to observed age-specific mortality rates, projected ones are also needed to construct the cohort life table. As far as the prevalence rates of morbidity are concerned, in this section we assume that they are time-independent. Therefore, we can obtain the period prevalence rates of morbidity directly from each sample year. For example, in order to estimate the health expectancy in 1998, we only need age-specific prevalence rates of morbidity from the 1998 CLHLS data. In the next section, we relax this assumption and allow for dynamic health improvements, namely prevalence rates of morbidity, like mortality rates, are also time-dependent. In order to take into account estimation uncertainties of life as well as health expectancy, we report a 95 percent confidence interval for each estimate using the bootstrap. Koissi, Shapiro, and Högnäs (2006) apply the bootstrap technique to the Lee-Carter model to construct confidence intervals for projected life expectancies. By doing so, their confidence intervals take into account uncertainties resulting from the variability from all parameters in the model. For the purpose of comparison, we also calculate the health expectancy using Sullivan's method based on period life tables and report results in appendix 1.

[Insert Table 4a and 4b]

Table 4a and 4b show the healthy life expectancy and disability free life expectancy based on Sullivan's method combining cohort life tables with period health data, for the four years for which health data is available (1998, 200, 2002, and 2005). First, both Chinese males and females experienced a strictly positive trend in life expectancy for all age groups during the sample period. For example, the cohort life expectancy of an 80-year old Chinese elderly increased from 6.89 years in 1998 to 8.48 years in 2005 for males, and from 8.46 years in 1998 to 9.66 years in 2005 for females, respectively. Second, health expectancies, regardless of health measurements, were better off in 2005 than in 1998 across age and sex groups. For example, an 80-year old male was expected to live 0.08 years more in 2005 than in 1998 based on the widely defined HLE, and 1.34 years more in 2005 than in 1998 based on the DFLE with ADLs active, which represent a 2 and 24 percent increase, respectively. Nevertheless, during the sample period the trends in health expectancy did not follow consistently increasing patterns but show substantial volatilities. For the HLE, regardless of the widely or narrowly defined healthy status, almost all age groups across sex followed an Increase-Decrease-Increase pattern. On the contrary, the DFLE showed mixed patterns, depending on health measurements and sex as well as age groups. For example, while males experienced a consistently positive trend in both the DFLE2 (without mild disability) and DFLE3 (without severe disability), females faced the same pattern only in the DFLE3 but an Increase-Decrease-Increase one in the DFLE1 (no disability) and DFLE2. Given that ADLs limitations and self-reported health are usually correlated (for example, no ADLs limitations resulting in good self-reported health), a decrease in the DFLE may cause the decline of HLE, like the case of Chinese females. As a result, the disparities in health expectancy trends across the HLE and DFLE for males might arise from their more pessimistic assessments of health status. Nevertheless, it seems that Chinese elderly are generally pessimistic towards their health status. For example, the objective health expectancies under the most rigorous definition (for example, with no ADLs limitation) are larger than their subjective counterparts that are also rigorously defined (for example, the "so-so" is included into the definition of bad health) for most age groups. Third, there exist sex differentials in the life as well as health expectancy. In our sample years, Chinese females performed better in both life expectancy and health expectancy than their sex counterparts for most age groups, which is in line with prior studies. Finally, without taking into account the future mortality improvement, the life expectancy in the period life table (see appendix 1) for all selected ages are consistently underestimated compared with those reported in table 4a and 4b.

[Insert Figure 2 and 3 here]

As both the life expectancy and health expectancy of the Chinese elderly experienced an absolute improvement from 1998 to 2005, we now use the health ratio, the ratio of health expectancy to life expectancy, to measure the relative trends in health status. Figure 2 and 3 demonstrate the trends in health ratio for the HLE and the DFLE, respectively. In each sample year, figure 2 shows that ratios of HLE to life expectancy are relatively stable or do even increase with advancing ages, whereas figure 3 shows the proportion of life lived in a healthy state, which, regardless of health definitions, decreases with advancing ages. In order to find out which theory regarding the past and possible future trends in mortality and morbidity is appropriate for Chinese elderly, we now turn to the trends in the health ratio over time. In terms of the HLE, health ratios in 2005 were generally smaller than those in 1998, indicating the deterioration in the relative health expectancy. With a larger proportion of lives in poor health, the health expectancy measured by the HLE can be explained by *expansion of morbidity*. However, figure 3 presents mixed results, depending on health measurements. Finally, sex differentials still exist in the health ratio. Though females live longer than males in terms of life expectancy and health expectancy, both figures show that males could expect to live a larger of their remaining lifetime in good health.

4. Conclusions

In this paper, we use the Chinese Longitudinal Healthy Longevity Survey (CLHLS) to estimate the health expectancy for the Chinese elderly. Unlike the previous studies ignoring the stationarity assumptions, we use Sullivan's method combining cohort life tables rather than period life tables with the prevalence rates of morbidity, taking into account the non-stationary data.

