Iran Mortality and Measures of Risk: Rankings for Public policy

*M Aalabaf-Sabaghi

E.C.O. College of Insurance, Allameh Tabatabai University, Tehran, Iran

(Received 12 Aug 2009; accepted 28 Feb 2010)

Abstract
Background: This paper offers mortality risk rankings for Iranian mortality data. It extends methods to include mixed cohorts, tests changes in mortality risks, compares measures of risk and discusses public policy implications.

Methods: The methodology used in risk measures takes current practice and extends it to include variations in population dynamics. The specification is presented and compared with existing literature.

Results: Our findings confirm literature results in the re-ordering that takes place when different risk measures are used. In addition, we find there is consistency in risk rankings between 1999 and 2000 records of Iranian mortality data. Thus, these risk measures are stable, robust across time and relay risk information consistently.

Conclusions: There are considerable implications in adopting particular risk measures for public policy. However, given properties of risk measures discussed here, it is clear that policy makers can select relevant risk measures depending on their priorities.

Keywords: Mortality risk, Value of life, Life lost expectancy, Risk ranking, Iran

Introduction
A major concern within health industries is some quantitative measure of mortality risk that may be faced by a member of population. Measures of mortality that only take the probability of death to represent risks faced by an individual do not take into account the timing of death and any discounting that may be present. Whereas, remaining life at risk, given life expectancies of individuals, are important in evaluating risks faced by the population as evidenced in the literature (1-7). Risk of death from different causes could be different due to the age of the individual exposed to such risks. Not all individuals, irrespective of their age, are subject to the same mortality risk from any cause. For example, death from a malignant neoplasm is far more likely to threaten the life of a 60 yr old than an infant is. While, congenital anomalies expose infants to higher risk that are almost nonexistent in older age groups. The method for incorporating other information that affects measurement of risk as suggested in (5) takes into account factors other than just the probability of death. It includes life expectancies at different ages to represent the remaining life at risk for an individual. As individuals may face risks from different ailments, then the incorporation of life expectancies brings in some measure of the magnitude of risk that is ex-ante based on a number of years the individual is expected to live. Life expectancies are given from life tables, which extrapolate remaining lives for individuals in all ages up to 100. In order to have some quantitative measure of lives lost, the expected years of life lost (EYLL) which is in a statistical sense an expected value of each life lost, provides a measure of human life lost because of each death following exposure to a risk. This factor is mainly the reason why a reordering of major causes of death ranks, takes place. The implication for health and safety regulation thus follows from this reordering of ranks of the major causes of death. As pointed out in (8-9) in most health services industries, a greater portion of health expenditure falls on therapy, for a few who experience an ailment. Thus, substantial financial resources are devoted to a few who are identified with having a condition. Whereas the re-

*Corresponding author: Tel: +98 21 88833 612, Fax: +98 21 88833 611, E-mail: aalabaf@eco.ac.ir.
ordering of these major causes of death changes the way, health policy and regulation can be adopted. Thus, preventing or reducing the risk of these conditions for people who have not yet been diagnosed as having a particular condition. Of course, this is a major concern within the economics profession and the health industry to evaluate the costs and benefits of public resources and to suggest courses of action for policy making.

Finally, as many health risks take effect in time and so there is a period during which the individual appears healthy while symptoms of a condition have not shown itself, a time lag between exposure and incidence of death is considered. We also provide a lag response rate estimated for all major conditions and the results confirm those found in (5). However, we are aware that such lag responses are ad-hoc. Some conditions take effect without any time lag, as in most accidents. Thus, it is meaningless to consider a measure of risk that lags the effect of some condition with immediate death implications.

This paper is presented in three sections. Section one presents the model adopted in here with extensions to include birth rates. Section two presents the empirical findings in four tables. Table 1 provides estimates for probability of death from major causes, life lost expectancies, expected years of life lost and the corresponding estimates that are discounted and then lagged. Table 2 ranks these major conditions based on probability of death, life lost expectancies and expected years of life lost and provides evidence for the reordering that takes place because of this method of measuring mortality risks. Tables 1 and 2 are estimates in eighteen groups of major conditions, thus aggregating the information that is provided in Tables 3 and 4. The aggregation will allow a comparison to be made in section three. Table 3 is similar to Table 2 except that the estimates are further sub-grouped in 150 headings. In Section three we calculate nonparametric tests for the existence of any shift in population distributions and find correlations in our mortality risk rankings for 1999 and 2000 data. Section four provides a comparison between our findings and those of the literature and concludes the study with further research suggestions.

Model specification

We adopt the methodology in (5) and offer extensions. That is in calculating mortality risk measures, which in addition to the lifetime probability of death from any condition faced by an individual, takes into account the life expectancy of those individuals at every age (x). Individuals face different risks from a condition depending on their age. The magnitude of measures of lives lost is thus affected by both the probability of death from a condition at a particular age and the individual’s life expectancy at that age. Therefore, the measures of mortality risk estimated in this way, changes the rank order of mortality risk in this model.

To be specific, a hypothetical cohort of $N_o$ people born at time $t=0$ are followed for $T$ years. Survivors aged $t, S_t$, at the end of every time period are given by

$$S_t = N_o \prod_{t=0}^{T} (1 - \gamma_t)$$  \hspace{1cm} (1)

Where $\gamma_t$ is the probability of death in time period $t$ and for $N_o$ people born at $t=0$, death at time $t$ implies they died aged $t$. For a cohort this implies all individuals who die are $t$ years old, i.e. $t=x$ where $x$ represents age. However, $D_j = \gamma_j S_{t-1}$ where $\gamma_j$, the probability of death is aged $t$ from condition $j$ faced by the members of the cohort. Published statistics also provide information about the number of $t$-year olds who have died from condition $j$. Thus in order to calculate lost life expectancy for each individual, we calculate $D_j l_t$ for each life lost. Then the average lost life expectancy LLE for all classified conditions are found from

$$LLE_j = \sum_{t=0}^{T} D_j l_t / \sum_{t=0}^{T} D_j \hspace{1cm} j=1,\ldots,J$$ \hspace{1cm} (2)

Where $l_t$ represents life expectancy at age $t$ and obtained from life tables. The information about life expectancies in our model is obtained from
While the estimates for expected years of life lost (EYLL) is obtained from
\[
EYLL_j = p_j \left( LLE_j \right) \quad j = 1, \ldots, J \quad [3]
\]
Where \( p_j \) is the lifetime probability of death from an ailment. The estimated discounted and lagged values of [2] and [3] are obtained using standard calculus and are given by
\[
disc LLE_j = \frac{\left(1 + i\right)^{LLE_j} - 1}{i \left(1 + i\right)^{LLE_{j-1}}} \quad [4]
\]
\[
disc EYLL_j = p_j \left( disc LLE_j \right) \quad [5]
\]
Where \( i \), is the rate of discount and set to 3%, as in (5) and the results are presented in Tables 1 and 3. However, it is worth noting that this 3% rate of discounting is the best estimate available, although it is rather ad-hoc. The evidence to support this rate of time preference is based on the goodness of fit presented in a number of regressions that examine factors affecting mortality risk perceptions. But the rate of time preference as may be indicated by inter-temporal decisions of individuals needs a more extensive discussion (3, 7, 8, 10). In discussions involving environmental issues, the role of discount rate is central to cost-benefit analysis, but finding the “right” discount rate has always been problematic (9). In order to calculate lagged values of LLE and EYLL by \( \tau \) years, equations in [4] and [5] are multiplied by \( \left(1 + i\right)^\tau \). This will evaluate the corresponding deferred symptom factor that may be present in some health risks. While the medical indication to verify the length of time lag for each condition is not provided by published data, we have insufficient information to justify any length of time lag. Thus this ten-year lag is, once again, rather ad-hoc. At best, the statistical methodology of best fitting regressors to explain variations in dependent variable, namely risk perception, is not always “medically” accurate in reflecting the correct lag response between exposure and the incidence of death.

