Chapter 4
The Health-Mortality Approach in Estimating the Healthy Life Years Lost Compared to the Global Burden of Disease Studies and Applications in World, USA and Japan

4.1 Introduction

Starting from the late 1980s a Global Burden of Disease (GBD) study was applied in many countries reflecting the optimistic views of many researchers and policy makers worldwide to quantify the health state of a population or a group of persons. In the time course they succeeded in establishing an international network collecting and providing adequate information to calculate health measures under terms as Loss of Healthy Life Years (LHLY) or Healthy Life Expectancy (HALE). The latter tends to be a serious measure important for the policy makers and national and international health programs. So far the process followed was towards statistical measures including surveys and data collection using questionnaires and disability and epidemiological data as well (McDowell 2006). They faced many views referring to the definition of health and to the inability to count the various health states and of course the different cultural and societal aspects of the estimation of health by various persons worldwide. Further to any objections posed when trying to quantify health, the scientific community had simply to express with strong and reliable measures that millions of people for centuries and thousands of years expressed and continue to repeat every day: That their health is good, fair, bad or very bad. As for many decades the public opinion is seriously quantified by using well established statistical and poll techniques it is not surprising that a part of these achievements helped to improve, establish and disseminate the health state measures. However, a serious scientific part is missing or it is not very much explored that is to find the model underlying the health state measures. Observing the health state measures by country from 1990 until nowadays it is clear that the observed and estimated health parameters follow a rather systematic way. If so why not to find the process underlying these measures? It will support the provided health measures with enough documentation while new horizons will open towards better estimates and data validation. From the early 1990s we have introduced and applied

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methods, models and techniques to estimate the health state of a population. The related results appear in several publications and we have already observed that our estimates are related or closely related to the provided by the World Health Organization (WHO) and other agencies as Eurostat or experts as the REVES group. However, our method based on a difficult stochastic analysis technique, is not easy to use especially by practitioners. The last four centuries demography and demographers are based on the classical Life Tables. Thus here we propose a very simple model based on the mortality μ_x of a population provided in a classical life table. To compare our results with those provided by WHO we use the μ_x included in the WHO abridged life tables. Our estimates are compared with the HALE estimates for all the WHO countries. Even more we provide the related simple program in Excel which provides immediately the Life Expectancy, the Loss of Healthy Life Years and the Healthy Life Expectancy estimate. The comparisons suggest an improved WHO estimate for the majority of the countries. There are countries results differing from the model and need further study.

4.1.1 Further Details

The Global Burden of Disease Study explored the health status of the population of all the countries members of the World Health Organization (WHO). It is a large team work started more than 25 years ago (see Murray and Lopez 1997, 2000; Mathers et al. 2000; Salomon et al. 2012; Murray et al. 2015; Hausman 2012; Vos et al. 2010; Robine et al. 1999; WHO 2001, 2002, 2004, 2013, 2014 and many other publications). The last years, with the financial support of the Bill and Melinda Gates foundation, the work was expanded via a large international group of researchers. The accuracy of the data collection methods was improved along with the data development and application techniques. So far the health status indicators were developed and gradually were established under terms as healthy life expectancy and loss of healthy life years. Methods and techniques developed during the seventies and eighties as the Sullivan method (Sullivan 1971) were used quite successfully. Several publications are done with the most important included in The Lancet under the terms DALE and HALE whereas a considerable number can be found in the WHO and World Bank publications. The same half part of a century several works appear in the European Union exploring the same phenomenon and providing more insight to the estimation of the health state of a population and providing tools for the estimation of severe, moderate and light disability. The use of these estimates from the health systems and the governments is obvious. To a surprise the development of the theoretical tools was not so large. The main direction was towards to surveys and collection of mass health state data instead of developing and using theoretical tools. The lessons learned during the last centuries were towards the introduction of models in the analysis of health and mortality. The classical examples are Edmund Halley for Life Tables and Benjamin Gompertz for the law of mortality and many others. Today our ability to use mass storage tools as the computers and the extensive application of surveys and polls to many political, social and economic activities directed the main health state studies. In other words we give much attention to opinions of the people for their health status followed by extensive health data collection. However, it remains a serious question: can we validate the health status results? As it is the standard procedure in science a systematic study as the Global Burden of Disease should be validated by one or more models. Especially as these studies are today the main tool for the health programs of many countries the need of verification is more important. People reply according to their experience. Two main approaches arise: The mortality focus approach and the health status approach. Although both look similar responds may have significant differences. The main reason is that health is a rather optimistic word opposed to the pessimistic mortality term. Twenty years ago we provided a model to express the health state of a population. We developed and expanded this model leading to a system providing health status indexes. Here we propose several methodologies to estimate the health indexes and to compare with the provided by WHO.