We find that the Chinese elderly of both sex groups experienced an improvement in life expectancy for all age groups during the sample period. While health expectancies, regardless of health measurements, were better off in 2005 than in 1998 across sex and age groups, during the sample period the trends in health expectancy show substantial volatilities, without following consistently increasing patterns. There exist sex differentials in life as well as health expectancy, with females showing a better "performance". In terms of the health ratio, however, the Chinese elderly experienced a declining trend over time, indicating the deterioration of older population health. On the contrary, the health ratio of DFLE shows a mixed picture.

The mixed estimation results of DFLE in both in-sample as well as out-sample years to some extent reflect uncertainties of health developments. Moreover, the disparities between the HLE and the DFLE should be highlighted to policy makers and the academic community. With the economic transition and family policy, the family size and family structure in China has dramatically changed over the past three decades. Traditionally, it is the family members that undertake the role of taking care of the elderly, but the family role is declining, with more Chinese elderly living alone. This might affect the attitudes of the Chinese elderly towards their health status, though their functional limitations have improved greatly.

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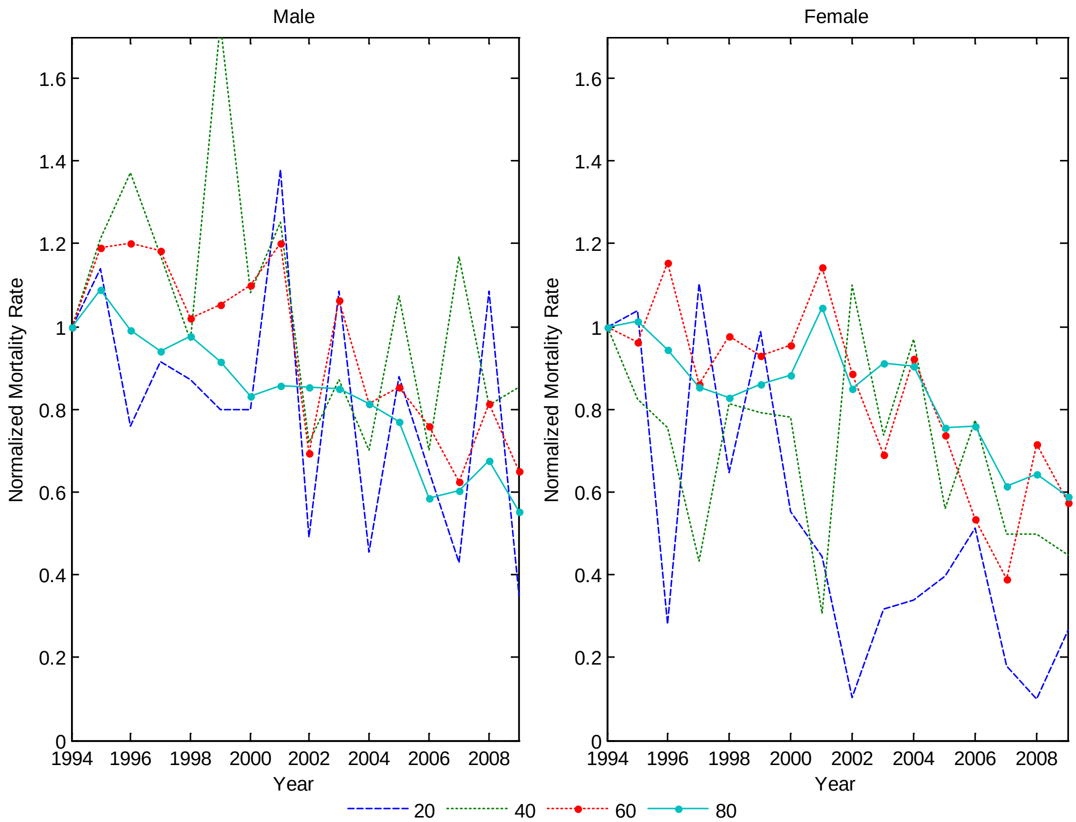
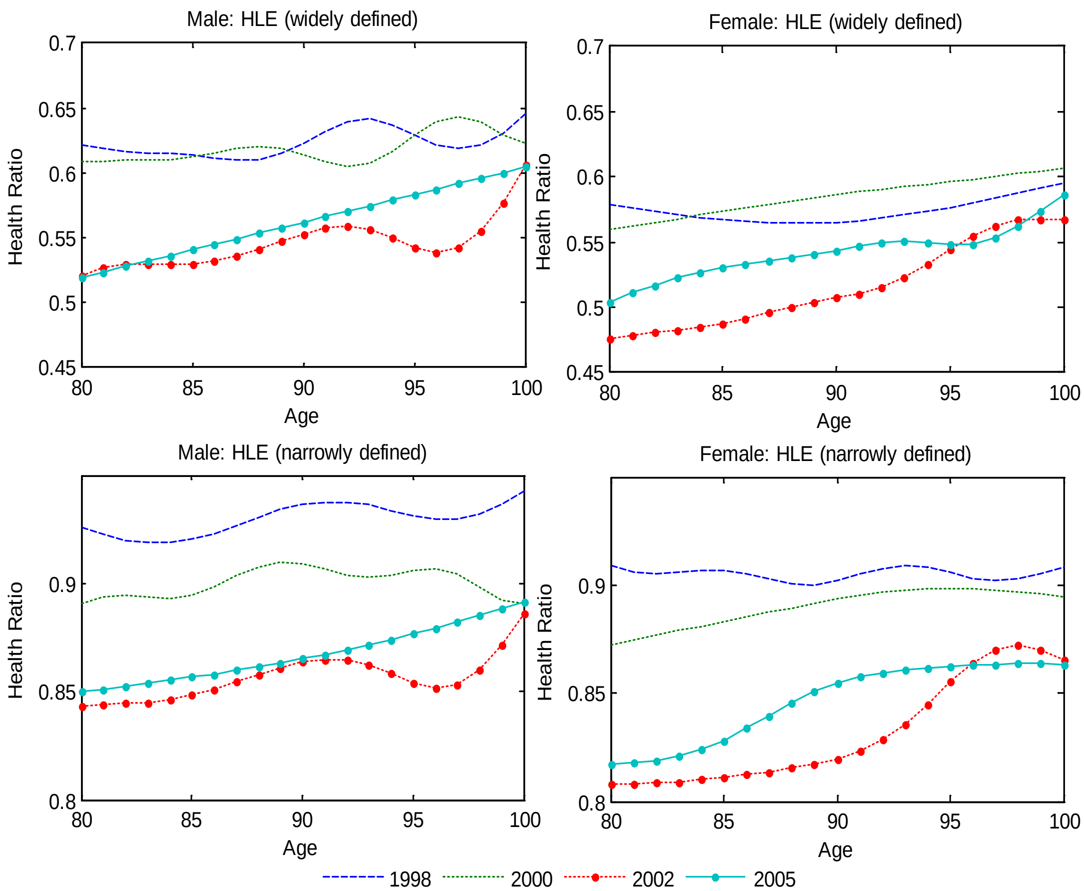
Figure 1: Normalized Mortality Rates for Selected Age Groups