We also wish to make our theoretical model more accountable to the fact that population under study includes birth as well as death rates. We assume birth, death rates are uniform and equal throughout the year, and there is no immigration or emigration such that the population remains stable. Hypothetical cohorts that construct theoretical models with changing populations, allowing variation in birth and death rates, are found in the demographic literature as in (12). The analysis in this paper tries to include birth rates using component method used in demographic studies. Thus if we reconsider our cohort of \( N_0 \) people and allow an inflow of newborns into this population, the above equations will change. Naturally, \( D_t \) and \( D_t' \) no longer represent the number of death, aged \( t \), from all ailments and ailment \( j \), correspondingly. However, \( D_t \) and \( D_t' \) represent the number who die in period \( t \), where \( t \) is not necessarily equal to the age of the deceased. The information about the age of the dead is available in published statistics and we are able to estimate mortality measures taking age variations into account in the composition of our population due to an inflow of newborns. Suppose \( M_0 \) is the best estimate of population at time \( t = 0 \). Let \( D_t \) be the outflow from our sample i.e. the dead and \( B_t \) represent the number of newborn i.e. the inflow. Survivors at the end of period \( t \), can then be shown to equal
\[
S_t = M_0 \prod_{j=0}^{t} \left(1 - \gamma_t + \beta_t\right) \quad [6]
\]
Where \( \beta_t \) is the birth rate and \( \gamma_t \) is the death rate in period \( t \) and
\[
\beta_t = \frac{B_t}{M_t}, \quad \gamma_t = \frac{D_t}{M_t} \quad [7]
\]
If however, we disallow the inflow of newborn in our population with \( \beta_t = 0 \) in [6] and assume a cohort in period \( t \), we then obtain equation [2] as a special case. Taking note of the fact that information about population statistics includes newborns, thus there is an inflow in the population as well as an outflow. Therefore, mortality measures are better represented in this way.
corresponding values of LLE in [2], EYLL in [3], the discounted and lagged values in [4] and [5] of our mortality measures follow from equation [6]. But, the probability of death from a condition \( j \) in year \( t \) is found by

\[
P_{jt} = \frac{D_{jt}}{D_t}
\]  

[8]

In addition, the lifetime probability of death for a condition is given by

\[
P_j = \sum_{t=1}^{T} P_{jt}
\]  

[9]

Where the probability of death for \( x \) year olds from condition \( j \) is

\[
P_{jx} = \frac{D_{jx}}{D_x}
\]  

[10]

Where, \( D_{jt} \) is the number of \( x \) year olds died from condition \( j \) and \( D_x \) is the number of \( x \) year olds died in period \( t \). Here \( p_{jx} \) is not equal to \( p_j \) unless we have a cohort.

However, not all births or deaths take place or are supervised under ministry run health centers. The underreporting of deaths may be more than births as they may involve expenses for the bereaved and not reporting may entail continuation of certain state benefits. Failure to report a birth or death has also legal and financial implications where beneficiaries of any left state, require official certification. Overall these records are representative of the population and the best available.

**Empirical findings**

In our model, data were obtained from official statistics as published in the Iranian Ministry of Health Mortality Tables Annual Almanac (13-17). These tables provide information about recorded deaths for 150 causes. Age at death is recorded and the statistics provide fourteen different age groups in which records are available. The classification also aggregates these 150 ailments into seventeen broader categories. This broad grouping enables us to make comparisons with other findings.

We present the first set of our findings in Table 1 where seven measures are estimated in eighteen categories. The probability of death is found directly from data and represents the ratio of the number of deaths from a condition to total number in the sample. As such, it represents an ex-post estimate of a measure of risk that individuals may consider for any health condition. Therefore, the probabilities offer some magnitude of a health risk based on the existing recorded information and are a measure of risk after the event. The novelty of this model is in the comparison that is made between measures of risk that represent an ex-ante quantitative measure and those that are ex-post. LLE reflects a quantitative measure of lives lost, but subject to life expectancy of all individuals that are likely to be affected by a particular condition. It is therefore, conditional and weighted according to the number of years those individuals affected, might have expected to live. Thus, it offers an ex-ante quantitative measure of risk that is faced by a member of population. The EYLL is by definition the product of probability of death and LLE. It is therefore a weighted quantitative measure, which radically reorders mortality risk ranking. The rank orders are shown in Tables 2 and 3. As it is seen in Table 2 Circulatory diseases are the most risky and ranks 1. Whereas according to the number of years of life lost, it ranks 17. This condition is in contrast with prenatal disorders that result in the highest years of life lost, since those affected are infants and expected to live much longer in the absence of the health risk. The rank orders according to LLE are highest for prenatal disorders and nearly the last for Circulatory diseases. As pointed out in (8, 14) a critical decision has to be made regarding public finances directed to health services and health insurance. The ranking here clearly indicates that any decision about funding and costing of medical care that is based on priorities, is dramatically affected by mortality risk measures adopted.
Table 1: Mortality risks for major conditions

| Condition                                    | Prob | LLE  | EYLL  | Disc LLE | Disc EYLL | Lag LLE | Lag EYLL |
|----------------------------------------------|------|------|-------|----------|-----------|---------|----------|
| Infections and parasitic diseases            | 0.0156 | 35.81 (4.16) 0.56 | 22.42 | 0.35 | 16.68 | 0.26 |
| Neoplasm (Cancer)                            | 0.0905 | 17.89 (1.17) 1.62 | 14.1 | 1.28 | 10.49 | 0.95 |
| Endocrine, nutritional and metabolic disease | 0.0108 | 21.29 (1.7) 0.23 | 16.04 | 0.17 | 11.93 | 0.13 |
| Blood disorders and blood forming organs     | 0.0048 | 38.41 (3.42) 0.18 | 23.3 | 0.11 | 17.34 | 0.08 |
| Mental disorders                             | 0.0056 | 40.37 (2.22) 0.22 | 23.92 | 0.13 | 17.8 | 0.1 |
| Disorders of the nervous system              | 0.0057 | 33.09 (1.79) 0.19 | 21.42 | 0.12 | 15.94 | 0.09 |
| Diseases of the circulatory system           | 0.3549 | 14.1 (1.27) 5.01 | 11.71 | 4.15 | 8.71 | 3.09 |
| Diseases of the respiratory system           | 0.0351 | 23.98 (2.6) 0.84 | 17.43 | 0.61 | 12.97 | 0.45 |
| Diseases of the digestive system             | 0.0237 | 20.02 (0.91) 0.47 | 15.34 | 0.36 | 11.41 | 0.27 |
| Genitourinary disorders                      | 0.0138 | 18.45 (1.0) 0.26 | 14.43 | 0.13 | 10.74 | 0.15 |
| Complications of pregnancy, child birth and the puerperium | 0.0007 | 38.62 (4.91) 0.03 | 23.37 | 0.02 | 23.37 | 0.02* |
| Skin and sub-tissue disorders                | 0.0055 | 31.61 (2.75) 0.01 | 20.84 | 0.01 | 15.51 | 0.01 |
| Diseases of the musculoskeletal system       | 0.0011 | 27.77 (1.07) 0.03 | 19.23 | 0.02 | 14.31 | 0.02 |
| Congenital anomalies                         | 0.0289 | 62.71 (15.96) 1.81 | 28.95 | 0.84 | 21.55 | 0.62 |
| Prenatal disorders                           | 0.0482 | 65.07 (18.78) 3.13 | 29.32 | 1.41 | 21.81 | 1.05 |
| Accidents and poisoning                      | 0.1153 | 38.06 (2.35) 4.39 | 23.19 | 2.67 | 17.25 | 1.99 |
| Ill defined conditions (old age)             | 0.1671 | 7.31 (1.86) 1.22 | 6.67 | 1.12 | 6.67 | 1.05 |
| Unspecified                                  | 0.0779 | 33.5 (5.21) 2.61 | 21.58 | 1.68 | 21.58 | 1.68* |