4.2 The Mortality Approach

4.2.1 The Simplest Model

We need a simple model to express the health status. The best achievement should be to propose a model in which the health measure should be presented by only one main parameter. We thus propose a two parameter model with one crucial health parameter:

$$\mu_x = (\frac{x}{T})^b, \tag{4.1}$$

The parameter T represents the age at which $\mu_x = 1$ and b is a crucial health state parameter expressing the curvature of μ_x. As the health state is improved b gets higher values. This simple model is illustrated in Fig. 4.1 where μ_x is plotted against the age x. The straight line (OA) expresses the simplest case with $b = 1$. As b is taking higher values the form of the graph for μ_x follows an exponential path of the curve (OCA). For high values of b the curve approaches asymptotically the path (OBA)

The main task is to find the area E_x under the curve OCABO in the mortality diagram (see Fig. 4.1) which is a measure of the mortality effect. This is done by estimating the integral

$$E_x = \int_0^T (\frac{x}{T})^b dx = \frac{T}{b+1}(\frac{x}{T})^b, \tag{4.2}$$

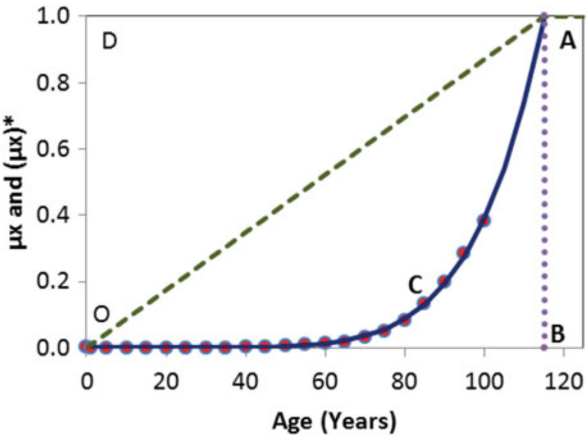

Fig. 4.1 The mortality diagram

The resulting value for E_x in the interval $[0, T]$ is given by the simple form:

$$E_{mortality} = \frac{T}{b+1} \tag{4.3}$$

It is clear that the total information for the mortality is the area provided under the curve μ_x and the horizontal axis. The total area E_{total} of the healthy and mortality part of the life span is nothing else but the area included into the rectangle of length T and height 1 that is $E_{total} = T$. The health area is given by

$$E_{health} = T - E_{mortality} = T - \frac{T}{b+1} = \frac{bT}{b+1}, \tag{4.4}$$

Then a very simple relation arises for the fraction $E_{health}/E_{mortality}$ that is

$$\frac{E_{health}}{E_{mortality}} = b \tag{4.5}$$

This is the simplest indicator for the loss of health status of a population. As we have estimated by another method it is more close to the severe disability causes indicator. The relation $E_{total}/E_{mortality}$ provides another interesting indicator of the form:

$$\frac{E_{total}}{E_{mortality}} = b + 1, \tag{4.6}$$

This indicator is more appropriate for the severe and moderate disability causes indicator (It is compatible with our estimates using the health state approach). It provides larger values for the disability measures as the E_{total} is larger or the $E_{mortality}$ area is smaller by means that as we live longer the disability period becomes larger. This method suggests a simple but yet interesting tool for classification of various countries and populations, for the loss of healthy life years. A correction multiplier λ should be added for specific situations so that the estimator of the loss of healthy life years should be of the form:

$$LHLY = \lambda \frac{E_{total}}{E_{mortality}} = \lambda(b+1)$$

$$LHLY = \lambda \frac{E_{total}}{E_{mortality}} = b+1$$

However, for comparisons between countries it is sufficient to select $\lambda = 1$. Even more the selection of $\lambda = 1$ is appropriate when we would like to develop a quantitative measure for the LHLY without introducing the public opinion for the health status and the estimates for the cause of diseases and other disability measures. From another point of view the influence of the health status of the society to the public opinions related to health may cause differences in the values for LHLY estimated with the HALE method thus a value for λ larger or smaller than unity is needed. By means that we will have to measure not exactly the health status but the public opinion related to the health status, the latter leading in a variety of health estimates in connection to socioeconomic and political situation along with crucial health information from the mass media. Both measures, the standard measure with $\lambda = 1$ and the flexible one with λ different from 1 could be useful for decision makes and health policy administrators and governmental planners. To our great surprise our model by selecting $\lambda = 1$ provided results very close to those provided by WHO as it is presented in the following Tables and in other applications. It is clear that we have found an interesting estimator for the loss of healthy life years. Our idea to find the loss of healthy life years as a fraction of surfaces in a mortality diagram was proven to be quite important for expressing the health state measures. A more detailed method based on the health state stochastic theory is presented in the book on The Health State Function of a Population and related publications (see Skiadas and Skiadas 2010b, 2012a, 2015) where more health estimators are found.

