# Iran Mortality and Measures of Risk

Aalabaf-Sabaghi, Morteza

December 2006

E.C.O. College of Insurance, Allameh Tabatabai University, No.1, Malek-o-Shoara Bahar, Taleghani Avenue, Tehran 15717-53111, Iran.
Tel. (009821) 88833 579, fax (009821) 88833 611
E-mail: maalabaf@yahoo.com , aalabaf@atu.ac.ir

# Iran Mortality and Measures of Risk

**Abstract**
Quantitative measures of lives lost that are limited to finding probabilities of death and some measure of life expectancy provide a ranking of mortality risk based on statistical lives lost. Whereas, mortality risk measures that take into account timing of death, the role of discounting and any lag between exposure and death provide a more accountable method of evaluating risks associated with a cause. However, high birth and death rates show predominantly young populations determining population profiles. For health policy purposes, resource allocation depends on profile of population. The inclusion of birth-rate picks causes affecting the young and changes probabilities and hence risks. We also find increased life expectancy does not affect LLE and EYLL. We use non-parametric tests which are easily accessible by policy makers and show LLE and EYLL are stable and robust across time.

Keywords: Mortality risk, value of life, life lost expectancy, risk ranking.

JEL classification: J-17, I-13

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. There are extensive studies among them, Viscusi, Hakes and Carlin (1997), Viscusi (1993), (1995), Viscusi and Moore (1989) and Moore and Viscusi (1988). Viscusi, Hakes and Carlin (1997), (hereafter VHC) consider the implication of including life expectancy of each individual exposed to a risk with the probability of death that provides a measure of statistical life lost. They further consider the effect of discounting any remaining life that is lost and the effect of any deferred rather than immediate risk.

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 year old than an infant. 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 by VHC 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, provide a measure of human life lost as a result 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 in VHC model and in our study. The implication for health and safety regulation thus follows from this reordering of ranks of the major causes of death.

As pointed out in Pratt and Zeckhauser (1996) and Jenni and Loewenstein (1997) most of the health expenditure falls on therapy in most health services industries, 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 reordering 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.

At the same time, the above methodology, which was developed in Viscusi and Moore (1989) and further discussed in Viscusi (1995), considers a life valuation factor in order to reflect the value of life now as opposed to in the future. VHC suggest a rate of 3% discounting for any remaining life at risk and we also take this 3% rate of time discount in our calculations and the results are presented in Tables 1 and 3.

However, it is worth noting that this 3%-12.4% rate of discounting as suggested by VHC is the best estimate available although rather ad-hoc. Their evidence to support this rate of time preference is based on the goodness of fit that are presented in a number of regressions that examine factors affecting mortality risk perceptions. The coefficient of correlation is considered to be a very significant test to see the explaining power of such regressions. But the rate of time preference as may be indicated by intertemporal decisions of individuals needs a more extensive discussion[1]. 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 as shown in Weitzman (2001).

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 has not shown itself, VHC consider a time lag between exposure and incidence of death. We also provide a lag response rate estimated for all major conditions and the results are very similar to those found in VHC. However, we are aware that such lag responses are, again, ad-hoc as noted by VHC. Some conditions take effect without any time lag, as in the case of most accidents. Thus it is meaningless to consider a measure of risk that lags the effect of some condition that has immediate death implications.

While the medical expertise 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.

This paper is presented in three sections. Section one presents the model adopted in here with some modifications that are suggestive. 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 at 3% and then lagged for ten years. 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 as a result of this method of measuring mortality risks.

Table 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 procedure is shown in Table 6 in Appendix C, which will allow a comparison to be made in section three. We further present mortality risk estimates in Table 3 and 4 that correspond to 150 conditions as classified by the Ministry of Health. Table 3 is similar to Table 2 except that the estimates are further sub-grouped in 150 headings and thus disaggregated. Table 4 provides ranking for these 150 conditions based on the probability of death, life lost expectancies and expected years of life lost. Thus provide further evidence for the reordering that takes place between these 150 conditions.

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 4 provides a comparison between our findings and those of VHC and concludes the study with further research suggestions.

## 1. Model specification

We adopt the methodology of VHC 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 a different risk 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 $N_0$ 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 (see Appendix A)

$$S_t = N_0 \prod_{t=0}^{T} (1-\gamma_t) \qquad (1)$$

Where $\gamma_t$ is the probability of death in time period t and for $N_0$ 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. But $D_{jt} = \gamma_{jt}\ S_{t-1}$ where $\gamma_{jt}$ is the probability of death 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 $D_{jt} l_t$ for each life lost. Then the average lost life expectancy LLE for all classified conditions are found from

$$LLE_j = \sum_{t=0}^{T} D_{jt} l_t \Big/ \sum_{t=0}^{T} D_{jt} \qquad j = 1, \cdots, J \qquad (2)$$

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 Zanjani and

Noorallahi (1999). While the estimates for expected years of life lost EYLL is obtained from

$$EYLL_j = p_j\left(LLE_j\right) \qquad j = 1, \cdots, J \tag{3}$$

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

$$disc\, LLE_j = \frac{(1+i)^{LLE_j} - 1}{i(1+i)^{(LLE_j - 1)}} \tag{4}$$

$$disc\, EYLL_j = p_j\left(disc\, LLE_j\right) \tag{5}$$

Where *i*, is the rate of discount and set equal to 3%.

In order to calculate lagged values of LLE and EYLL by $\tau$ years, equations in (4) and (5) are multiplied by $(1+i)^{\tau}$. This will evaluate the corresponding deferred symptom factor that may be present in some health risks.

However, we wish to make our theoretical model more accountable to the fact that population under study includes birth as well as death rates. Hypothetical cohorts that construct theoretical models with changing populations, allowing variation in birth and death rates, are found in the demographic literature as in Brown (1997). The analysis in this paper tries to include birth rates using component method used in demographic studies. In order to make the derivation in Appendix A more accountable, we include assumptions regarding population at the beginning of period t, $N_t$. Our assumption is that birth and death rates are uniform and equal throughout the year and there are no immigration or emigration such that the population remains stable.