This figure plots the observed mortality rates of Chinese males (left) and females (right) for selected age groups during the period of 1994-2009, normalized to one for year 1994. The data originates from the China Population Statistical Yearbook and the China Statistical Yearbook compiled by the National Bureau of Statistics of China (NBSC).

Figure 2: The Ratio of Healthy Life Expectancy to Life Expectancy

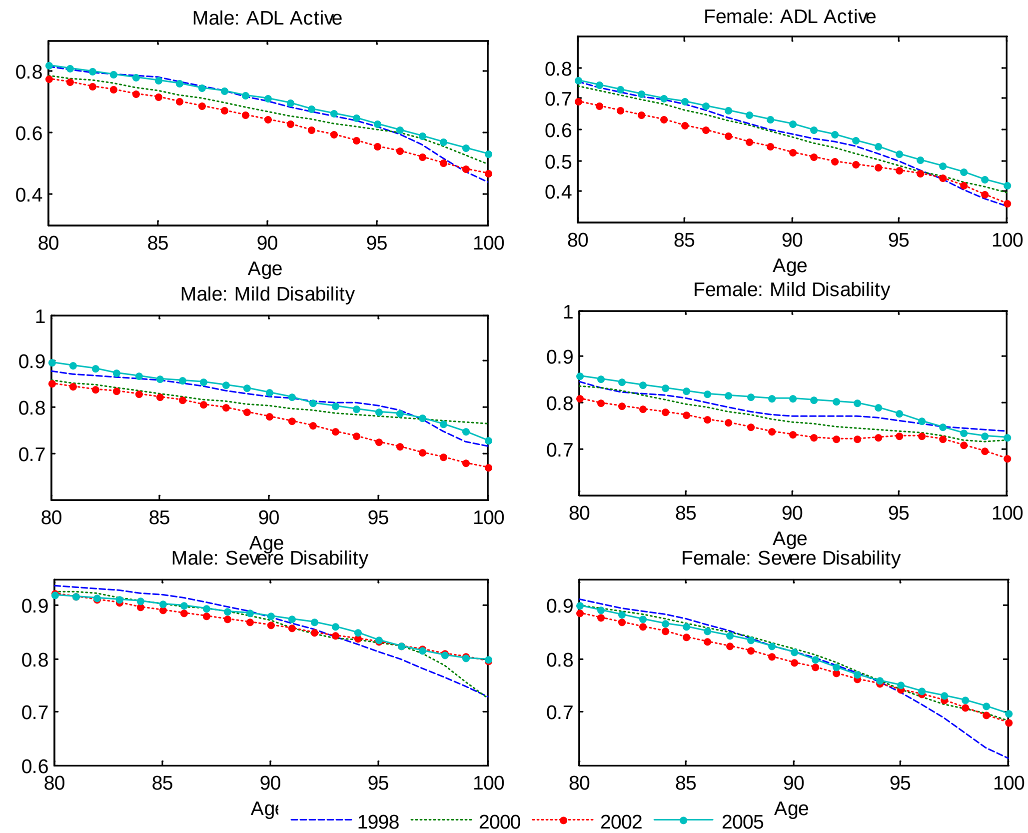
(1998-2005)