Notes: Prob denotes probability of death, LLE denotes Lost Life Expectancy with corresponding standard errors in brackets, EYLL denotes Expected Years of Life Lost, Disc LLE and Disc EYLL incorporate a 3% annual discount rate. Lag LLE and lag EYLL take ten-year lags into account between exposure to an illness and the incidence of death. For entries that are not lagged, * indicates values of the corresponding Disc LLE and Disc EYLL have been carried over.

Table 2: Rank order of mortality risks for major conditions

| Condition                                    | Rank |
|----------------------------------------------|------|
| Diseases of the circulatory system           | 1    |
| Ill defined conditions (old age)             | 2    |
| Accidents and poisoning                       | 3    |
| Neoplasm (Cancer)                            | 4    |
| Unspecified                                  | 5    |
| Prenatal disorders                           | 6    |
| Diseases of the respiratory system           | 7    |
| Congenital anomalies                         | 8    |
| Diseases of the digestive system             | 9    |
| Infectious and parasitic diseases            | 10   |
| Genitourinary disorders                      | 11   |
| Endocrine, nutritional and metabolic disease | 12   |
| Disorders of the nervous system              | 13   |
| Mental disorders                             | 14   |
| Blood disorders and blood forming organs     | 15   |
| Diseases of the musculoskeletal system       | 16   |
| Complications of pregnancy, child birth and the puerperium | 17   |
| Skin and sub-tissue disorders                | 18   |

Notes: For entries marked with * values of the corresponding Disc LLE and Disc EYLL were not lagged.
The order in Table 3 to categorize ailments into diagnostically similar groups is made by the medical profession and does not reflect any risk attribute. The discounted values of LLE and EYLL are accordingly scaled down compared to the corresponding values of LLE and EYLL. Discounting LLE and EYLL are non-linear but monotonic. While at different ages, people have a different time horizon to discount their expected life, a higher LLE value will always lead to a higher discounted LLE without affecting the rank orders between risk factors. The lagged values in Tables 1 and 3 further dampen down the effect of lives lost by a further lagged element. Hence values of lagged LLE and EYLL are smaller compared to the corresponding discounted and actual values of LLE and EYLL. Some values in Table 3 and 4 are starred. This is in order to avoid lagging the effect of any health risk that takes effect without any time delay such as in most accidents.