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 $D_{jt}$ no longer represent the number of death, aged t, from all ailments and ailment j, correspondingly. However, $D_t$ and $D_{jt}$ 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 (see Appendix A)

$$S_t = M_0 \prod_{t=0}^{T} \left(1 - \gamma_t + \beta_t\right) \tag{6}$$

Where $\beta_t$ is the birth rate and $\gamma_t$ is the death rate in period t and

$$\beta_t = \frac{B_t}{M_t} \quad , \quad \gamma_t = \frac{D_t}{M_t} \tag{7}$$

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 the newborns, thus there is an inflow in the population as well as an outflow. Thus mortality measures are better represented in this way. The corresponding values for life lost expectancies in (2), expected years of life lost in (3), the discounted and lagged values in (4) and (5) of our mortality measures thus follow from equation (6). But, the probability of death from a condition j in year t is found by

$$p_{jt} = \frac{D_{jt}}{D_t} \tag{8}$$

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

$$p_j = \sum_{t=1}^{T} p_{jt} \tag{9}$$

where the probability of death for x year olds from condition j is

$$p_{jx} = \frac{D_{jx}}{D_{tx}} \tag{10}$$

where $D_{jx}$ is the number of x year olds died from condition j and $D_{tx}$ is the number of x year olds died in period t. Here $p_{jx}$ is not equal to $p_{jt}$ unless we have a cohort.

## 2. Empirical findings

In our model, data are obtained from the official statistics as published in the Iranian Ministry of Health Mortality Tables Annual Almanac for the year 1999. These tables provide information about recorded deaths in the entire Ministry run hospitals throughout the country for 150 ailments. Age at death is also recorded, but the statistics provide fourteen different age groups in which records are available. The classification also aggregates these 150 ailments into seventeen broader categories (see Appendix C). This broad grouping enables us to make a comparison with other findings, in particular the results of the VHC study.

However, not all births or deaths take place or are supervised under the 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.

We present the first set of our findings in Table 1 where seven measures are estimated in eighteen categories, while in Table 3 we provide our results for 150 conditions. 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 thus 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. Lost life expectancy (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.

Table 1. Mortality risks for major conditions.

| Condition | Prob | LLE | EYLL | Disc LLE | Disc EYLL | Lag LLE | Lag EYLL |
|---|---|---|---|---|---|---|---|
| Infectionus 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 | 0.2 | 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 | 0.0005 | 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* | 1.12* |
| 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.

The expected years of life lost EYLL, is by definition the product of probability of death and life lost expectancy. 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 heart conditions are the most risky and it has rank 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 thus expected to live much longer in the absence of the health risk. The rank orders according to life lost expectancies are highest for prenatal disorders and nearly the last for heart conditions.

As pointed out by Pratt and Zeckhauser (1996) and Diamond (1992) 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 the mortality risk measure adopted.

Table 2. Rank order of mortality risks for major conditions

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

Notes: Prob denotes probability of death, LLE denotes Lost Life Expectancy, 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 marked with * values of the corresponding Disc LLE and Disc EYLL were not lagged.

Table 3 shows extensive measures of mortality risk for 150 ailments. The order in this table is to categorize ailments into diagnostically similar