4.2.1.1 Application Details

As our method needs life table data we prefer to use full life tables when available. The Human Mortality Database is preferred for a number of countries providing full life tables. However, only a small part of the world countries are included and thus we also use the abridged life tables provided by the World Health Organization. The new abridged life tables from WHO including data from 0 to 100 years provide good results when applying our method. Instead the previous life tables (0 to 85 years) are not easily applied. It could be possible to use these life tables by expanding from 85 to 100 years. For both the abridged and the full life table data we have developed the appropriate models and estimation programs in Excel thus make it easy to use.

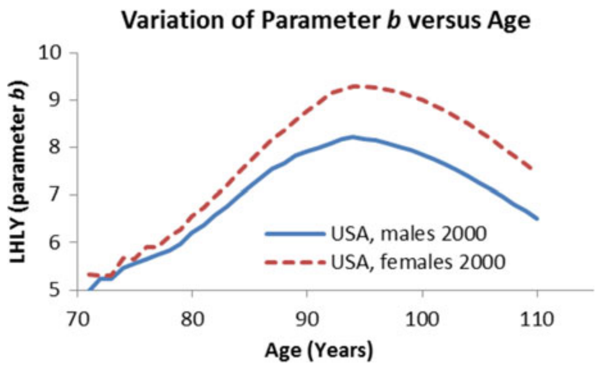

Fig. 4.2 Development of the health parameter

4.2.1.2 Stability of the Coefficients of the Simple Model

Here we discuss some important issues regarding the application of the simple model proposed by Eq. (4.1). To apply this model to data we use a non-linear regression analysis technique by using a Levenberg-Marquardt algorithm. The data are obtained from the WHO database providing abridged life tables of the 0–100 years form. The important part of the model is the parameter b expressing the loss of healthy life years. Even more b can express the curvature of mortality function μ_x. Applying the model to data we need a procedure for the selection of the most appropriate value for b.

4.2.1.3 When *b* Should Be Accepted

The simpler is to find if b follows a systematic change versus age. We start by selecting all the n data points $(m_0, m_1, \ldots, m_n)$ for μ_x to find b and then we select $n-1, n-2, \ldots, n-m$ for a sufficient number of $m < n$. As is presented in Fig. 4.2 the parameter b follows a systematic change. The example is for USA males and females the year 2000 and the data are from the full life tables of the Human Mortality Database. As it is expected b is larger for females than for males. In both cases a distinct maximum value in a specific year of age appears. Accordingly a specific minimum appears for the other not so important parameter T (see Fig. 4.3). It is clear that only the specific maximum value for b should be selected. Even more the estimates for the maximum b account for a local minimum for the first difference dx' of dx provided from the life table. Next Fig. 4.4 illustrates this case for USA males the year 2000 along with a fit curve from our model SK-6. The maximum b is at 94 years for males and females the same as for the minimum of the first difference corresponding to the right inflection point of the death curve dx. Table 4.1 includes the parameter estimates for b and T the year 2000 for USA males and females.

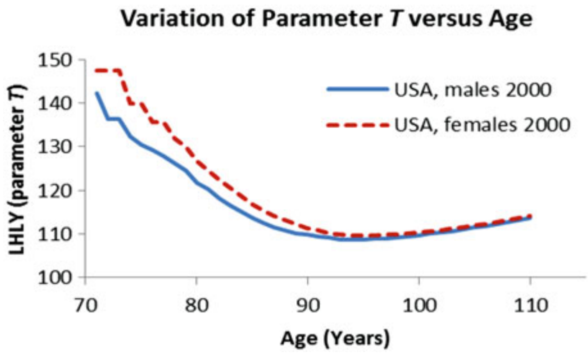

Fig. 4.3 Development of T parameter

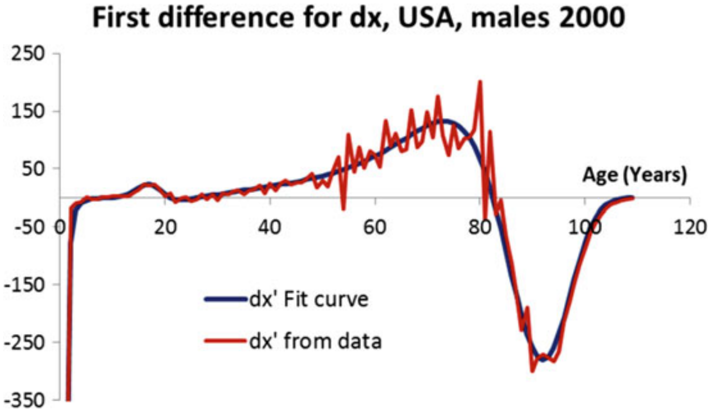

Fig. 4.4 First difference (derivative) of *dx* versus age

4.2.2 Estimation Without a Model (Direct Estimation)

As the needed data sets in the form of m_x or q_x data are provided from the life tables we have developed a method of direct estimation of the loss of healthy life year estimators directly from the life table by expanding the life table to the right.