Table 3: Mortality risks for 150 conditions

| Condition                                      | Prob    | LLE    | EYLL   | Disc   | Disc   | Lag    | Lag    |
|------------------------------------------------|---------|--------|--------|--------|--------|--------|--------|
| 1 Cholera                                      | 0.00012 | 36.03  | (3.98) | 0.0044 | 22.5   | 0.0028 | 16.74  |
| 2 Typhoid fever                                | 0.00022 | 21.33  | (1.12) | 0.0047 | 16.06  | 0.0036 | 11.95  |
| 3 Paratyphoid fever & other salmonella infections | 0.00015 | 43.1   | (5.51) | 0.0063 | 24.73  | 0.0036 | 18.4   |
| 4 Bacillary dysentery and amoebiasis           | 0.00022 | 48.27  | (5.93) | 0.0107 | 26.09  | 0.0058 | 19.41  |
| 5 Enteritis and other diarrhoeal diseases      | 0.00189 | 53.81  | (9.7)  | 0.1018 | 27.34  | 0.0517 | 20.34  |
| 6 Tuberculosis of respiratory system           | 0.00101 | 17.46  | (1.31) | 0.0176 | 13.84  | 0.014  | 10.3   |
| 7 Tuberculosis of meninges and central nervous system | 0.00027 | 19.67  | (2.38) | 0.0054 | 15.14  | 0.0041 | 11.26  |
| 8 Tuberculosis of intestines peritoneum and mesenteric glands | 0.00014 | 26.25  | (1.38) | 0.0036 | 18.53  | 0.0025 | 13.79  |
| 9 Tuberculosis of bones and joints             | 0.00012 | 23.95  | (1.84) | 0.0028 | 17.42  | 0.0021 | 12.96  |
| 10 Other tuberculosis including late effects   | 0.00037 | 20.67  | (1.1)  | 0.0076 | 15.69  | 0.0058 | 11.68  |
| 11 Plague                                      | 0       | 0      | 0      | 0      | 0      | 0      | 0      |
| 12 Anthrax                                     | 0.00001 | 27.13  | (5.62) | 0.0004 | 18.94  | 0.0003 | 14.09  |
| 13 Brucellosis                                  | 0.00008 | 32.43  | (2.36) | 0.0024 | 21.17  | 0.0016 | 15.75  |
| 14 Leprosy                                     | 0.0001  | 31.41  | (6.25) | 0.0031 | 20.76  | 0.0021 | 15.45  |
| 15 Diphtheria                                  | 0.00013 | 61.3   | (16.26)| 0.0081 | 28.72  | 0.0038 | 21.37  |
| 16 Whooping cough                              | 0.0002  | 13.4   | (1.7)  | 0.0027 | 11.23  | 0.0023 | 8.35   |
| 17 Streptococcal sore throat and a Scarlet fever | 0.00018 | 42.86  | (2.88) | 0.0077 | 24.66  | 0.0044 | 18.35  |
| 18 Erysipelis                                  | 0.00001 | 11.71  | (2.5)  | 0.0001 | 10.04  | 0.0001 | 7.47   |
| 19 Meningococcal infection                     | 0.00004 | 34.63  | (3.64) | 0.0015 | 22     | 0.0009 | 16.37  |
| 20 Tetanus                                     | 0.00008 | 47.78  | (8.12) | 0.0041 | 25.97  | 0.0022 | 19.32  |
| 21 Other bacterial diseases                    | 0.00133 | 18.36  | (1.19) | 0.0243 | 14.38  | 0.0191 | 10.7   |
| 22 Acute poliomyelitis                         | 0.00008 | 41.83  | (3.89) | 0.0036 | 24.36  | 0.0021 | 18.13  |
| 23 Late effect of acute poliomyelitis          | 0.00007 | 44.19  | (4.13) | 0.0029 | 25.03  | 0.0017 | 18.63  |
| 24 Smallpox                                    | 0       | 0      | 0      | 0      | 0      | 0      | 0      |
| 25 Measles                                     | 0.00012 | 43.95  | (3.73) | 0.0054 | 24.97  | 0.0031 | 18.58  |
| 26 Yellow fever                                | 0       | 0      | 0      | 0      | 0      | 0      | 0      |
| 27 Viral encephalitis                          | 0.00028 | 41.6   | (4.76) | 0.0118 | 24.29  | 0.0069 | 18.08  |
| 28 Infectious hepatitis                        | 0.00165 | 36.81  | (3.69) | 0.0606 | 22.76  | 0.0375 | 16.94  |
| 29 Other viral diseases                        | 0.00026 | 41.45  | (4.57) | 0.011  | 24.25  | 0.0064 | 18.04  |
| 30 Typhus and other rickettsioses              | 0       | 0      | 0      | 0      | 0      | 0      | 0      |
| 31 Malaria                                     | 0.00008 | 26.86  | (3.58) | 0.0022 | 18.81  | 0.0015 | 14     |
| 32 Trypanosomiasis                             | 0       | 0      | 0      | 0      | 0      | 0      | 0      |
| 33 Relapsing fever                             | 0       | 0      | 0      | 0      | 0      | 0      | 0      |
| 34 Congenital syphilis                         | 0.00005 | 48.65  | (4.04) | 0.0002 | 26.18  | 0.0001 | 19.48  |
| No. | Category                                                                                           | Value   |
|-----|---------------------------------------------------------------------------------------------------|---------|
| 35  | Early syphilis, symptomatic                                                                      | 0.0007  |
| 36  | Syphilis of central nervous system                                                                | 0.00004 |
| 37  | Other syphilis                                                                                    | 0.0004  |
| 38  | Gonococcal infections                                                                            | 0.0004  |
| 39  | Schistosomiasis                                                                                   | 0.0001  |
| 40  | Hydatidosis                                                                                      | 0.0001  |
| 41  | Filariatic infection                                                                             | 0.0002  |
| 42  | Ancylostomiasis                                                                                  | 0.0015  |
| 43  | Other helminthias                                                                                 | 0.0027  |
| 44  | All other infectious and parasitic diseases                                                       | 0.0056  |
| 45  | Malignant neoplasm of buccal cavity & pharynx                                                    | 0.0057  |
| 46  | Malignant neoplasm of esophagus                                                                   | 0.00397 |
| 47  | Malignant neoplasm of stomach                                                                     | 0.017   |
| 48  | Malignant neoplasm of intestine, except rectum                                                    | 0.0033  |
| 49  | Malignant neoplasm of rectum & recto-sigmoid junction                                             | 0.0035  |
| 50  | Malignant neoplasm of larynx                                                                     | 0.00222 |
| 51  | Malignant neoplasm of trachea, bronchus & lung                                                    | 0.00881 |
| 52  | Malignant neoplasm of bone                                                                        | 0.00148 |
| 53  | Malignant neoplasm of skin                                                                        | 0.00092 |
| 54  | Malignant neoplasm of breast                                                                      | 0.00286 |
| 55  | Malignant neoplasm of cervix uteri                                                                 | 0.0008  |
| 56  | Other malignant neoplasm of uterus                                                                | 0.00085 |
| 57  | Malignant neoplasm of prostate                                                                    | 0.00239 |
| 58  | Malignant neoplasm of other and unspecified sites                                                | 0.02961 |
| 59  | Leukemia                                                                                         | 0.00819 |
| 60  | Other neoplasm of lymphatic & haemotopoietic tissue                                               | 0.00256 |
| 61  | Benign neoplasm & neoplasms of unspecified nature                                                | 0.00458 |
| 62  | Non-toxic goitre                                                                                 | 0.00021 |
| 63  | Thyrotoxicosis with or without goitre                                                             | 0.0001  |
| 64  | Diabetes mellitus                                                                                | 0.00685 |
| 65  | Avitaminoses and other nutritional deficiency                                                     | 0.00113 |
| 66  | Other endocrine and metabolic diseases                                                            | 0.00249 |
| 67  | Anemia                                                                                            | 0.00129 |
| 68  | Other diseases of blood and blood-forming organs                                                 | 0.00349 |
| 69  | Psychoses                                                                                       | 0.00116 |
| 70  | Neuroses, personality disorders & other non-psychoactive mental disorders                       | 0.00159 |
| 71  | Mental retardation                                                                               | 0.00282 |
| 72  | Meningitis                                                                                       | 0.00103 |
| 73  | Multiple sclerosis                                                                               | 0.00117 |
| 74  | Epilepsy                                                                                        | 0.00134 |
| 75  | Inflammatory diseases of eye                                                                      | 0.00007 |
| 76  | Cataract                                                                                        | 0.00005 |
| 77  | Glaucoma                                                                                       | 0.00005 |
| 78  | Otitis media and mastoiditis                                                                     | 0.00013 |
| 79  | Other diseases of nervous system and sense organs                                                | 0.00185 |
| 80  | Active rheumatic fever                                                                            | 0.00015 |
| 81  | Chronic rheumatic heart disease                                                                  | 0.00055 |
| 82  | Hypertensive disease                                                                             | 0.00696 |
| 83  | Ischaemic heart disease                                                                          | 0.09818 |
| 84  | Other forms of heart disease                                                                     | 0.16409 |
| 85  | Cerebrovascular disease                                                                          | 0.06621 |
| 86  | Diseases of arteries arterioles & capillaries                                                     | 0.00269 |
| 87  | Venous thrombosis and embolism                                                                    | 0.00589 |
### Table 3: Continued…