groups and is made by the medical profession but does not reflect any risk attribute. The discounted values of lost life expectancy and expected years of life lost are accordingly scaled down compared to the corresponding values of LLE and EYLL. The discounting for 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 LLE | Disc EYLL | Lag LLE | Lag EYLL |
|---|---|---|---|---|---|---|---|---|
| 1 | Cholera | 0.00012 | 36.03 (3.98) | 0.0044 | 22.5 | 0.0028 | 16.74 | 0.0021 |
| 2 | Typhoid fever | 0.00022 | 21.33 (1.12) | 0.0047 | 16.06 | 0.0036 | 11.95 | 0.0026 |
| 3 | Paratyphoid fever & other salmonella infections | 0.00015 | 43.1 (5.51) | 0.0063 | 24.73 | 0.0036 | 18.4 | 0.0027 |
| 4 | Bacillary dysentery and amoebiasis | 0.00022 | 48.27 (5.93) | 0.0107 | 26.09 | 0.0058 | 19.41 | 0.0043 |
| 5 | Enteritis and other diarrhoeal diseases | 0.00189 | 53.81 (9.7) | 0.1018 | 27.34 | 0.0517 | 20.34 | 0.0385 |
| 6 | Tuberculosis of respiratory system | 0.00101 | 17.46 (1.31) | 0.0176 | 13.84 | 0.014 | 10.3 | 0.0104 |
| 7 | Tuberculosis of meninges and central nervous system | 0.00027 | 19.67 (2.38) | 0.0054 | 15.14 | 0.0041 | 11.26 | 0.0031 |
| 8 | Tuberculosis of intestines peritoneum and mesenteric glands | 0.00014 | 26.25 (1.38) | 0.0036 | 18.53 | 0.0025 | 13.79 | 0.0019 |
| 9 | Tuberculosis of bones and joints | 0.00012 | 23.95 (1.84) | 0.0028 | 17.42 | 0.0021 | 12.96 | 0.0015 |
| 10 | Other tuberculosis including late effects | 0.00037 | 20.67 (1.1) | 0.0076 | 15.69 | 0.0058 | 11.68 | 0.0043 |
| 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 | 0.0002 |
| 13 | Brucellosis | 0.00008 | 32.43 (2.36) | 0.0024 | 21.17 | 0.0016 | 15.75 | 0.0012 |
| 14 | Leprosy | 0.0001 | 31.41 (6.25) | 0.0031 | 20.76 | 0.0021 | 15.45 | 0.0015 |
| 15 | Diphtheria | 0.00013 | 61.3 (16.26) | 0.0081 | 28.72 | 0.0038 | 21.37 | 0.0028 |
| 16 | Whooping cough | 0.0002 | 13.4 (1.7) | 0.0027 | 11.23 | 0.0023 | 8.35 | 0.0017 |
| 17 | Streptococcal sore throat and acarlet fever | 0.00018 | 42.86 (2.88) | 0.0077 | 24.66 | 0.0044 | 18.35 | 0.0033 |
| 18 | Erysipelas | 0.00001 | 11.71 (2.5) | 0.0001 | 10.04 | 0.0001 | 7.47 | 0.0001 |
| 19 | Meningococcal infection | 0.00004 | 34.63 (3.64) | 0.0015 | 22 | 0.0009 | 16.37 | 0.0007 |
| 20 | Tetanus | 0.00008 | 47.78 (8.12) | 0.0041 | 25.97 | 0.0022 | 19.32 | 0.0016 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 21 | Other bacterial diseases | 0.00133 | 18.36 (1.19) | 0.0243 | 14.38 | 0.0191 | 10.7 | 0.0142 |
| 22 | Acute poliomyelitis | 0.00008 | 41.83 (3.89) | 0.0036 | 24.36 | 0.0021 | 18.13 | 0.0015 |
| 23 | Late effect of acute poliomyelitis | 0.00007 | 44.19 (4.13) | 0.0029 | 25.03 | 0.0017 | 18.63 | 0.0012 |
| 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 | 0.0023 |
| 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 | 0.0051 |
| 28 | Infectious hepatitis | 0.00165 | 36.81 (3.69) | 0.0606 | 22.77 | 0.0375 | 16.94 | 0.0279 |
| 29 | Other viral diseases | 0.00026 | 41.45 (4.57) | 0.011 | 24.25 | 0.0064 | 18.04 | 0.0048 |
| 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 | 0.0011 |
| 32 | Trypanosomiasis | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | Relapsing fever | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 34 | Congenital syphilis | 0 | 48.65 (14.04) | 0.0002 | 26.18 | 0.0001 | 19.48 | 0.0001 |
| 35 | Early syphilis, symptomatic | 0 | 66.11 (19.08) | 0.0003 | 29.47 | 0.0001 | 21.93 | 0.0001 |
| 36 | Syphilis of central nervous system | 0.00007 | 18.21 (2.06) | 0.0012 | 14.29 | 0.0009 | 10.63 | 0.0007 |
| 37 | Other syphilis | 0.00005 | 14.51 (2.68) | 0.0008 | 11.97 | 0.0006 | 8.91 | 0.0005 |
| 38 | Gonococcal infections | 0.00004 | 18.33 (3.1) | 0.0007 | 14.36 | 0.0005 | 10.69 | 0.0004 |
| 39 | Schistosomiasis | 0.00001 | 29.67 (5.8) | 0.0004 | 20.05 | 0.0003 | 14.92 | 0.0002 |
| 40 | Hydatidosis | 0.0001 | 23.79 (2.53) | 0.0024 | 17.34 | 0.0017 | 12.9 | 0.0013 |
| 41 | Filarial infection | 0.00002 | 27.71 (4.48) | 0.0007 | 19.2 | 0.0005 | 14.28 | 0.0003 |
| 42 | Ancylostomiasis | 0.00015 | 53.51 (7.19) | 0.0081 | 27.27 | 0.0041 | 20.29 | 0.0031 |
| 43 | Other helminthiasis | 0.00027 | 45.33 (5.25) | 0.0122 | 25.34 | 0.0068 | 18.86 | 0.0051 |
| 44 | All other infective and parasitic diseases | 0.0056 | 38.04 (5.05) | 0.2131 | 23.18 | 0.1298 | 17.25 | 0.0966 |
| 45 | Malignant neoplasm of buccal cavity & pharynx | 0.00057 | 16.25 (1.49) | 0.0092 | 13.09 | 0.0074 | 9.74 | 0.0055 |
| 46 | Malignant neoplasm of esophagus | 0.00397 | 13.38 (1.47) | 0.0531 | 11.21 | 0.0445 | 8.34 | 0.0331 |
| 47 | Malignant neoplasm of stomach | 0.017 | 13.86 (1.44) | 0.2356 | 11.54 | 0.1962 | 8.59 | 0.146 |
| 48 | Malignant neoplasm of intestine, except rectum | 0.0033 | 17.18 (1.36) | 0.0567 | 13.67 | 0.0451 | 10.17 | 0.0336 |
| 49 | Malignant neoplasm of rectum & recto-sigmoid junction | 0.00035 | 16.13 (1.66) | 0.0056 | 13.02 | 0.0045 | 9.69 | 0.0034 |
| 50 | Malignant neoplasm of larynx | 0.00222 | 14.13 (1.45) | 0.0313 | 11.72 | 0.026 | 8.72 | 0.0193 |