$$b + 1 = \frac{E_{total}}{E_{mortality}} = \frac{xm_x}{\sum_0^x m_x}, \tag{4.7}$$

$$b = \frac{E_{health}}{E_{mortality}} = \frac{xm_x - \sum_0^x m_x}{\sum_0^x m_x} = \frac{xm_x}{\sum_0^x m_x} - 1, \tag{4.8}$$

The only needed is to estimate the above fractions from the life table data. A similar indicator results by selecting the q_x data from the life table and using the:

Table 4.1 Parameter estimates for the model (USA, 2000)

Age	Females		Males		Age	Females		Males	
Years	b	T	b	T	Years	b	T	b	T
71	5.318	147.5	4.975	142.3	91	8.942	110.7	7.992	109.4
72	5.308	147.5	5.244	136.4	92	9.143	110.0	8.081	109.1
73	5.296	147.5	5.231	136.4	93	9.224	109.8	8.173	108.8
74	5.663	140.0	5.459	132.3	94	9.291	109.6	8.218	108.6
75	5.649	140.0	5.559	130.5	95	9.286	109.6	8.189	108.7
76	5.905	135.6	5.642	129.2	96	9.263	109.6	8.148	108.8
77	5.896	135.6	5.736	127.8	97	9.224	109.7	8.094	109.0
78	6.146	131.9	5.844	126.3	98	9.167	109.9	8.027	109.2
79	6.280	130.1	5.981	124.5	99	9.093	110.1	7.947	109.4
80	6.551	126.8	6.214	121.8	100	9.002	110.3	7.856	109.7
81	6.748	124.6	6.368	120.2	101	8.896	110.6	7.754	110.0
82	6.972	122.5	6.587	118.2	102	8.775	110.8	7.642	110.3
83	7.209	120.4	6.774	116.6	103	8.641	111.2	7.521	110.7
84	7.453	118.5	6.981	115.0	104	8.495	111.5	7.391	111.0
85	7.710	116.8	7.186	113.6	105	8.339	111.9	7.255	111.4
86	7.947	115.3	7.378	112.5	106	8.173	112.3	7.114	111.8
87	8.185	114.0	7.546	111.5	107	8.000	112.7	6.967	112.3
88	8.369	113.1	7.665	110.9	108	7.822	113.1	6.818	112.7
89	8.579	112.2	7.826	110.1	109	7.638	113.5	6.666	113.2
90	8.778	111.3	7.916	109.8	110	7.452	114.0	6.512	113.6

$$b + 1 = \frac{E_{total}}{E_{mortality}} = \frac{xq_x}{\sum_0^x q_x}, \tag{4.9}$$

$$b = \frac{E_{health}}{E_{mortality}} = \frac{xq_x - \sum_0^x q_x}{\sum_0^x q_x} = \frac{xq_x}{\sum_0^x q_x} - 1, \tag{4.10}$$

In both cases the results are similar as it is presented in the following Figs. 4.5 and 4.6. The estimates from m_x are slightly larger than from q_x. In both cases the b estimators growth to a maximum at old ages and then decline. The selected b or $b + 1$ indicator for the life years lost from birth are those of the maximum value. A smoothing technique averaging over 5 years estimators is used to avoid sharp fluctuations in the maximum range area for the direct method. For the Model method a simple 3 point averaging gives good results. The maximum HLYL for the direct estimation is 9.84 for m_x and 9.26 for q_x. For the Model estimation with m_x data the related HLYL is 10.0. As we have estimated for other cases both the estimation of the b indicator by this direct method and the method by using a model give similar results.

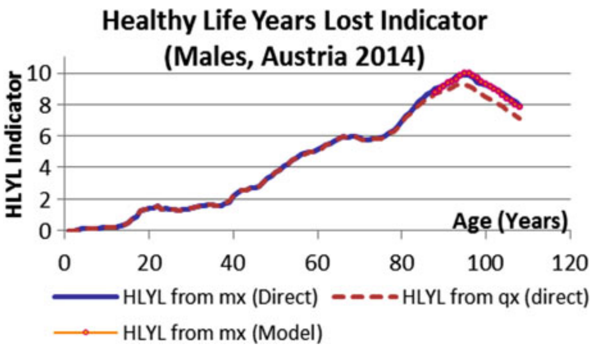

Fig. 4.5 Estimation of the HLYL indicator (b) by the direct method and by the simple model (Full results)

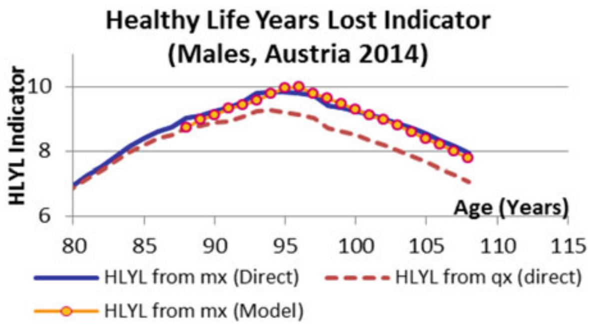

Fig. 4.6 Estimation of the HLYL indicator (b) by the direct method and by the simple model (expanded around the maximum)