This figure plots the ratio of healthy life expectancy (HLE) to life expectancy across age and sex groups for the year 1998, 2000, 2002, and 2005. The healthy life expectancy is calculated through Sullivan's method combining the cohort life table with the period prevalence of morbidity. The life expectancy is calculated with the cohort life table. In the upper panel, bad health consists of the self-reported ratings "so-so", "bad', and "very bad". In the lower panel, bad health consists of the self-reported ratings "bad" and "very bad". These ratios are smoothed using cubic p-splines.

Figure 3: The Ratio of Disability Free Life Expectancy to Life Expectancy

(1998-2005)



This figure plots the ratio of disability free life expectancy (DFLE) to life expectancy across age and sex groups for the year 1998, 2000, 2002, and 2005. The disability free life expectancy is calculated through Sullivan's method combining the cohort life table with the period prevalence of morbidity. The life expectancy is calculated with the cohort life table. In the upper panel, ADL active is defined as having no ADL limitations; in the middle panel, mild disability is defined as having one or two ADL limitations; in the lower panel, severe disability is defined as having three or more ADL limitations. These ratios are smoothed using cubic p-splines.

Table 1: Sample Distribution by Sex and Age, 1998-2005

Panel A: Males

	Number of Observations				Percentage of Observations			
Age	1998	2000	2002	2005	1998	2000	2002	2005
60-64	0	0	19	9	0.00%	0.00%	0.28%	0.13%
65-69	0	0	817	841	0.00%	0.00%	11.94%	12.57%
70-74	0	0	841	838	0.00%	0.00%	12.29%	12.53%
75-79	72	21	780	828	1.98%	0.45%	11.40%	12.38%
80-84	992	1391	1098	674	27.26%	29.91%	16.04%	10.08%
85-89	795	1076	1030	1258	21.85%	23.13%	15.05%	18.81%
90-94	759	1126	1040	1098	20.86%	24.21%	15.19%	16.42%
95-99	540	519	544	561	14.84%	11.16%	7.95%	8.39%
100-104	443	463	609	513	12.17%	9.95%	8.90%	7.67%
105-109	34	49	61	68	0.93%	1.05%	0.89%	1.02%
110-114	3	5	5	0	0.08%	0.11%	0.07%	0.00%
115+	1	1	1	0	0.03%	0.02%	0.01%	0.00%
Total	3639	4651	6845	6688	100.00%	100.00%	100.00%	100.00%

Panel B: Females

	Number of Observations				Percentage of Observations			
Age	1998	2000	2002	2005	1998	2000	2002	2005
60-64	0	0	25	16	0.00%	0.00%	0.27%	0.18%
65-69	0	0	791	831	0.00%	0.00%	8.58%	9.28%
70-74	0	0	830	804	0.00%	0.00%	9.00%	8.98%
75-79	62	17	786	813	1.14%	0.26%	8.53%	9.08%
80-84	947	1274	1013	672	17.36%	19.46%	10.99%	7.51%
85-89	794	1177	1098	1305	14.56%	17.97%	11.91%	14.58%
90-94	868	1293	1286	1351	15.91%	19.75%	13.95%	15.09%
95-99	846	874	877	942	15.51%	13.35%	9.51%	10.53%
100-104	1749	1671	2215	1849	32.07%	25.52%	24.03%	20.66%
105-109	171	210	257	334	3.14%	3.21%	2.79%	3.73%
110-114	16	29	37	29	0.29%	0.44%	0.40%	0.32%
115+	1	3	4	4	0.02%	0.05%	0.04%	0.04%
Total	5454	6548	9219	8950	100.00%	100.00%	100.00%	100.00%

This table provides the sample distribution of the CLHLS by sex and age group in the years 1998, 2000, 2002, and 2005, respectively.