| 51 | Malignant neoplasm of trachea, bronchus & lung | 0.00881 | 13.76 (1.43) | 0.1212 | 11.47 | 0.1011 | 8.54 | 0.0752 |
| 52 | Malignant neoplasm of bone | 0.00148 | 26.02 (1.48) | 0.0384 | 18.42 | 0.0272 | 13.71 | 0.0202 |
| 53 | Malignant neoplasm of skin | 0.00092 | 17.06 (1.26) | 0.0157 | 13.6 | 0.0125 | 10.12 | 0.0093 |
| 54 | Malignant neoplasm of breast | 0.00286 | 21.45 (2.39) | 0.0614 | 16.12 | 0.0462 | 11.99 | 0.0344 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 55 | Malignant neoplasm of cervix uteri | 0.0008 | 16.27 (1.84) | 0.013 | 13.11 | 0.0105 | 9.75 | 0.0078 |
| 56 | Other malignant neoplasm of uterus | 0.00085 | 20.17 (2.04) | 0.0172 | 15.42 | 0.0132 | 11.47 | 0.0098 |
| 57 | Malignant neoplasm of prostate | 0.00239 | 9.58 (1.6) | 0.0229 | 8.47 | 0.0202 | 6.3 | 0.015 |
| 58 | Malignant neoplasm of other and unspecified sites | 0.02961 | 18.7 (1.15) | 0.5537 | 14.58 | 0.4317 | 10.85 | 0.3212 |
| 59 | Leukemia | 0.00819 | 29.01 (1.22) | 0.2376 | 19.77 | 0.1619 | 14.71 | 0.1205 |
| 60 | Other neoplasm of lymphatic & haemotopoietic tissue | 0.00256 | 22.45 (0.94) | 0.0574 | 16.65 | 0.0426 | 12.39 | 0.0317 |
| 61 | Benign neoplasm & neoplasm of unspecified nature | 0.00458 | 19.14 (1.09) | 0.0877 | 14.84 | 0.068 | 11.04 | 0.0506 |
| 62 | Non-toxic goitre | 0.00021 | 36.52 (3.47) | 0.0078 | 22.67 | 0.0048 | 16.87 | 0.0036 |
| 63 | Thyrotoxicosis with or without goitre | 0.0001 | 24.47 (2.2) | 0.0024 | 17.68 | 0.0018 | 13.15 | 0.0013 |
| 64 | Diabetes mellitus | 0.00685 | 14.72 (1.29) | 0.1009 | 12.11 | 0.083 | 9.01 | 0.0618 |
| 65 | Avitaminoses and other nutritional deficiency | 0.00113 | 55.3 (11.78) | 0.0624 | 27.64 | 0.0312 | 20.57 | 0.0232 |
| 66 | Other endocrine and metabolic diseases | 0.00249 | 22.53 (1.27) | 0.0561 | 16.7 | 0.0416 | 12.42 | 0.0309 |
| 67 | Anemia | 0.00129 | 48.08 (4.11) | 0.0619 | 26.04 | 0.0335 | 19.38 | 0.025 |
| 68 | Other diseases of blood and blood-forming organs | 0.00349 | 34.84 (3.31) | 0.1215 | 22.07 | 0.077 | 16.42 | 0.0573 |
| 69 | Psychoses | 0.00116 | 28.8 (1.47) | 0.0333 | 19.68 | 0.0227 | 14.64 | 0.0169 |
| 70 | Neuroses, personality disorders & other non-psychotic mental disorders | 0.00159 | 28.47 (0.98) | 0.0451 | 19.54 | 0.031 | 14.54 | 0.023 |
| 71 | Mental retardation | 0.00282 | 51.8 (3.94) | 0.1462 | 26.91 | 0.0759 | 20.02 | 0.0565 |
| 72 | Meningitis | 0.00103 | 43.63 (3.63) | 0.0449 | 24.88 | 0.0256 | 18.51 | 0.019 |
| 73 | Multiple sclerosis | 0.00117 | 19.63 (1.24) | 0.023 | 15.11 | 0.0177 | 11.25 | 0.0132 |
| 74 | Epilepsy | 0.00134 | 44.16 (2.97) | 0.059 | 25.03 | 0.0334 | 18.62 | 0.0249 |
| 75 | Inflammatory diseases of eye | 0.00007 | 16.5 (1.91) | 0.0012 | 13.25 | 0.0009 | 9.86 | 0.0007 |
| 76 | Cataract | 0.00005 | 13.99 (1.81) | 0.0007 | 11.63 | 0.0006 | 8.65 | 0.0004 |
| 77 | Glaucoma | 0.00005 | 20.21 (2.81) | 0.001 | 15.44 | 0.0007 | 11.49 | 0.0005 |
| 78 | Otitis media and mastoiditis | 0.00013 | 18.21 (1.49) | 0.0024 | 14.29 | 0.0019 | 10.63 | 0.0014 |
| 79 | Other diseases of nervous system and sense organs | 0.00185 | 30.32 (1.77) | 0.0562 | 20.32 | 0.0377 | 15.12 | 0.028 |
| 80 | Active rheumatic fever | 0.00015 | 36.87 (2.74) | 0.0054 | 22.79 | 0.0033 | 16.96 | 0.0025 |
| 81 | Chronic rheumatic heart disease | 0.00055 | 18.97 (1.22) | 0.0105 | 14.73 | 0.0081 | 10.96 | 0.0061 |
| 82 | Hypertensive disease | 0.00696 | 11.25 (1.48) | 0.0783 | 9.72 | 0.0676 | 7.23 | 0.0503 |
| 83 | Ischaemic heart disease | 0.09818 | 13.57 (1.35) | 1.3322 | 11.34 | 1.1138 | 8.44 | 0.8287 |
| 84 | Other forms of heart disease | 0.16409 | 14.05 (1.28) | 2.3061 | 11.67 | 1.9151 | 8.68 | 1.425 |
| 85 | Cerebovascular disease | 0.06621 | 14.32 (1.22) | 0.9479 | 11.85 | 0.7843 | 8.81 | 0.5836 |
| 86 | Diseases of arteries arterioles & capillaries | 0.00269 | 16.26 (1.12) | 0.0437 | 13.1 | 0.0352 | 9.75 | 0.0262 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 87 | Venous thrombosis and embolism | 0.00589 | 15.39 (1.23) | 0.0906 | 12.55 | 0.0739 | 9.34 | 0.055 |
| 88 | Other diseases of circulatory system | 0.01007 | 18.81 (0.93) | 0.1894 | 14.65 | 0.1475 | 10.9 | 0.1097 |
| 89 | Acute respiratory infection | 0.00385 | 42.31 (7.47) | 0.1631 | 24.5 | 0.0945 | 18.23 | 0.0703 |
| 90 | Influenza | 0.00022 | 38.82 (4.23) | 0.0086 | 23.43 | 0.0052 | 17.44 | 0.0039 |
| 91 | Viral pneumonia | 0.00174 | 28.37 (3.67) | 0.0494 | 19.49 | 0.0339 | 14.5 | 0.0252 |
| 92 | Other pneumonia | 0.00337 | 32.46 (4.6) | 0.1094 | 21.18 | 0.0714 | 15.76 | 0.0531 |
| 93 | Bronchitis, emphysema and asthma | 0.00838 | 13.9 (1.29) | 0.1166 | 11.57 | 0.097 | 8.61 | 0.0722 |
| 94 | Hypertrophy of tonsils and adenoids | 0.00023 | 31.29 (2.53) | 0.0071 | 20.72 | 0.0047 | 15.42 | 0.0035 |
| 95 | Emphysema and abscess of lung | 0.00153 | 16.53 (1.16) | 0.0253 | 13.27 | 0.0203 | 9.88 | 0.0151 |
| 96 | Other diseases of respiratory system | 0.01572 | 22.96 (2.35) | 0.361 | 16.92 | 0.266 | 12.59 | 0.1979 |