4.2.3 More Details: The Gompertz and the Weibull Distributions

It should be noted that a more convenient (Gompertz 1825) model form is provided by Carriere (1992) in the form $\mu_x = Bc^x$, where B and c are parameters. This is close to our simple model selected. However, we have also selected and applied the following form for the probability density function of the Gompertz model:

$$f_x = e^{-k+bx-e^{-l+bx}}, \tag{4.11}$$

The characteristic parameter expressing the loss of healthy life years is the parameter l. this is also demonstrated by observing the cumulative distribution function of the form:

$$F_x = e^{-e^{-l+bx}}, \tag{4.12}$$

The related survival function is

$$S_x = 1 - e^{-e^{-l+bx}}, \tag{4.13}$$

The probability density function is:

$$f_x = be^{-l+bx}e^{-e^{-l+bx}}, \tag{4.14}$$

And the hazard function is

$$h(x) = \frac{f_x}{F_x} = be^{-l+bx} = e^{\ln b - l + bx} = e^{-k+bx}, \tag{4.15}$$

Thus explaining the above Gompertz form selected ($k = l - \ln(b)$). The selected value for the estimation of the healthy life years lost is provided by the parameter l. In the same paper Carriere suggests the use the Weibull model. This model has density function (b and T are parameters):

$$f_x = \frac{b}{T}(\frac{x}{T})^{b-1}e^{-(\frac{x}{T})^b}, \tag{4.16}$$

The Weibull model provides an important form for the hazard function:

$$h(x) = \frac{b}{T}(\frac{x}{T})^{b-1}, \tag{4.17}$$

Even more the cumulative hazard is given by:

$$H(x) = (\frac{x}{T})^b, \tag{4.18}$$

Another important point is that the Cumulative Hazard provided by the Weibull model is precisely the form for the simple model presented earlier and the parameter b expresses the healthy life years lost.

4.3 The Health State Models

4.3.1 The Health State Distribution

Although the health state models are introduced from 1995 (see Janssen and Skiadas 1995 and more publications from Skiadas and Skiadas 2007, 2010b, 2012a, 2014) few applications appear. The main reason is due to the very laborious first exit time stochastic theory needed and that it is assumed that the use of the Gompertz and the Weibull models along with the related extensions give enough tools for the practical applications. This is not correct as the first exit time stochastic models are produced by using one of the most elegant and accurate methodology to model the health-death process as it is demonstrated in the following. The probability distribution of the general health state model is of the form (see Jennen and Lerche 1981):

$$f(x) = \frac{|H - xH'|}{\sigma\sqrt{2\pi x^3}} e^{-\frac{[H(x)]^2}{2\sigma^2 x}}, \quad (4.19)$$

For the main applications in Demography we can set $\sigma = 1$ reducing to the simpler from:

$$f(x) = \frac{|H - xH'|}{\sqrt{2\pi x^3}} e^{-\frac{[H(x)]^2}{2x}}, \quad (4.20)$$

While the simpler form arises for the following health state function

$$H(x) = l - (bx)^c, \quad (4.21)$$

That is

$$f(x) = \frac{|l + (c-1)(bx)^c|}{\sqrt{2\pi x^3}} e^{-\frac{[l-(bx)^c]^2}{2x}}, \quad (4.22)$$

The simpler model of this form arises when $c = 1$ and it is the so-called Inverse Gaussian expressing the probability density function for the first exit time of a linearly decaying process:

$$f(x) = \frac{|l|}{\sqrt{2\pi x^3}} e^{-\frac{[l-(bx)]^2}{2x}}, \quad (4.23)$$

Applications of this or similar type forms can found in Ting and Whitmore (2006) and in Weitz and Fraser (2001). The last model as right skewed cannot express the human death process expressed by a highly left skewed probability density function. Instead the previous 4-parameter model is applied very successfully. Even more this form is very flexible providing very good fitting in the case of high levels of infant mortality, as it was the case for time periods some decades ago and also for nowadays when infant mortality is relatively low. Two different options arise for the model. That corresponding to the health state estimation with the parameter l expressing the high level of the health state and represented with Figs. 4.7 and 4.9 and another form with low levels for the parameter l expressing the Infant Mortality (see Figs 4.8 and 4.10). In the latter case the form of the density function is:

$$f(x) = \frac{2|l + (c-1)(bx)^c|}{\sqrt{2\pi x^3}} e^{-\frac{[l-(bx)^c]^2}{2x}}, \quad (4.24)$$

When the parameter l is very small a 2-parameter model termed here as the Half-Inverse Gaussian distribution results:

$$f(x) = \frac{2|(c-1)(bx)^c|}{\sqrt{2\pi x^3}} e^{-\frac{[-(bx)^c]^2}{2x}}, \quad (4.25)$$

The name arises from the similarity of this form with the Half-Normal distribution.