Table 2: Prevalence Rates of Self-rated Bad Health by Sex

Panel A: Wide Definition

	Males				Females			
Age	1998	2000	2002	2005	1998	2000	2002	2005
60-64	--	--	52.63%	77.78%	--	--	48.00%	43.75%
65-69	--	--	45.41%	42.09%	--	--	51.33%	46.93%
70-74	--	--	46.37%	45.58%	--	--	53.61%	50.75%
75-79	37.50%	38.10%	50.13%	50.24%	37.10%	58.82%	52.67%	52.77%
80-84	37.10%	39.83%	48.54%	51.19%	40.65%	44.27%	53.60%	52.98%
85-89	39.50%	38.48%	49.51%	47.62%	42.82%	44.60%	53.19%	47.82%
90-94	37.81%	39.52%	43.27%	44.17%	42.63%	41.61%	50.54%	45.74%
95-99	37.22%	35.84%	45.40%	42.07%	43.62%	40.27%	45.27%	45.75%
100+	34.93%	37.45%	38.46%	37.87%	40.11%	37.85%	43.22%	41.70%
Total:	37.51%	38.72%	46.19%	45.51%	41.51%	41.43%	49.21%	46.78%

Panel B: Narrow Definition

	Males				Females			
Age	1998	2000	2002	2005	1998	2000	2002	2005
60-64	--	--	10.53%	44.44%	--	--	20.00%	18.75%
65-69	--	--	11.51%	11.65%	--	--	15.30%	14.68%
70-74	--	--	11.77%	13.72%	--	--	14.82%	18.03%
75-79	8.33%	9.52%	15.77%	15.22%	8.06%	29.41%	18.07%	19.43%
80-84	7.16%	11.29%	17.30%	16.47%	8.76%	13.81%	19.45%	20.54%
85-89	8.55%	11.15%	15.53%	14.31%	8.69%	12.40%	19.95%	19.31%
90-94	6.06%	9.24%	12.40%	13.57%	10.02%	10.60%	19.28%	13.99%
95-99	7.04%	9.25%	14.34%	13.19%	10.05%	9.95%	14.14%	13.91%
100+	6.03%	9.85%	11.69%	10.84%	9.12%	10.40%	14.09%	13.90%
Total	7.09%	10.36%	13.94%	13.76%	9.26%	11.45%	16.63%	16.16%

This table presents the prevalence rates of self-rated bad health by sex for the years 1998, 2000, 2002, and 2005. In panel A, bad health consists of the self-reported ratings “so-so”, “bad’, and “very bad”. In panel B, bad health consists of the self-reported ratings “bad” and “very bad”.

Table 3: Prevalence Rates of ADL Limitations by Sex

Panel A: ADL Active

	Males				Females			
Age	1998	2000	2002	2005	1998	2000	2002	2005
60-64	--	--	94.74%	72.73%	--	--	100.00%	87.50%
65-69	--	--	96.08%	96.91%	--	--	96.08%	97.59%
70-74	--	--	95.12%	94.99%	--	--	92.41%	95.52%
75-79	84.72%	80.95%	89.23%	92.27%	74.19%	70.59%	89.06%	91.88%
80-84	84.48%	84.04%	82.42%	87.83%	83.00%	82.10%	78.28%	84.67%
85-89	82.26%	76.58%	76.12%	80.76%	75.19%	72.64%	67.40%	74.79%
90-94	71.54%	67.94%	66.83%	74.77%	60.71%	60.56%	54.98%	66.47%
95-99	60.74%	62.81%	57.54%	64.17%	48.58%	48.74%	48.23%	52.97%
100+	44.79%	47.53%	44.44%	50.33%	36.03%	40.14%	36.05%	42.28%
Total	72.39%	71.89%	77.38%	81.53%	56.22%	59.44%	63.16%	69.59%

Panel B: Mild Disability

	Males				Females			
Age	1998	2000	2002	2005	1998	2000	2002	2005
60-64	--	--	5.26%	0.00%	--	--	0.00%	12.50%
65-69	--	--	2.69%	2.38%	--	--	3.16%	1.81%
70-74	--	--	3.57%	2.74%	--	--	6.14%	3.48%
75-79	11.11%	19.05%	8.33%	3.99%	22.58%	11.76%	8.65%	5.54%
80-84	10.58%	11.72%	12.02%	6.38%	12.46%	11.93%	15.10%	10.12%
85-89	12.70%	15.33%	15.44%	11.53%	16.37%	17.59%	20.13%	15.48%
90-94	17.26%	20.16%	20.67%	14.66%	23.04%	24.44%	26.44%	17.47%
95-99	20.37%	20.42%	26.29%	20.32%	23.88%	26.32%	27.25%	22.82%
100+	27.08%	23.57%	32.59%	24.92%	25.97%	26.35%	30.90%	26.34%
Total	16.04%	16.92%	14.42%	10.29%	21.39%	21.54%	20.31%	15.54%