| 97 | Diseases of teeth and supporting structures | 0.00003 | 37.33 (5.98) | 0.0012 | 22.94 | 0.0008 | 17.07 | 0.0006 |
| 98 | Peptic ulcer | 0.00035 | 17.05 (1.16) | 0.006 | 13.59 | 0.0048 | 10.11 | 0.0036 |
| 99 | Gastritis and duodenitis | 0.00068 | 16.77 (1.39) | 0.0115 | 13.42 | 0.0092 | 9.98 | 0.0068 |
| 100 | Appendicitis | 0.00037 | 34.03 (1.92) | 0.0125 | 21.78 | 0.008 | 16.2 | 0.006 |
| 101 | Intestinal obstruction and hernia | 0.00068 | 27.75 (3.86) | 0.0189 | 19.22 | 0.0131 | 14.3 | 0.0097 |
| 102 | Cirrhosis of liver | 0.00537 | 20.08 (1.12) | 0.1078 | 15.37 | 0.0825 | 11.44 | 0.0614 |
| 103 | Cholelithiasis and cholecystitis | 0.00062 | 16.55 (1.17) | 0.0103 | 13.28 | 0.0083 | 9.88 | 0.0062 |
| 104 | Other diseases of digestive system | 0.01559 | 19.64 (0.89) | 0.3061 | 15.12 | 0.2357 | 11.25 | 0.1754 |
| 105 | Acute nephritis | 0.00053 | 18.72 (1.15) | 0.01 | 14.59 | 0.0078 | 10.86 | 0.0058 |
| 106 | Other nephritis and nephrosis | 0.00148 | 17.35 (1.11) | 0.0256 | 13.77 | 0.0203 | 10.25 | 0.0151 |
| 107 | Infections of kidney | 0.00641 | 20.09 (0.94) | 0.1287 | 15.38 | 0.0985 | 11.44 | 0.0733 |
| 108 | Calculus of urinary system | 0.00017 | 17.56 (1.78) | 0.0029 | 13.9 | 0.0023 | 10.35 | 0.0017 |
| 109 | Hyperplasia of prostate | 0.00026 | 9.16 (1.66) | 0.0024 | 8.14 | 0.0021 | 6.06 | 0.0016 |
| 110 | Diseases of breast | 0.00004 | 18.4 (2.55) | 0.0008 | 14.4 | 0.0006 | 10.72 | 0.0005 |
| 111 | Other diseases of genito-urinary system | 0.00495 | 17.13 (1.09) | 0.0848 | 13.64 | 0.0675 | 10.15 | 0.0502 |
| 112 | Toxaemias of pregnancy and the puerperium | 0.00003 | 38.91 (4.29) | 0.0011 | 23.46 | 0.0007 | 17.46 | 0.0005 |
| 113 | Haemorrohage of pregnancy and childbirth | 0.00017 | 40.69 (5.77) | 0.0069 | 24.02 | 0.0041 | 24.02* | 0.0041* |
| 114 | Abortion induced for legal indications | 0 | 6.84 (1.97) | 0 | 6.28 | 0 | 6.28* | 0* |
| 115 | Other and unspecified abortion | 0.00014 | 42.98 (6.0) | 0.0059 | 24.7 | 0.0034 | 24.7* | 0.0034* |
| 116 | Sepsis of childbirth and the puerperium | 0.00008 | 31.4 (3.14) | 0.0024 | 20.76 | 0.0016 | 20.76* | 0.0016* |
| 117 | Other complication of pregnancy, childbirth and the puerperium | 0.00025 | 37.84 (5.32) | 0.0095 | 23.11 | 0.0058 | 23.11* | 0.0058* |
| 118 | Delivery without mention of complication | 0.00002 | 35.9 (4.44) | 0.0008 | 22.45 | 0.0005 | 22.45* | 0.0005* |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 119 | Infections of skin and subcutaneous tissue | 0.0002 | 24.16 (2.5) | 0.0048 | 17.52 | 0.0035 | 13.04 | 0.0026 |
| 120 | Other diseases of skin and subcutaneous tissue | 0.00025 | 37.4 (3.33) | 0.0095 | 22.97 | 0.0059 | 17.09 | 0.0044 |
| 121 | Arthritis & spondylitis | 0.00012 | 14.85 (1.67) | 0.0018 | 12.2 | 0.0014 | 9.08 | 0.0011 |
| 122 | Non-articular rheumatism and rheumatism unspecified | 0.00013 | 19.81 (1.49) | 0.0025 | 15.21 | 0.0019 | 11.32 | 0.0014 |
| 123 | Osteomyelitis and periostitis | 0.00006 | 39.14 (3.14) | 0.0024 | 23.54 | 0.0014 | 17.51 | 0.0011 |
| 124 | Ankylosis and acquired musculoskeletal deformities | 0.00003 | 33.88 (4.8) | 0.0011 | 21.72 | 0.0007 | 16.16 | 0.0005 |
| 125 | Other diseases of musculoskeletal system and connective tissue | 0.00081 | 29.81 (1.17) | 0.024 | 20.11 | 0.0162 | 14.96 | 0.0121 |
| 126 | Spina bifidia | 0.00016 | 33.01 (6.22) | 0.0051 | 21.39 | 0.0033 | 15.92 | 0.0025 |
| 127 | Congenital anomalies of heart | 0.0037 | 62.91 (14.55) | 0.233 | 28.99 | 0.1074 | 21.57 | 0.0799 |
| 128 | Other congenital anomalies of circulatory system | 0.0011 | 59.81 (13.08) | 0.0658 | 28.47 | 0.0313 | 21.19 | 0.0233 |
| 129 | Cleft palate and cleft lip | 0.00015 | 66.11 (19.08) | 0.01 | 29.47 | 0.0044 | 21.93 | 0.0033 |
| 130 | All other congenital anomalies | 0.02377 | 62.99 (16.38) | 1.4974 | 29 | 0.6893 | 21.58 | 0.5129 |
| 131 | Birth injury and difficult labour | 0.00263 | 65.88 (19.02) | 0.1734 | 29.44 | 0.0775 | 29.44* | 0.0775* |
| 132 | Conditions of placenta and cord | 0.00127 | 62.98 (18.16) | 0.0802 | 29 | 0.0369 | 29* | 0.0369* |
| 133 | Haemolytic disease of newborn | 0.00274 | 66.11 (19.08) | 0.1809 | 29.47 | 0.0806 | 29.47* | 0.0806* |
| 134 | Anoxic and hypoxic conditions not elsewhere classified | 0.00206 | 64.62 (18.65) | 0.1332 | 29.25 | 0.0603 | 21.76 | 0.0449 |
| 135 | Other causes of prinatal morbidity and mortality | 0.03943 | 65.03 (18.77) | 2.5641 | 29.31 | 1.1557 | 21.81 | 0.8599 |
| 136 | Senility without mention of psychosis | 0.16704 | 7.31 (1.86) | 1.2213 | 6.67 | 1.1147 | 6.67* | 1.1147* |
| 137 | Symptoms and other ill-defined conditions | 0.04095 | 25.39 (1.43) | 1.0399 | 18.12 | 0.7422 | 18.12* | 0.7422* |
| 138 | Motor vehicle accidents | 0.02723 | 37.12 (2.23) | 1.0108 | 22.87 | 0.6228 | 22.87* | 0.6228* |
| 139 | Other transport accidents | 0.00999 | 37.04 (2.17) | 0.3702 | 22.85 | 0.2283 | 22.85* | 0.2283* |
| 140 | Accidental poisoning | 0.00557 | 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: 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.