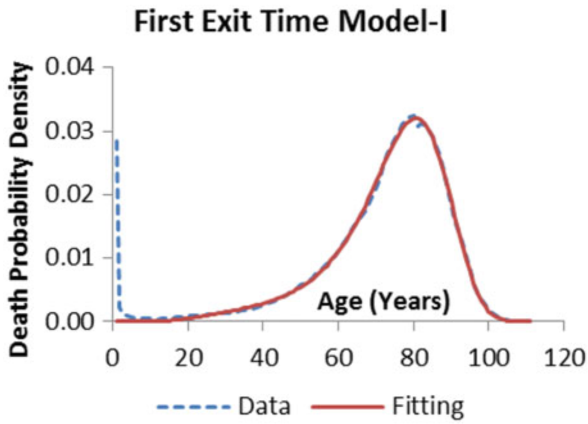

Fig. 4.7 First exit time model applied in USA death probability density for females the year 1950

Fig. 4.8 First exit time model-IM including the infant mortality applied in USA death probability density for females the years 1950

The advantage of the proposed half-inverse Gaussian or IM-Model for the infant mortality modeling is obvious in the case of the application in USA females in 1950. The IM-Model provides a fairly well $R^2 = 0.990$ instead of $R^2 = 0.920$ for the Health State Model which provides similar results with the 2-parameter model (see the Table 4.2). The resulting R^2 for the year 2010 in USA females are similar as the infant mortality is relatively small (see Figs. 4.9 and 4.10 and Table 4.2).

4.3.2 An Important Extension: The Simplest IM-Model

Jennen (1985) suggested a second order approximation to improve the previous model with the first order approximation form:

$$f(x) = \frac{|H - xH'|}{\sqrt{2\pi x^3}} e^{-\frac{[H(x)]^2}{2x}}, \tag{4.26}$$

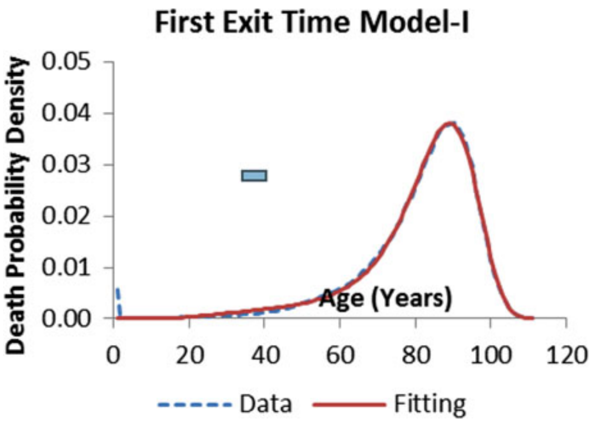

Fig. 4.9 First exit time model applied in USA death probability density for females the year 2010

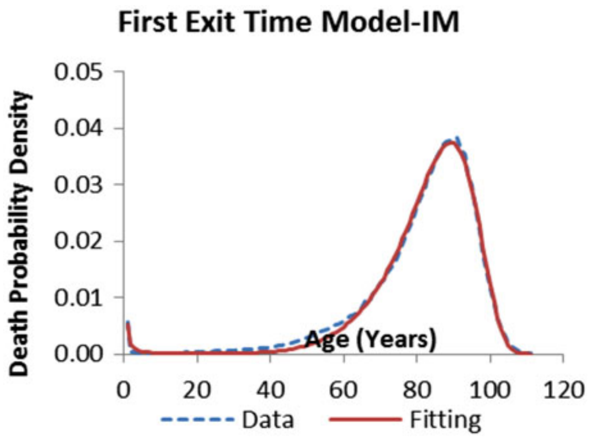

Fig. 4.10 First exit time model-IM including the infant mortality applied in USA death probability density for females the years 2010

Table 4.2 Parameters of the models

Year	2010	2010	2010	1950	1950	1950
Parameter/R^2	Health state	IM model	2-parameter	Health state	IM model	2-parameter
c	5.28	7.91	7.91	4.18	6.26	6.27
b	0.0192	0.0148	0.0148	0.0239	0.0173	0.0173
l	13.84	0.0066	–	13.05	0.0314	–
R^2	0.993	0.995	0.993	0.920	0.990	0.927

However, we propose and apply here a simpler form adequate for the applications in demography data:

$$f(x) = \frac{2}{\sqrt{2\pi}}\left[\frac{|H - xH'|}{\sqrt{x^3}} + \frac{k\sqrt{x^3}H''}{2|H - xH'|}\right]e^{-\frac{[H(x)]^2}{2x}}, \tag{4.27}$$