| Code | Condition                                                                 | Mortality Rate | Prevalence Rate | Case Fatality Rate | Reference Mortality Rate |
|------|---------------------------------------------------------------------------|----------------|-----------------|--------------------|-------------------------|
| 88   | Other diseases of circulatory system                                       | 0.01007        | 18.81 (0.93)    | 0.1894             | 14.65                   |
| 89   | Acute respiratory infection                                                | 0.00385        | 42.31 (7.47)    | 0.1631             | 24.5                    |
| 90   | Influenza                                                                 | 0.00022        | 38.82 (4.23)    | 0.0086             | 23.43                   |
| 91   | Viral pneumonia                                                           | 0.00174        | 28.37 (5.67)    | 0.0096             | 19.49                   |
| 92   | Other pneumonia                                                           | 0.00337        | 32.46 (4.6)     | 0.1094             | 21.18                   |
| 93   | Bronchitis, emphysma and asthma                                            | 0.00838        | 13.9 (1.29)     | 0.1166             | 11.57                   |
| 94   | Hypertrrophy of tonsils and adenoids                                       | 0.00023        | 31.29 (2.53)    | 0.0071             | 20.72                   |
| 95   | Emphysma and abscess of lung                                              | 0.00153        | 16.53 (1.16)    | 0.0253             | 13.27                   |
| 96   | Other diseases of respiratory system                                       | 0.01572        | 22.96 (3.25)    | 0.361              | 16.92                   |
| 97   | Diseases of teeth and supporting structures                               | 0.00003        | 37.33 (5.98)    | 0.0012             | 22.94                   |
| 98   | Peptic ulcer                                                              | 0.00035        | 17.05 (1.16)    | 0.006              | 13.59                   |
| 99   | Gastritis and duodenitis                                                  | 0.00068        | 16.77 (1.39)    | 0.0115             | 13.42                   |
| 100  | Appendicitis                                                              | 0.00037        | 34.03 (1.92)    | 0.0125             | 21.78                   |
| 101  | Intestinal obstruction and hernia                                          | 0.00068        | 27.75 (3.86)    | 0.0189             | 19.22                   |
| 102  | Cirrhosis of liver                                                        | 0.00537        | 20.08 (1.12)    | 0.1078             | 15.37                   |
| 103  | Cholelithiasis and cholecystitis                                          | 0.00062        | 16.55 (1.17)    | 0.0103             | 13.28                   |
| 104  | Other diseases of digestive system                                        | 0.01559        | 19.64 (0.89)    | 0.0601             | 15.12                   |
| 105  | Acute nephritis                                                           | 0.00053        | 18.72 (1.15)    | 0.01                | 14.59                   |
| 106  | Other nephritis and nephrosis                                             | 0.00148        | 17.35 (1.11)    | 0.0256             | 13.77                   |
| 107  | Infections of kidney                                                     | 0.00641        | 20.09 (0.94)    | 0.1287             | 15.38                   |
| 108  | Calculus of urinary system                                                | 0.00017        | 17.56 (1.78)    | 0.0029             | 13.9                   |
| 109  | Hyperplasia of prostate                                                  | 0.00026        | 9.16 (1.66)     | 0.0024             | 8.14                    |
| 110  | Diseases of breast                                                       | 0.00004        | 18.4 (2.55)     | 0.0008             | 14.4                    |
| 111  | Other diseases of genito-urinary system                                    | 0.00495        | 17.13 (1.09)    | 0.0848             | 13.64                   |
| 112  | Toxaemias of pregnancy and the puerperium                                 | 0.00003        | 38.91 (4.29)    | 0.0011             | 23.46                   |
| 113  | Haemorrhage of pregnancy and childbirth                                   | 0.00017        | 40.69 (5.77)    | 0.0069             | 24.02                   |
| 114  | Abortion induced for legal indications                                     | 0                | 6.84 (1.97)     | 0                | 6.28                   |
| 115  | Other and unspecified abortion                                            | 0.00014        | 42.98 (6.0)     | 0.0059             | 24.7                   |
| 116  | Sepsis of childbirth and the puerperium                                   | 0.00008        | 31.34 (3.14)    | 0.0024             | 20.76                   |
| 117  | Other complication of pregnancy, childbirth and the puerperium            | 0.00025        | 37.84 (5.32)    | 0.0095             | 23.11                   |
| 118  | Delivery without mention of complication                                  | 0.00002        | 35.9 (4.44)     | 0.0008             | 22.45                   |
| 119  | Infections of skin and subcutaneous tissue                               | 0.0002         | 24.16 (2.5)     | 0.0048             | 17.52                   |
| 120  | Other diseases of skin and subcutaneous tissue                            | 0.00025        | 37.4 (3.33)     | 0.0095             | 22.97                   |
| 121  | Arthritis & spondylitis                                                   | 0.00012        | 14.85 (1.67)    | 0.0012             | 12.08                   |
| 122  | Non-articular rheumatism and rheumatism unspecified                       | 0.00013        | 19.81 (1.49)    | 0.0025             | 15.21                   |
| 123  | Osteomyelitis and periostitis                                             | 0.00006        | 39.14 (3.14)    | 0.0024             | 23.54                   |
| 124  | Arthritis and acquired musculoskeletal deformities                        | 0.00003        | 33.88 (4.8)     | 0.0011             | 21.72                   |
| 125  | Other diseases of musculoskeletal system and connective tissue            | 0.00081        | 29.81 (1.17)    | 0.024              | 20.11                   |
| 126  | Spina bifida                                                             | 0.00016        | 33.01 (6.22)    | 0.0051             | 21.39                   |
| 127  | Congenital anomalies of heart                                             | 0.0037         | 62.91 (14.55)   | 0.233              | 28.99                   |
| 128  | Other congenital anomalies of circulatory system                          | 0.0011         | 59.81 (13.08)   | 0.0658             | 28.47                   |
| 129  | Cleft palate and cleft lip                                               | 0.00015        | 66.11 (19.08)   | 0.01               | 29.47                   |
| 130  | All other congenital anomalies                                            | 0.02377        | 62.99 (16.38)   | 1.4974             | 29.693                  |
| 131  | Birth injury and difficult labour                                        | 0.00263        | 65.88 (19.02)   | 0.1734             | 29.44                   |
| 132  | Conditions of placenta and cord                                          | 0.00127        | 62.98 (18.16)   | 0.0802             | 29.06                   |
| 133  | Haemolytic disease of newborn                                             | 0.00274        | 66.11 (19.08)   | 0.1809             | 29.47                   |
| 134  | Anoxic and hypoxic conditions not elsewhere classified                    | 0.00206        | 64.62 (18.65)   | 0.1332             | 29.25                   |
| 135  | Other causes of prenatal morbidity and mortality                          | 0.03943        | 65.03 (18.77)   | 2.5641             | 29.31                   |
| 136  | Senility without mention of psychosis                                     | 0.16704        | 7.31 (1.86)     | 1.2213             | 6.67                    |
| 137  | Symptoms and other ill-defined conditions                                 | 0.04095        | 25.39 (1.43)    | 1.0399             | 18.12                   |
| 138  | Motor vehicle accidents                                                   | 0.02723        | 37.12 (2.23)    | 1.0108             | 22.87                   |
In Table 3 there are also two categories that are not well defined 137 & 151: The “symptoms and other ill-defined conditions” plus “unspecified causes”. As data stand, the amount of unexplained death probability is 0.04095 plus 0.0369 i.e. 0.07785 or 7.8% of all deaths. In order to see how demographic composition of this group may affect EYLL, a look at the age at death is helpful. For “symptoms and other ill-defined conditions” the largest count is 3221 out of a total 8679, which are in the 65+ age group. Perhaps due to old age, the significance of cause of death has been overlooked. While for the “unspecified causes”, the largest count of 2968 out of a total 7820 is for aborted pregnancies. Again, perhaps due to a very early form of life, cause of death is overlooked. Raw data includes abortive deaths and stillbirths and it might be argued that these two categories should be excluded. However, taking an economic point of view, both of these categories impose a cost on people and health services and are therefore included in the calculations of EYLL.

We have also calculated EYLL for this 7.8% “unspecified” deaths based on age at death that is available for each record. Therefore, for the 215 death records for the age group 5-9 yr that were due to “symptoms and other ill-defined conditions” or just “unspecified” the calculated EYLL takes age composition into account.

The results in Table 4 giving rank orders for an extensive list of medical conditions highlight how this model changes the priority that is attached to any ailment may be contrary to the perceived image. But it is quite clear how reordering is affecting priorities. The ranking based on the probability of death is quite markedly different from the LLE measure. The EYLL also offer a somewhat in between measure of mortality risk than the probability of death or LLE. It is also worth noting that aggregation also affects the ranking as it is seen in Tables 2 and 4. In Table 2, it is shown that heart conditions are the riskiest, while in Table 4 the old age appears the most risky condition. This condition, i.e. senility (old age) is put in the “ill defined” category in Table 2, thus ranking second.

In addition to providing disaggregated information for the medical profession, Table 4 may also provide indications as to the level of insurance coverage that may be needed. This can be seen by noting risks involved. The higher is the ranking, the higher insurance premium. However, discussions regarding the consequences of insurance premiums and cost-effectiveness of various decisions based on this reordering are beyond this study (15).