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 years 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. While VHC discuss perception issues, we discuss the problem of perception elsewhere. But it is quite apparent how reordering is affecting priorities. The ranking based on the probability of death is quite markedly different from the lost life expectancy measure. The years of life lost also offer a somewhat in between measure of mortality risk between the probability of death and LLE.

It is also worth noting that the aggregation which is taking place to collate and group these 150 conditions into eighteen categories, also affect 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 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. However, discussions regarding the

consequences of insurance premiums and cost-effectiveness of various decisions based on this reordering (as in for example Sloan (1995)) are beyond this study.

Table 4. Rank orders of mortality risks for 150 conditions

| Condition | Rank | | | | |
|---|---|---|---|---|---|
| | 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 | 1 | 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 | 17* | 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 & haemotopoietic 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 | 50 | 131 | 65 | 131 | 63 |
| Injury resulting from operations of war | 51 | 39 | 43 | 11* | 40* |
| Anoxic and hypoxic conditions not elsewhere classified | 52 | 6 | 30 | 24 | 44 |
| Enteritis and other diarrhoeal diseases | 53 | 13 | 39 | 31 | 45 |
| Other diseases of nervous system and sense organs | 54 | 69 | 55 | 70 | 52 |
| Viral pneumonia | 55 | 75 | 58 | 76 | 56 |
| Infectious hepetitis | 56 | 52 | 51 | 58 | 53 |
| Neuroses, personality disorders & other non-psychotic mental disorders | 57 | 74 | 60 | 75 | 61 |
| Empyema and abscess of lung | 58 | 120 | 67 | 119 | 66 |
| Malignant neoplasm of bone | 59 | 81 | 63 | 82 | 62 |
| Other nephritis and nephrosis | 59 | 113 | 66 | 113 | 66 |
| Epilepsy | 61 | 23 | 52 | 40 | 58 |
| Other bacterial diseases | 62 | 107 | 68 | 107 | 69 |
| Anaemias | 63 | 19 | 49 | 36 | 57 |
| Conditions of placenta and cord | 64 | 8 | 45 | 3* | 46* |
| Multiple sclerosis | 65 | 100 | 70 | 99 | 70 |
| Psychoses | 66 | 73 | 64 | 74 | 65 |
| Avitaminoses and other nutritional deficiency | 67 | 12 | 48 | 30 | 60 |
| Accidents mainly of industrial type | 68 | 26 | 59 | 5* | 54* |
| Other congenital anomalies of circulatory system | 69 | 11 | 47 | 28 | 59 |
| Meningitis | 70 | 25 | 61 | 42 | 64 |
| Tuberculosis of respiratory system | 71 | 112 | 73 | 112 | 72 |
| Malignant neoplasm of skin | 72 | 116 | 75 | 116 | 75 |
| Other malignant neoplasm of uterus | 73 | 94 | 74 | 94 | 73 |
| Other diseases of musculoskeletal system and connective tissue | 74 | 70 | 69 | 71 | 71 |
| Malignant neoplasm of cervix uteri | 75 | 122 | 76 | 122 | 76 |
| Gastritis and duodenitis | 76 | 118 | 80 | 118 | 77 |
| Intestinal obstruction and hernia | 76 | 76 | 72 | 77 | 74 |
| Cholelithiasis and cholecystitis | 78 | 119 | 84 | 119 | 78 |
| Malignant neoplasm of buccal cavity & pharynx | 79 | 124 | 89 | 124 | 83 |
| Chronic rheumatic heart disease | 80 | 102 | 83 | 102 | 79 |
| Acute nephritis | 81 | 104 | 85 | 104 | 81 |
| Other tuberculosis including late effects | 82 | 92 | 95 | 92 | 88 |
| Appendicitis | 82 | 61 | 77 | 63 | 80 |
| Malignant neoplasm of rectum & rectosigmoid junction | 84 | 125 | 101 | 125 | 95 |
| Peptic ulcer | 84 | 117 | 99 | 117 | 92 |
| Viral encephalitis | 86 | 35 | 79 | 49 | 84 |
| Tuberculosis of meninges and central nervous system | 87 | 98 | 102 | 98 | 99 |
| Other helminthiasis | 87 | 21 | 78 | 38 | 84 |
| Other viral diseases | 89 | 36 | 81 | 50 | 86 |
| Hyperplasia of prostate | 89 | 143 | 118 | 145 | 112 |
| Other complication of pregnancy, childbirth and the puerperium | 91 | 45 | 87 | 13* | 81* |
| Other diseases of skin and subcutaneous tissue | 91 | 46 | 87 | 55 | 87 |

| | | | | | |
|---|---|---|---|---|---|
| Hypertrophy of tonsils and adenoids | 93 | 68 | 96 | 69 | 94 |
| Typhoid fever | 94 | 91 | 107 | 91 | 103 |
| Bacillary dysentery and amoebiasis | 94 | 18 | 82 | 35 | 88 |
| Influenza | 94 | 42 | 90 | 53 | 91 |
| Non-toxic goitre | 97 | 53 | 93 | 59 | 92 |
| Whooping cough | 98 | 138 | 116 | 138 | 110 |
| Infections of skin and subcutaneous tissue | 98 | 84 | 106 | 84 | 103 |
| Streptococcal sore throat and acarlet fever | 100 | 29 | 94 | 44 | 97 |
| Calculus of urinary system | 101 | 111 | 113 | 111 | 110 |
| Haemorrohage of pregnancy and childbirth | 101 | 37 | 97 | 9* | 90* |
| Spina bifidia | 103 | 63 | 105 | 65 | 105 |
| Paratyphoid fever & other salmonela infections | 104 | 27 | 98 | 43 | 102 |
| 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 cenral 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: Prob denotes probability of death, LLE denotes Lost Life Expectancy, 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 marked with * values of the corresponding Disc LLE and Disc EYLL were not lagged.