The parameter k expresses the level of the influence of the second order correction term. When $k = 0$ the last equation form reduces to the first order approximation. The next step is to use the expression presented earlier for $H(x)$ to find the advanced form of IM-model:

$$f(x) = \frac{2}{\sqrt{2\pi}}\left[\frac{|l + (c-1)(bx)^c|}{\sqrt{x^3}} - \frac{k\sqrt{x^3}c(c-1)b^c x^{(c-2)}}{2|l + (c-1)(bx)^c|}\right]e^{-\frac{[l-(bx)^c]^2}{2x}}, \qquad (4.28)$$

This is the simpler 4-parameter model providing quite well fitting for the logarithm of the force of mortality, providing not only good estimates for the infant mortality but also very good estimates for all the period of the life time for males and females as is illustrated in Figs. 4.11, 4.12, 4.13, 4.14, 4.15, and 4.16. We have thus demonstrated that the model proposed in 1995 and the new versions and advanced forms provided in several publications and in this paper, approach fairly well the mortality data sets provided by the bureau of the census and statistical agencies. This is important in order to straighten the findings when applying the first exit time theory to life table data.

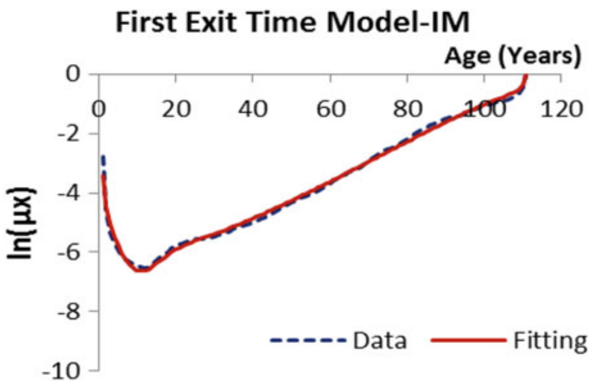

Fig. 4.11 The first exit time model-IM including the infant mortality applied in the USA force of mortality data in logarithmic form for males the year 1933

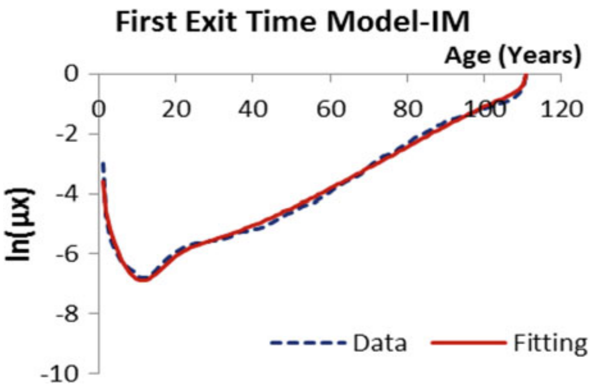

Fig. 4.12 The first exit time model-IM including the infant mortality applied in the USA force of mortality data in logarithmic form for females the year 1933

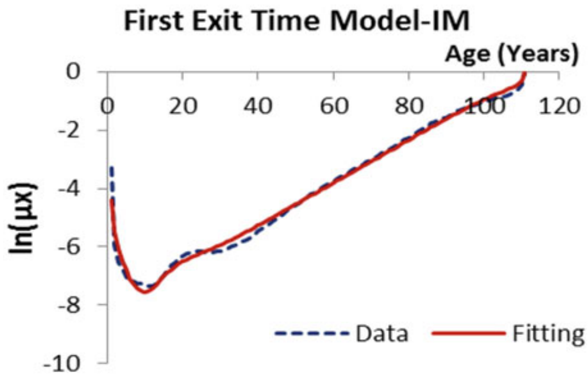

Fig. 4.13 The first exit time model-IM including the infant mortality applied in the USA force of mortality data in logarithmic form for males the year 1950

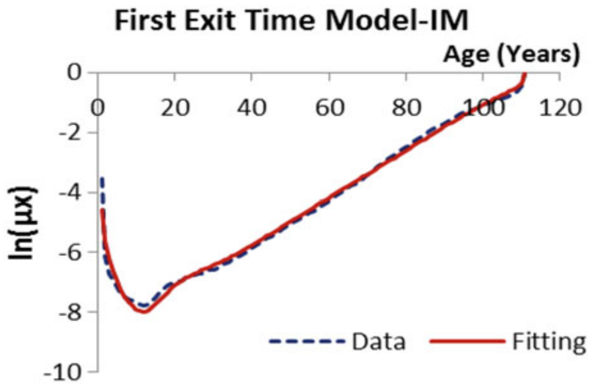

Fig. 4.14 The first exit time model-IM including the infant mortality applied in the USA force of mortality data in logarithmic form for females the year 1950