Table 3: Continued…

| Code | Description                                      | Disc LLE | Disc EYLL |
|------|--------------------------------------------------|----------|----------|
| 139  | Other transport accidents                        | 0.09999  | 37.04(2.17) | 0.3702  | 22.85  | 0.2283  | 22.85*  | 0.2283* |
| 140  | Accidental poisoning                             | 0.0557   | 36.88(2.15) | 0.2053  | 22.79  | 0.1269  | 22.79*  | 0.1269* |
| 141  | Accidental falls                                 | 0.00309  | 34.8(1.64)  | 0.1074  | 22.06  | 0.0681  | 22.06*  | 0.0681* |
| 142  | Accidents caused by fires                        | 0.00925  | 42.24(3.35) | 0.3907  | 24.48  | 0.2264  | 24.48*  | 0.2264* |
| 143  | Accidental drowning and submersion               | 0.00655  | 48.45(3.53) | 0.3173  | 26.13  | 0.1712  | 26.13*  | 0.1712* |
| 144  | Accidents caused by firearm missiles             | 0.00271  | 41.89(4.21) | 0.1137  | 24.38  | 0.0661  | 24.38*  | 0.0661* |
| 145  | Accidents mainly of industrial type              | 0.00111  | 43.21(3.05) | 0.0479  | 24.76  | 0.0275  | 24.76*  | 0.0275* |
| 146  | All other accidents                              | 0.02329  | 34.83(1.91) | 0.811   | 22.07  | 0.5139  | 22.07*  | 0.5139* |
| 147  | Suicide and self inflicted injury                 | 0.00848  | 40.23(4.26) | 0.3413  | 23.88  | 0.2026  | 23.88*  | 0.2026* |
| 148  | Homicide and injury purposely inflicted by intervention | 0.0049  | 38.18(3.31) | 0.187   | 23.23  | 0.1138  | 23.23*  | 0.1138* |
| 149  | Injury undetermined whether accidentally or purposely inflicted | 0.01083  | 36.33(2.12) | 0.3936  | 22.6   | 0.2449  | 22.6*   | 0.2449* |
| 150  | Injury resulting from operations of war           | 0.00218  | 39.58(3.42) | 0.0861  | 23.68  | 0.0515  | 23.68*  | 0.0515* |
| 151  | Unspecified causes                               | 0.0369   | 42.5(9.67)  | 1.5683  | 24.56  | 0.9062  | 18.27   | 0.6743  |

Notes: For entries that are not lagged, * indicates values of the corresponding Disc LLE and Disc EYLL have been carried over.
Table 4: Rank orders of mortality risks for 150 conditions

| Condition                                                      | Prob | LLE | EYLL | Lag LLE | Lag EYLL |
|---------------------------------------------------------------|------|-----|------|---------|----------|
| Senility without mention of psychosis                         | 1    | 144 | 6    | 142*    | 2*       |
| Other forms of heart disease                                  | 2    | 132 | 2    | 132     | 1        |
| Ischaemic heart disease                                       | 3    | 137 | 5    | 137     | 4        |
| Cerebrovascular disease                                       | 4    | 130 | 9    | 130     | 8        |
| Symptoms and other ill-defined conditions                     | 5    | 82  | 7    | 48*     | 5*       |
| Other causes of prenatal morbidity and mortality              | 6    | 5   | 5    | 23      | 3        |
| Unspecified causes                                            | 7    | 30  | 3    | 45      | 6        |
| Malignant neoplasm of other and unspecified sites             | 8    | 105 | 11   | 105     | 11       |
| Motor vehicle accidents                                       | 9    | 48  | 8    | 14*     | 7*       |
| All other congenital anomalies                                | 10   | 7   | 4    | 25      | 10       |
| All other accidents                                           | 11   | 58  | 10   | 19*     | 9*       |
| Malignant neoplasm of stomach                                 | 12   | 135 | 20   | 135     | 19       |
| Other diseases of respiratory system                          | 13   | 87  | 15   | 87      | 16       |
| Other diseases of digestive system                            | 14   | 99  | 18   | 99      | 17       |
| Injury undetermined whether accidentally or purposely inflicted| 15   | 54  | 12   | 23      | 12*      |
| Other diseases of circulatory system                          | 16   | 103 | 24   | 103     | 23       |
| Other transport accidents                                     | 17   | 49  | 14   | 15*     | 13*      |
| Accidents caused by fires                                     | 18   | 32  | 13   | 7*      | 14*      |
| Malignant neoplasm of trachea, bronchus & lung                | 19   | 136 | 33   | 136     | 28       |
| Suicide and self inflicted injury                              | 20   | 38  | 16   | 10*     | 15*      |
| Bronchitis, emphysema and asthma                              | 21   | 134 | 34   | 134     | 30       |
| Leukaemia                                                     | 22   | 72  | 19   | 73      | 21       |
| Hypertensive disease                                          | 23   | 141 | 46   | 141     | 42       |
| Diabetes mellitus                                             | 24   | 128 | 40   | 128     | 34       |
| Accidental drowning and submersion                            | 25   | 17  | 17   | 4*      | 18*      |
| Infections of kidney                                          | 26   | 95  | 31   | 95      | 29       |
| Venous thrombosis and embolism                                | 27   | 126 | 41   | 126     | 38       |
| All other infective and parasitic diseases                    | 28   | 44  | 22   | 54      | 24       |
| Accidental poisoning                                          | 29   | 50  | 23   | 16*     | 20*      |
| Cirrhosis of liver                                            | 30   | 96  | 37   | 95      | 35       |
| Other diseases of genito-urinary system                       | 31   | 115 | 44   | 115     | 43       |
| Homicide and injury purposely inflicted by intervention        | 32   | 43  | 25   | 12*     | 22*      |
| Benign neoplasm & neoplasms of unspecified nature             | 33   | 101 | 42   | 101     | 41       |
| Malignant neoplasm of oesophagus                              | 34   | 139 | 57   | 139     | 49       |
| Acute respiratory infection                                   | 35   | 31  | 28   | 46      | 31       |
| Congenital anomalies of heart                                 | 36   | 9   | 21   | 26      | 26       |
| Other diseases of blood and blood-forming organs              | 37   | 57  | 32   | 61      | 36       |
| Other pneumonia                                               | 38   | 64  | 36   | 66      | 39       |
| Malignant neoplasm of intestine, except rectum                | 39   | 114 | 54   | 114     | 48       |
| Accidental falls                                              | 40   | 59  | 38   | 20*     | 32*      |
| Malignant neoplasm of breast                                  | 41   | 90  | 50   | 90      | 47       |
| Mental retardation                                            | 42   | 15  | 29   | 33      | 37       |
| Haemolytic disease of newborn                                 | 43   | 1   | 26   | 1*      | 25*      |
| Accidents caused by firearm missiles                          | 44   | 33  | 35   | 8*      | 33*      |
| Diseases of arteries arterioles & capillaries                 | 45   | 123 | 62   | 122     | 55       |
| Birth injury and difficult labour                             | 46   | 4   | 27   | 2*      | 27*      |
| Other neoplasm of lymphatic & haemopoietic tissue             | 47   | 89  | 53   | 89      | 50       |
| Other endocrine and metabolic diseases                        | 48   | 88  | 56   | 88      | 51       |
| Malignant neoplasm of prostate                               | 49   | 142 | 71   | 143     | 68       |
Malignant neoplasm of larynx & pharynx, 50 131 65 131 63
Malignant neoplasm of bone, 59 81 63 82 62
Malignant neoplasm of cervix uteri, 75 122 76 122 76
Malignant neoplasm of uterus, 73 94 74 94 73
Other malignant neoplasm of skin, 76 118 80 118 77
Psychoses, 66 73 64 74 65
Psychoses, 67 12 48 30 60
Psychoses, 68 26 59 5* 54*
Psychoses, 69 11 47 28 59
Psychoses, 70 25 61 42 64
Psychoses, 71 112 73 112 72
Psychoses, 72 116 75 116 75
Psychoses, 73 94 74 94 73
Psychoses, 74 70 69 71 71
Psychoses, 75 122 76 122 76
Psychoses, 76 76 72 77 74
Psychoses, 77 78 84 119 78
Psychoses, 78 119 84 119 78
Psychoses, 79 124 89 124 83
Psychoses, 80 102 83 102 79
Psychoses, 81 104 85 104 81
Psychoses, 82 92 95 92 88
Psychoses, 83 61 77 63 80
Psychoses, 84 125 101 125 95
Psychoses, 85 117 99 117 92
Psychoses, 86 35 79 49 84
Psychoses, 87 98 102 98 99
Psychoses, 88 98 102 98 99
Psychoses, 89 36 81 50 86
Psychoses, 90 45 87 13* 81*
Psychoses, 91 46 87 55 87
Psychoses, 92 68 96 69 94
Psychoses, 93 68 96 69 94
Psychoses, 94 91 107 91 103
Psychoses, 95 18 82 35 88
Psychoses, 96 42 90 53 91
Psychoses, 97 53 93 59 92
Psychoses, 98 138 116 138 110
Psychoses, 99 84 106 84 103
Psychoses, 100 29 94 44 97
Psychoses, 101 111 113 111 110
Psychoses, 102 37 97 9* 90*
Psychoses, 103 63 105 65 105
Psychoses, 104 27 98 43 102