Since we started our mortality investigation for the year 1999, data for the year 2000 became available and naturally we wanted to test the 2000 data as well. The presentation of results involves a considerable length of tables that are avoided to save space. But, we state that our findings for the year 2000 also confirm a reordering of mortality risks as presented in Section 2. However, we compare the mortality risk ranks for the two years and present them in Section 3.

## 3. Tests

As we obtained the year 2000 data, we carried out the exercises conducted in section 2 on this new data. The results confirmed our findings as for 1999. But here we present the results of our 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 for example Spatz and Johnston (1989) and Daniel (1990).

The Mann-Whitney U test for a change in the location of population distribution is calculated and the results are shown in Table 5. We have also calculated the Spearmen rank correlation coefficient to test the strength of association between the two mortality risk rankings.

For the Spearman rank correlation coefficient the null hypothesis $H_0$ is that the observed ranks of mortality risks in 1999 and 2000 are positively correlated against the alternative $H_1$ that they are independent.

For Mann-Whitney U test, the null hypothesis $H_0$ is that there has been no change in mortality risk ranking from 1999 to 2000 against the alternative $H_1$ that there has been a shift in the distribution of mortality risk rankings.

Table 5. Nonparametric tests of mortality risk ranking

| 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 |

Note: LLE denotes Lost Life Expectancy, EYLL denotes Expected Years of Life Lost and $z = r_s\sqrt{J-1}$.

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. We are trying to see if the orders in which various mortality causes appear in our 1999 sample are different from the 2000 sample. That is, whether some causes have become more or less significant in terms of posing a risk according to the measures of risk LLE, EYLL or probability to individuals. If an event A caused more deaths in 2000 than in 1999, its rank among the 151 causes would change. This change in rank reduces the correlation between the two samples. For large samples, i.e. 100 pairs or more $r_s\sqrt{J-1}$ is distributed approximately normally and its test of significance is compared with the corresponding standard normal tables. The z-score is therefore a function of ranks of data.

However, the smaller value of 0.6861 for the Spearman rank correlation coefficient for LLE indicates that there has been some variation in the age composition of death frequencies with probabilities of deaths remaining fairly unchanged. 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, I think would have to be in the properties of non-parametric statistics. EYLL is found through a non-linear operation ( $p_j\left(LLE_j\right)$), 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.

For example in Table 4, for "Other causes of prenatal morbidity and mortality" probability of death 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 "Schistosomiasis" rank 140 in probability, but the LLE's are 78 and 71 while the corresponding EYLL have remained unchanged at 140. While for "Erysipelas" 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 years). 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 Table 5 the coefficient of correlation, which is a parametric test, is only shown to make a comparison with the Spearman rank correlation coefficient, which is a nonparametric test. As expected this nonparametric test gives a very close result to its parametric counterpart. Their differences in Table 5 are in the third and forth decimal places.

In order to test for correlation in the ranks of mortality risks we use a large sample approximation as suggested in Daniel (1990). Our data includes 151 pairs of observations, thus z scores are calculated which are approximately distributed as standard normal. If both $r$ and $r_s$ in Table 5 were to be considered, they show very significant positive correlation between mortality risk rankings. The values are statistically significant at 0.1% level of significance.

The z scores which are approximately N(0,1), are very significant. The probability of a z = 4 is 0.99997[2]. Thus, we accept the null hypothesis of positive correlation between 1999 and 2000 mortality risk rankings. The two mortality risk ranks are highly correlated.

With the Mann-Whitney U test in Table 5 we accept the null hypothesis of no shift in the distribution of our mortality risk rankings. The results are statistically significant at 5% level.

The test results in this section indicate that mortality risk measures offered in section 2, are carried over to year 2000 and that there are no statistically significant changes in the order of mortality risk ranking in our observations.

## 4. Conclusion

This study re-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 the VCH findings that a major reordering of mortality risk ranks takes place once we allow for the risk weighting measures. The conditions that appear in the same rank order for the same measure of mortality risks are very similar in the two studies. The most significant risks facing the population in both studies are

heart conditions that rank first. Cancer also appears as ranking high in both studies. But medical classification of health conditions, as they appear in the published data require some medical judgment, not present in this author to evaluate and compare like with like between the two studies. The results of nonparametric tests in Section 3, confirms that the mortality risk ranking has remained the same for two years.

As the way effects of regulation may change the mortality risk present 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.

**Appendix A**

Let $N_0$ be population born during period t = 0 (i.e. a cohort).

$M_t$ number of people i.e. the best estimate at the beginning of period t.

$S_t$ survivors at the end of period t.

$D_t$ number of deaths in year t.

$D_{tx}$ number of x year olds died in period t,

$\gamma_t$ population death rate at time t.

$B_t$ number of newborn in year t.

$\beta_t$ birth rate in year t.

$l_t$ life expectancy at age t.

Using induction and assuming a cohort, we can find number of survivors aged t, at the end of period t.

At $t=0,\ \gamma_0 = \dfrac{D_0}{N_0}$ $\qquad S_0 = N_0 - D_0 = N_0(1-\gamma_0)$

$t=1,\ \gamma_1 = \dfrac{D_1}{S_0},$ $\qquad S_1 = S_0 - D_1 = (1-\gamma_1)S_0 = (1-\gamma_0)(1-\gamma_1)N_0$

$t=2,\ \gamma_2 = \dfrac{D_2}{S_1},$ $\qquad S_2 = S_1 - D_2 = (1-\gamma_0)(1-\gamma_1)(1-\gamma_2)N_0$

$\vdots$

$t=t,\ \gamma_t = \dfrac{D_t}{S_{t-1}},$

Therefore, $S_t = \prod_{i=0}^{t}(1-\gamma_i)N_0$ this is our equation (1) in the text where survivors at the end of period t are t years old.