Panel C: Severe Disability

	Males				Females			
Age	1998	2000	2002	2005	1998	2000	2002	2005
60-64	--	--	0.00%	9.09%	--	--	0.00%	0.00%
65-69	--	--	1.22%	0.71%	--	--	0.76%	0.60%
70-74	--	--	1.31%	2.27%	--	--	1.45%	1.00%
75-79	4.17%	0.00%	2.44%	3.74%	3.23%	17.65%	2.29%	2.58%
80-84	4.94%	4.24%	5.56%	5.79%	4.54%	5.97%	6.61%	5.21%
85-89	5.03%	8.09%	8.45%	7.71%	8.44%	9.77%	12.48%	9.73%
90-94	11.20%	11.90%	12.50%	10.56%	16.24%	15.00%	18.58%	16.06%
95-99	18.89%	16.76%	16.18%	15.51%	27.54%	24.94%	24.52%	24.20%
100+	28.13%	27.19%	22.96%	19.38%	38.00%	33.51%	33.05%	31.38%
Total	11.35%	10.94%	8.20%	7.66%	22.38%	19.02%	16.52%	14.87%

This table presents the prevalence rates of ADLs limitations by sex for the years 1998, 2000, 2002, and 2005. In panel A, ADLs active is defined as having no ADL limitations; In panel B, mild disability defined as having one or two ADL limitations; In panel C, severe disability is defined as having three or more ADL limitations.

Table 4a: Trends in Healthy Life Expectancy based on Sullivan's Method, 1998-2005

Panel A: Male

	1998			2000			2002			2005		
Age	LE	HLE1	HLE2	LE	HLE1	HLE2	LE	HLE1	HLE2	LE	HLE1	HLE2
80	6.89	4.30	6.39	7.28	4.44	6.50	7.70	4.00	6.50	8.48	4.38	7.19
	(6.63-7.05)	(4.13-4.40)	(6.16-6.54)	(6.83-7.56)	(4.19-4.62)	(6.09-6.77)	(7.01-8.15)	(3.62-4.24)	(5.95-6.89)	(7.38-9.29)	(3.76-4.84)	(6.22-7.89)
85	4.82	2.94	4.44	5.14	3.17	4.60	5.45	2.89	4.67	6.13	3.32	5.27
	(4.75-4.88)	(2.90-2.98)	(4.37-4.48)	(4.97-5.25)	(3.06-3.24)	(4.44-4.70)	(5.12-5.68)	(2.71-3.02)	(4.37-4.86)	(5.42-6.61)	(2.91-3.61)	(4.65-5.70)
90	3.34	2.07	3.13	3.64	2.25	3.31	3.77	2.15	3.30	4.33	2.46	3.75
	(3.33-3.35)	(2.06-2.08)	(3.11-3.14)	(3.59-3.67)	(2.21-2.27)	(3.27-3.35)	(3.63-3.85)	(2.07-2.20)	(3.19-3.37)	(3.91-4.62)	(2.21-2.63)	(3.38-4.00)
95	2.31	1.48	2.15	2.58	1.65	2.35	2.55	1.43	2.19	3.18	1.86	2.77
	(2.31-2.31)	(1.48-1.48)	(2.15-2.15)	(2.57-2.59)	(1.65-1.65)	(2.34-2.35)	(2.51-2.57)	(1.41-1.44)	(2.16-2.21)	(2.95-3.33)	(1.71-1.96)	(2.57-2.89)

Panel B: Female

	1998			2000			2002			2005		
Age	LE	HLE1	HLE2	LE	HLE1	HLE2	LE	HLE1	HLE2	LE	HLE1	HLE2
80	8.46	4.93	7.70	8.74	4.94	7.64	8.94	4.26	7.24	9.66	4.88	7.90
	(8.12-8.73)	(4.75-5.09)	(7.39-7.94)	(8.21-9.17)	(4.65-5.19)	(7.16-8.02)	(8.21-9.54)	(3.89-4.58)	(6.66-7.74)	(8.56-10.58)	(4.28-5.45)	(6.97-8.69)
85	6.04	3.44	5.48	6.23	3.54	5.51	6.56	3.20	5.31	6.99	3.73	5.84
	(5.90-6.14)	(3.36-3.50)	(5.38-5.57)	(5.98-6.41)	(3.40-3.66)	(5.29-5.68)	(6.18-6.89)	(2.97-3.39)	(4.98-5.59)	(6.17-7.64)	(3.30-4.08)	(5.18-6.36)
90	4.26	2.39	3.82	4.40	2.61	3.95	4.54	2.32	3.73	4.94	2.69	4.26
	(4.22-4.28)	(2.37-2.41)	(3.79-3.84)	(4.31-4.47)	(2.56-2.65)	(3.87-4.00)	(4.37-4.69)	(2.23-2.41)	(3.58-3.85)	(4.50-5.32)	(2.44-2.90)	(3.86-4.61)
95	2.96	1.63	2.67	3.04	1.85	2.75	3.13	1.71	2.67	3.60	1.98	3.10
	(2.95-2.96)	(1.62-1.63)	(2.67-2.68)	(3.02-3.06)	(1.84-1.87)	(2.73-2.76)	(3.08-3.18)	(1.68-1.73)	(2.63-2.71)	(3.35-3.80)	(1.83-2.09)	(2.89-3.28)