Table 4: Continued...
Table 4: Continued…

| Condition                                              | 2011 | 2012 | 2013 | 2014 | 2015 |
|--------------------------------------------------------|------|------|------|------|------|
| Ancylostomiasis                                        | 104  | 14   | 91   | 32   | 99   |
| Active rheumatic fever                                  | 104  | 51   | 102  | 57   | 105  |
| Cleft palate and cleft lip                              | 104  | 1    | 85   | 21   | 97   |
| Tuberculosis of intestines peritoneum and mesenteric glands | 108  | 80   | 110  | 81   | 109  |
| Other and unspecified abortion                          | 108  | 28   | 100  | 6*   | 95*  |
| Diphtheria                                             | 110  | 10   | 91   | 27   | 101  |
| Otitis media and mastoiditis                            | 110  | 109  | 118  | 109  | 118  |
| Non-articular rheumatism and rheumatism unspecified    | 110  | 97   | 117  | 97   | 118  |
| Cholera                                                | 113  | 55   | 108  | 60   | 108  |
| Tuberculosis of bones and joints                        | 113  | 85   | 115  | 85   | 115  |
| Measles                                                | 113  | 24   | 102  | 41   | 107  |
| Arthritis & spondylitis                                | 113  | 127  | 126  | 127  | 124  |
| Leprosy                                                | 117  | 66   | 112  | 68   | 115  |
| Hydatidosis                                            | 117  | 86   | 118  | 86   | 120  |
| Thyrotoxicosis with or without goitre                   | 117  | 83   | 118  | 83   | 120  |
| Brucellosis                                            | 120  | 65   | 118  | 67   | 122  |
| Tetanus                                                | 120  | 20   | 109  | 37   | 112  |
| Acute poliomyelitis                                    | 120  | 34   | 110  | 47   | 115  |
| Malaria                                                | 120  | 79   | 125  | 80   | 124  |
| Sepsis of childbirth and the puerperium                 | 120  | 67   | 118  | 29*  | 112* |
| Late effect of acute poliomyelitis                     | 125  | 22   | 113  | 39   | 122  |
| Syphilis of central nervous system                      | 125  | 109  | 128  | 109  | 127  |
| Inflammatory diseases of eye                            | 125  | 121  | 128  | 121  | 127  |
| Osteomyelitis and periostitis                           | 128  | 40   | 118  | 51   | 124  |
| Other syphilis                                         | 129  | 129  | 134  | 129  | 131  |
| Cataract                                               | 129  | 133  | 137  | 133  | 137  |
| Glaucoma                                               | 129  | 93   | 133  | 93   | 131  |
| Meningococcal infection                                | 132  | 60   | 127  | 62   | 127  |
| Gonococcal infections                                  | 132  | 108  | 137  | 108  | 137  |
| Diseases of breast                                     | 132  | 106  | 134  | 106  | 131  |
| Diseases of teeth and supporting structures             | 135  | 47   | 128  | 56   | 130  |
| Toxaemias of pregnancy and the puerperium               | 135  | 41   | 131  | 52   | 131  |
| Ankylosis and acquired musculoskeletal deformities      | 135  | 62   | 131  | 64   | 131  |
| Filarial infection                                      | 138  | 77   | 137  | 78   | 139  |
| Delivery without mention of complication                | 138  | 56   | 134  | 18*  | 131* |
| Anthrax                                                | 140  | 78   | 140  | 79   | 140  |
| Erysipelas                                             | 140  | 140  | 144  | 140  | 142  |
| Schistosomiasis                                        | 140  | 71   | 140  | 72   | 140  |
| Plague                                                 | 143  | 146  | 145  | 146  | 145  |
| Smallpox                                               | 143  | 146  | 145  | 146  | 145  |
| Yellow fever                                           | 143  | 146  | 145  | 146  | 145  |
| Typhus and other rickettsioses                         | 143  | 146  | 145  | 146  | 145  |
| Trypanosomiasis                                        | 143  | 146  | 145  | 146  | 145  |
| Relapsing fever                                        | 143  | 146  | 145  | 146  | 145  |
| Congenital syphilis                                    | 143  | 16   | 143  | 34   | 142  |
| Early syphilis, symptomatic                            | 143  | 1   | 142  | 21   | 142  |
| Abortion induced for legal indications                  | 143  | 145  | 145  | 144* | 145* |

Notes: For entries marked with * values of the corresponding Disc LLE and Disc EYLL were not lagged.

Estimations were carried out for year 2000 as data became available but the presentation of these results involves considerable length of tables that are avoided to save space (as in 18). However, we state that our findings for the year 2000 also confirm a reordering of mortality risks as presented in Section 2. However, we compare mortality risk ranks for the 2 yr and present them in Section 3.
3. Tests
Here we present the results of nonparametric tests with the intention of examining if there has been any tendency for the data to shift between these two years. This is done using the Mann-Whitney U test, which detects shifts in the distribution of our mortality risk ranking. The results presented in section 2 enable us to examine ranks using nonparametric methods. We have ranks of various mortality risk measures and we wish to know if mortality risk ranking is significantly different between these two years. Differences between these two mortality data could be in the form of a shift among various causes of death between the two years. Ranks of some causes may have changed and therefore we would like to know if there are any significant changes in mortality risk ranking. Since we are dealing with ranks, nonparametric tests are used. Procedures to carry out these tests are found in many statistical texts as in (16-19).

The test statistic to take account of large samples is \( z = r_s \sqrt{J - 1} \) where \( r_s \) represent the Spearman rank correlation coefficient. However, the smaller value of 0.6861 for the Spearman rank correlation coefficient for LLE compared with the corresponding values of probability and EYLL indicates that there seems to be some variation in the age composition of death frequencies with probabilities of deaths remaining unchanged. This may be clearer by considering equation [2]. The interpretation is in the number of death frequencies for infants and childhood diseases that affect LLE. The LLE seem to show some variation from year to year. But, this variation does not seem to be carried through to the EYLL. The reason, we think would have to be in the properties of non-parametric statistics. EYLL is found through a non-linear operation \( p, \{LLE_j\} \), whereas ranking is a linear comparison that does not take into account the size of the difference between any two adjacent numbers. Only their relative size is important. Ranking LLE, EYLL and probability does not take into account what these numbers are explaining or are about. The fact that probabilities vary from 0 to 1 (in Table 4 from 0 to 0.16704) and that LLE vary from 0 to 66.77 i.e. the concentration or dispersion of these numbers, has nothing to do with their rank. Consequently, their product could provide a different ranking not necessarily showing any systematic dominance of either probability or LLE. As an example from Table 4, “Other causes of prenatal morbidity and mortality” probability ranks 6 and LLE ranks 5, but EYLL ranks first. Taking another example at the bottom of the Table 4, we see that conditions “Anthrax” and “Schis-

| Test                              | Probability of death | LLE  | EYLL |
|-----------------------------------|----------------------|------|------|
| Coefficient of correlation \( r \)| 0.9727               | 0.6923 | 0.9734 |
| Spearman rank correlation coefficient \( r_s \)| 0.9722               | 0.6861 | 0.9728 |
| z-score                           | 11.87                | 8.38  | 11.88 |
| Mann-Whitney U                    | -0.058               | -0.351 | -0.074 |
tosomiasis” rank 140 in probability, but the LLE’s are 78 and 71 while the corresponding EYLL have remained unchanged at 140. While for “Ery-sipelas” that has probability rank of 140 and LLE rank of 140, the corresponding EYLL rank is 144.