Now suppose we have a best estimate of the population at time t ($M_t$) and allow for newborns such that the number of x year olds dying in period t is $D_{tx}$ and the number of x year olds surviving at the end of period t, is $S_{tx}$. Assuming an equal birth and death rates with no immigration or emigration such that the population remains stable, we can find the number of survivors at the end of period t.

At $t=0,\ D_0 = \sum_{\forall x} D_{0x}$ and $\gamma_0 = \sum_{\forall x}\gamma_{0x}$

where $\gamma_{0x} = \dfrac{D_{0x}}{M_0}$ and $\beta_0 = \dfrac{B_0}{M_0}$

Therefore $\gamma_0 = \dfrac{D_0}{M_0},$ $\qquad$ and $S_0 = M_0 - D_0 + B_0$

Now substituting for birth and death rates we get $S_0 = M_0(1-\gamma_0+\beta_0)$

At $t = 1$, $D_1 = \sum_{\forall x} D_{1x}$ and $\gamma_1 = \sum_{\forall x} \gamma_{1x}$

where $\gamma_{1x} = \frac{D_{1x}}{M_1}$ and $\beta_1 = \frac{B_1}{M_1}$

Therefore $\gamma_1 = \frac{D_1}{M_1}$ and $S_1 = M_1 - D_1 + B_1$

Substituting for $M_1$, $D_1$ and $B_1$ we get,

$$S_1 = M_0(1 - \gamma_0 + \beta_0)(1 - \gamma_1 + \beta_1)$$

Therefore, by induction we find that,

At $t = t$, $S_t = M_0 \prod_{i=0}^{t} (1 - \gamma_i + \beta_i)$

This is equation (6) in the text.

**Appendix B**

In order to test for Spearman rank correlation coefficient, we calculate

$$r_s = 1 - \frac{6\sum_{j=1}^{J}\left(R(X_j) - R(Y_j)\right)^2}{J\left(J^2-1\right)}$$

Where J is equal to 151, the number of pairs of observations $R(X_j)$ is the rank of our first observations and $R(Y_j)$ is the rank of our second observations. However as our sample is large, we use a large sample approximation i.e. for $J(=151) > 100$, we use $z = r_s\sqrt{J-1}$ as suggested in Daniel(1990) which is distributed approximately as a standard normal.

To test any shift in the distribution of our data in 1999 and 2000, we use a Mann-Whitney U test. The test statistic is (Daniel (1990))

$U = S - \frac{n_1(n_2+1)}{2}$ where $S = \sum_{j=1}^{151} rank(X_j)$ and $n_1 = n_2 = J = 151$.

As our sample is large, we use a normal approximation with a z score distributed as $z \approx N\left(\frac{n_1 n_2}{2} \quad , \quad \frac{n_1 n_2(n_1+n_2+1)}{12}\right)$ and compare the result with a standard normal. But given a relatively large number of ties, we use a correction suggested in Daniel (1990), thus our z score is

$$z = \frac{U - \frac{n_1 n_2}{2}}{\sqrt{\frac{n_1 n_2(n_1+n_2+1)}{12} - \frac{n_1 n_2\left(\sum_{j=1}^{151} t_j{}^3 - \sum_{j=1}^{151} t_j\right)}{12(n_1+n_2)(n_1+n_2-1)}}}$$

Where $t_j$ is the number of ties for a given rank.

## Appendix C

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 |

## Bibliography


Brown, R.L. (1997), Introduction to the Mathematics of Demography, 3rd ed., Actex Publications.

Daniel, W.W. (1990) Applied Nonparametric Statistics, 2nd ed., PWS-Kent Publishing Company.

Diamond, P. (1992) Organizing the Health Insurance Market, *Econometrica*, 60, 6, 1233-1254.

Eeckhoudt, L.T. and J.K. Hammitt (2001) Background Risks and the Value of a Statistical Life, *Journal of Risk and Uncertainty*, 23,3,261-279.

Jenni, K.E. and G. Lowenstein (1997) Explaining the "Identifiable Victim Effect", *Journal of Risk and Uncertainty*, 14,235-257.

Lundley, D.V. and J.C.P. Miller (1952) Cambridge Elementary Statistical Tables, Cambridge University Press.

Moore, M.J. and W.K. Viscusi (1988) The Quality-Adjusted Value of Life, *Economic Inquiry*, 26,3,369,388.

Mortality Table Annual Almanac (1999) Iranian Ministry of Health, Tehran, Iran.

Pratt, J.W. and J. Zeckhauser (1996) Willingness to Pay and the Distribution of Risk and Wealth, *Journal of Political Economy*, vol.104, No.4: 747-763.

Sloan, F.A. (1995) Valuing health Care, Cambridge University Press.

Spatz, C. and J.O. Johnston (1989) Basic Statistics, 4th ed., Brooke/Cole Publishing Company.

Viscusi, W.K. (1993) The Value of Risks of Life and Health, *Journal of Economic Literature*, 31,4,1912-1946.

----------(1995) Discounting Health Effects for Medical Decisions, in F.A. Sloan, ed. Valuing Health Care, Cambridge University Press.

----------, J.K. Hakes and A. Carlin (1997) Measures of Mortality Risks, *Journal of Risk and Uncertainty,* 14: 213-233.

---------- and M.J. Moore (1989) Rates of Time Preference and Valuations of the Duration of Life, *Journal of Public Economics*, 8(3), 393-417.

Weitzman, M. (2001) "Gamma Discounting" *American Economic Review,* vol. 91, No.1, pp260-271.

Zanjani, H. and T. Noorallahi (1999) The Iranian Life Table for 1996, The Higher Institute for Social Security Research, Tehran, Iran.


---

## Notes

[1] See for example, Eeckhoudt and Hammitt (2001), Pratt and Zeckhauser (1996), Viscusi (1993) and Moore and Viscusi (1988).

[2] Lundley and Miller (1952).