Note: LE-life expectancy; HLE1- widely defined healthy life expectancy; HLE2-narrowly defined healthy life expectancy; 95% confidence intervals are reported in the parentheses.

This table presents the life expectancy and healthy life expectancy (HLE) for selected ages by sex groups during the sample period of 1998-2005. The life expectancy is calculated with the cohort life table, whereas the healthy life expectancy through Sullivan's method combining the cohort life table with the period prevalence of morbidity. In the widely defined healthy life expectancy (HLE1), bad health consists of the self-reported ratings "so-so", "bad', and "very bad". In the narrowly defined healthy life expectancy (HLE2), bad health consists of the self-reported ratings "bad" and "very bad".

Table 4b: Trends in Disability-Free Life Expectancy based on Sullivan's Method, 1998-2005

Panel A: Male

	1998			2000			2002			2005		
Age	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3
80	5.61	6.05	6.45	5.72	6.24	6.77	5.95	6.56	7.10	6.95	7.61	7.83
	(5.46-5.70)	(5.86-6.18)	(6.28-6.57)	(5.43-5.88)	(5.90-6.47)	(6.41-7.01)	(5.57-6.21)	(6.05-6.91)	(6.54-7.51)	(6.05-7.52)	(6.64-8.28)	(6.89-8.51)
85	3.79	4.15	4.47	3.77	4.28	4.64	3.92	4.47	4.89	4.71	5.29	5.54
	(3.75-3.82)	(4.10-4.19)	(4.41-4.51)	(3.68-3.83)	(4.15-4.36)	(4.51-4.72)	(3.75-4.04)	(4.24-4.63)	(4.59-5.09)	(4.20-5.03)	(4.62-5.71)	(4.82-5.94)
90	2.34	2.77	2.92	2.45	2.91	3.18	2.44	2.94	3.26	3.10	3.63	3.81
	(2.34-2.35)	(2.76-2.77)	(2.91-2.93)	(2.42-2.46)	(2.87-2.93)	(3.14-3.20)	(2.38-2.48)	(2.84-3.01)	(3.14-3.33)	(2.82-3.27)	(3.30-3.85)	(3.43-4.02)
95	1.44	1.89	1.87	1.61	2.06	2.13	1.44	1.87	2.12	2.00	2.50	2.67
	(1.44-1.45)	(1.88-1.89)	(1.87-1.87)	(1.61-1.62)	(2.05-2.06)	(2.13-2.14)	(1.43-1.45)	(1.84-1.89)	(2.09-2.14)	(1.88-2.07)	(2.34-2.61)	(2.50-2.78)

Panel B: Female

	1998			2000			2002			2005		
Age	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3
80	6.38	7.14	7.71	6.43	7.30	7.88	6.20	7.24	7.93	7.35	8.31	8.70
	(6.22-6.51)	(6.87-7.35)	(7.47-7.90)	(6.16-6.64)	(6.92-7.62)	(7.47-8.18)	(5.83-6.51)	(6.70-7.66)	(7.43-8.38)	(6.67-7.92)	(7.32-9.07)	(7.79-9.43)
85	4.14	4.90	5.28	4.14	4.96	5.41	4.03	5.06	5.53	4.84	5.81	6.05
	(4.09-4.18)	(4.80-4.98)	(5.20-5.34)	(4.03-4.22)	(4.79-5.10)	(5.24-5.55)	(3.83-4.18)	(4.76-5.29)	(5.23-5.77)	(4.37-5.19)	(5.23-6.32)	(5.50-6.52)
90	2.46	3.26	3.45	2.54	3.32	3.61	2.43	3.34	3.63	3.08	4.00	4.03
	(2.45-2.47)	(3.24-3.28)	(3.43-3.47)	(2.50-2.56)	(3.26-3.38)	(3.56-3.66)	(2.36-2.48)	(3.21-3.45)	(3.52-3.72)	(2.85-3.27)	(3.66-4.29)	(3.71-4.30)
95	1.48	2.26	2.17	1.50	2.28	2.26	1.45	2.25	2.33	1.87	2.78	2.69
	(1.47-1.48)	(2.26-2.27)	(2.17-2.17)	(1.49-1.50)	(2.27-2.29)	(2.25-2.27)	(1.43-1.47)	(2.21-2.29)	(2.29-2.36)	(1.76-1.94)	(2.60-2.93)	(2.54-2.84)

Note: DFLE1-life expectancy with no ADL limitations; DFLE2-life expectancy with mild disability; DFLE3-life expectancy with severe disability. 95% confidence intervals are reported in the parentheses.