The EYLL measure of risk averages somewhat non-linearly the information content of LLE and probability of death. The weights that are given to each element in this product are unity, i.e. giving equal weight to each, but distributions are different. \( p_j \) varies from 0 to 0.16704 (theoretically 0 to 1) and LLE is distributed from 0 to 66.77 (hypothetically up to 100 yr). Thus EYLL is a measure of risk that tells us, in a non-linear way, how much risk there is in every condition in terms of so many probable life years.

In order to test for correlation in the ranks of mortality risks we use a large sample approximation (20). Our data includes 151 pairs of observations, thus \( z \) scores are calculated which are approximately distributed as standard normal. If both \( r \) and \( r' \) in Table 5 were to be considered, they show very significant positive correlation between mortality risk ranks. The values are statistically significant at 0.001 level. The \( z \) scores which are approximately \( N (0,1) \), are significant. The probability of \( z = 4 \) is 0.99997 see (21).

Thus, we could not reject the null hypothesis of positive correlation between 1999 and 2000 mortality risk rankings and the two sets of risk rankings are highly correlated. With the Mann-Whitney U test in Table 5 we do not reject the null hypothesis and thus conclude that there were no shifts within the distribution of our mortality risk rankings. The results are statistically significant at 0.05 level. The test results in this section indicate that mortality risk measures offered in section 2 are stable across the two. Thus, these risk measures are robust across time and relay risk information consistently.

**Conclusion**

This study emphasizes the significance of considering measures of mortality risk that take into account life expectancies at different ages as well as discounted and lagged symptom effects. Our results confirm findings in (5, 18) that a major reordering of mortality risk ranks takes place once we allow for the risk weighting measures. The most significant risks facing the population in both studies are heart conditions. Cancer also appears ranking high in (5) as in here. Nevertheless, aggregation and classification of health conditions make comparison difficult between this study and others. The results of nonparametric tests in Section 3, confirms that the risk rankings have remained the same for the two years. However, it has not been possible to see how public regulations could change mortality risk rankings in Iran. It has not been possible to find the corresponding regulations and the relevant data. Such impacts and their research are thought to occupy future research and we hope that this study may provide some encouragement in that respect.

**Table 6: Aggregation of causes**

| Group | Condition                                      | Condition(s) in Table 3 |
|-------|------------------------------------------------|-------------------------|
| 1     | Infectious and parasitic diseases              | 1-44                    |
| 2     | Neoplasm (Cancer)                              | 45-61                   |
| 3     | Endocrine, nutritional and metabolic disease   | 62-66                   |
| 4     | Blood disorders and blood forming organs       | 67-68                   |
| 5     | Mental disorders                               | 69-71                   |
| 6     | Disorders of the nervous system                | 72-79                   |
| 7     | Diseases of the circulatory system             | 80-88                   |
| 8     | Diseases of the respiratory system             | 89-96                   |
| 9     | Diseases of the digestive system               | 97-104                  |
| 10    | Genitourinary disorders                        | 105-111                 |
| 11    | Complications of pregnancy, child birth and the puerperium | 112-118                |
| 12    | Skin and sub-tissue disorders                  | 119-120                 |
| 13    | Diseases of the musculoskeletal system         | 121-125                 |
| 14    | Congenital anomalies                           | 126-130                 |
| 15    | Prenatal disorders                             | 131-135                 |
| 16    | Accidents and poisoning                        | 138-150                 |
| 17    | Senility without mention of psychosis (old age) | 136                    |
| 18    | Unspecified                                    | 137,151                 |
Acknowledgements
I would like to thank the editors and two anonymous referees for their helpful comments and suggestions. However any remaining errors remain with me. The authors declare that they have no conflicts of interest.

References
1. Aalabaf-Sabaghi M (2008). Mortality and Approximate Hazard Plots. 12th International Congress of Insurance: Mathematics and Economics, Dalian, China.
2. Aalabaf-Sabaghi M (2009). Risk Perceptions and Rationality in Measures of Risk. Journal of Computational and Applied Mathematics, 233: 46-50.
3. Viscusi WK (1993). The Value of Risks of Life and Health. Journal of Economic Literature, 31(4): 1912-46.
4. Viscusi WK (1995). Discounting Health Effects for Medical Decisions. In: F.A. Sloan. Ed. Valuing Health Care. Cambridge University Press, pp. 125-48.
5. Viscusi WK, Hakes JK, Carlin A (1997). Measures of Mortality Risks. Journal of Risk and Uncertainty, 14: 213-33.
6. Viscusi WK, Moore MJ (1989). Rates of Time Preference and Valuations of the Duration of Life. Journal of Public Economics, 8(3): 393-417.
7. Moore MJ, Viscusi WK (1988). The Quality-Adjusted Value of Life. Economic Inquiry, 26(3): 369-88.
8. Pratt JW, Zeckhauser J (1996). Willingness to Pay and the Distribution of Risk and Wealth. Journal of Political Economy, 104 (4): 747-63.
9. Jenni KE, Lowenstein G (1997). Explaining the “Identifiable Victim Effect”. Journal of Risk and Uncertainty, 14: 235-257.
10. Weitzman M (2001). Gamma Discounting. American Economic Review, 91(1): 260-71.
11. Zanjani H, Noorallah T (1999). The Iranian Life Table for 1996. The Higher Institute for Social Security Research, Tehran, Iran.
12. Brown RL (1997). Introduction to the Mathematics of Demography. 3rd ed. Actex Publications. 13. Mortality Table Annual Almanac (1999). Iranian Ministry of Health, Tehran, Iran, publication No. 341, www.amar.hbi.or.ir.
13. Diamond P (1992). Organizing the Health Insurance Market. Econometrica, 60(6): 1233-54.
14. Sloan FA (1995). Valuing health Care. Cambridge University Press. 16. Spatz C and Johnston JO (1989). Basic Statistics. 4th ed. Brooke/Cole Publishing Company. 17. Mortality Table Annual Almanac (2000). Iranian Ministry of Health, Tehran, Iran, publication No. 345. www.amar.hbi.or.ir.
15. Aalabaf-Sabaghi M (2002). Mortality Risk in Iran. 6th International Congress of Insurance: Mathematics and Economics, ISEG, Lisbon, Portugal, and at the annual meeting of the American Risk and Insurance Association (ARIA), Montreal, Canada.
16. Daniel WW (1990). Applied Nonparametric Statistics. 2nd ed. PWS-Kent Publishing Company.
17. Eeckhoudt LT, Hammitt JK (2001). Background Risks and the Value of a Statistical Life. Journal of Risk and Uncertainty, 23(3): 261-79.
18. Lundley DV, Miller JCP (1952). Cambridge Elementary Statistical Tables. Cambridge University Press.