This table presents the disability-free life expectancy (DFLE) for selected ages by sex groups during the sample period of 1998-2005. The disability free life expectancy is calculated through Sullivan's method combining the cohort life table with the period prevalence of morbidity. The prevalence of disability is calculated based on the activities of daily living (ADL) limitations. ADL active is defined as having no ADL limitations, mild disability as having one or two ADL limitations, and severe disability as having three or more ADL limitations.

Appendix 1a: Trends in Healthy Life Expectancy based on Sullivan's Method, 1998-2005

Panel A: Male

	1998			2000			2002			2005		
Age	LE	HLE1	HLE2	LE	HLE1	HLE2	LE	HLE1	HLE2	LE	HLE1	HLE2
80	5.86	3.66	5.43	6.88	4.19	6.13	6.56	3.38	5.52	7.09	3.61	6.00
85	4.19	2.55	3.85	5.19	3.20	4.65	4.82	2.54	4.13	5.25	2.82	4.51
90	2.96	1.83	2.76	3.87	2.39	3.52	3.48	1.99	3.05	3.89	2.20	3.36
95	2.08	1.34	1.93	2.87	1.83	2.61	2.50	1.39	2.15	2.85	1.66	2.48

Panel B: Female

	1998			2000			2002			2005		
Age	LE	HLE1	HLE2	LE	HLE1	HLE2	LE	HLE1	HLE2	LE	HLE1	HLE2
80	8.03	4.69	7.31	7.68	4.31	6.69	7.74	3.65	6.24	8.44	4.21	6.86
85	5.92	3.37	5.38	5.63	3.19	4.97	5.62	2.71	4.53	6.25	3.31	5.18
90	4.28	2.40	3.84	4.04	2.40	3.63	3.98	2.02	3.25	4.51	2.45	3.88
95	3.05	1.68	2.75	2.87	1.75	2.59	2.79	1.52	2.37	3.43	1.88	2.94

Note: LE-life expectancy; HLE1- widely defined healthy expectancy; HLE2-narrowly defined healthy life expectancy;

This table presents the life expectancy and healthy life expectancy (HLE) for selected ages by sex groups during the sample period of 1998-2005. The life expectancy is calculated with the period life table, whereas the healthy life expectancy through Sullivan's method combining the period life table with the period prevalence of morbidity. In the widely defined healthy life expectancy (HLE1), bad health consists of the self-reported ratings "so-so", "bad', and "very bad". In the narrowly defined healthy life expectancy (HLE2), bad health consists of the self-reported ratings "bad" and "very bad".

Appendix 1b: Trends in Disability-Free Life Expectancy based on Sullivan's Method, 1998-2005

Panel A: Male

	1998			2000			2002			2005		
Age	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3
80	4.88	5.20	5.55	5.47	5.93	6.43	5.20	5.65	6.11	5.93	6.44	6.58
85	3.37	3.64	3.93	3.83	4.33	4.69	3.54	3.99	4.36	4.10	4.57	4.77
90	2.11	2.46	2.60	2.60	3.09	3.37	2.29	2.75	3.03	2.82	3.27	3.43
95	1.32	1.71	1.69	1.78	2.28	2.36	1.43	1.84	2.09	1.80	2.25	2.40

Panel A: Male

	1998			2000			2002			2005		
Age	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3	DFLE1	DFLE2	DFLE3
80	6.16	6.81	7.38	5.80	6.48	7.00	5.54	6.32	6.95	6.56	7.31	7.69
85	4.10	4.82	5.21	3.82	4.51	4.95	3.56	4.38	4.80	4.40	5.21	5.45
90	2.49	3.28	3.48	2.37	3.06	3.35	2.17	2.94	3.21	2.84	3.65	3.70
95	1.52	2.33	2.24	1.42	2.15	2.14	1.32	2.01	2.09	1.78	2.64	2.57

Note: LE-life expectancy; DFLE1-life expectancy with no ADL limitations; DFLE2-life expectancy with mild disability; DFLE3-life expectancy with severe disability.

This table presents the life expectancy and disability-free life expectancy (DFLE) for selected ages by sex groups during the sample period of 1998-2005. The life expectancy is calculated with the period life table, whereas the disability free life expectancy through Sullivan's method combining the period life table with the period prevalence of morbidity. The prevalence of disability is calculated based on the activities of daily living (ADL) limitations. ADL active is defined as having no ADL limitations, mild disability as having one or two ADL limitations, and severe disability as having three or more ADL limitations.