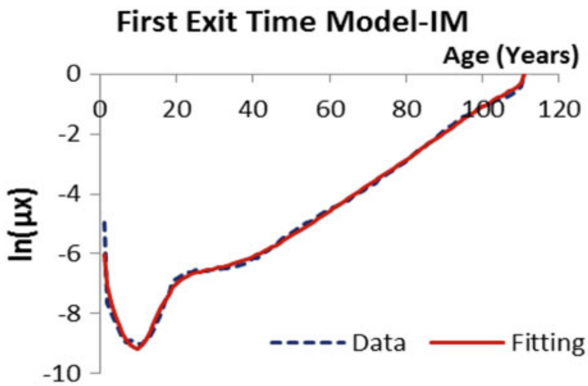

Fig. 4.15 The first exit time model-IM including the infant mortality applied in the USA force of mortality data in logarithmic form for males the year 2010

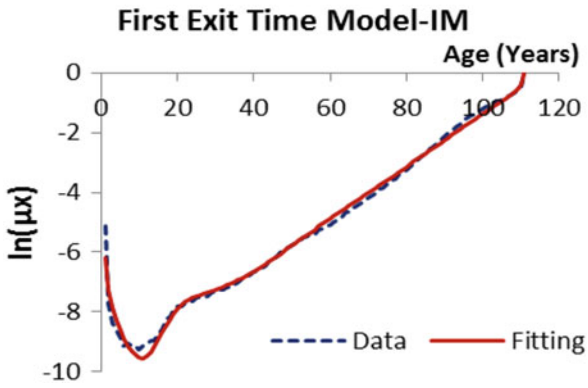

Fig. 4.16 The first exit time model-IM including the infant mortality applied in the USA force of mortality data in logarithmic form for females the year 2010

4.3.3 The Health State Function and the Relative Impact on Mortality

Considering the high importance of the proposed model and the related indicator for the verification of the GBD results we proceed in the introduction of a second method based on the health state of the population instead of the previous one which was based on mortality. This model was proposed earlier (see Skiadas and Skiadas 2010b, 2012a, 2013, 2014). These works were based on an earlier publication modeling the health state of a population via a first exit time stochastic methodology. Here we develop a special application adapted to WHO data provided as abridged life tables (0 to 100 with 5 year periods). First we expand the abridged life table to full and then we estimate the health indicators and finally the loss of healthy life years indicators.

By observing the above graph (Fig. 4.17) we can immediately see that the area between the health state curve and the horizontal axis (OMCO) represents the total health dynamics (THD) of the population. Of particular importance is also the area of the health rectangle (OABC) which includes the health state curve. This rectangle is divided in two rectangular parts the smaller (OAMN) indicating the first part of the human life until reaching the point M at the highest level of health state (usually the maximum is between 30 and 45 years) and the second part (NMBC) characterized by the gradual deterioration of the human organism until the zero level of the health state. This zero point health age C is associated with the maximum death rate. After this point the health state level appears as negative in the graph and characterizes a part of the human life totally unstable with high mortality; this is also indicated by a positively increasing form of the logarithm of the force of mortality $ln(\mu x)$. We call the second rectangle NMBC as the deterioration rectangle. Instead the first rectangle OAMN is here called as the development rectangle. For both cases we can find the relative impact of the area inside each rectangle but outside the health state area to the overall health state. In this study we analyze the relative impact

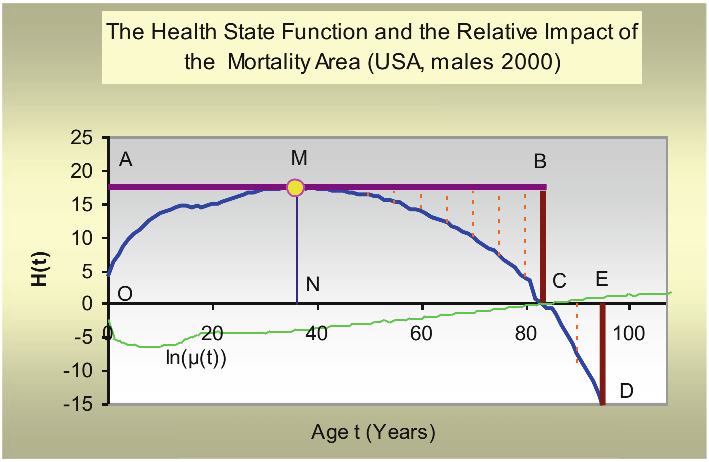

Fig. 4.17 The impact of the mortality area to health state

of the deterioration area MBCM indicated by dashed lines in the deterioration rectangle. It should be noted that if no-deterioration mechanism was present or the repairing mechanism was perfect the health state should continue following the straight line AMB parallel to the X-axis at the level of the maximum health state. The smaller the deterioration area related to the health state area, the higher the healthy life of the population. This comparison can be done by estimating the related areas and making a simple division. However, when trying to expand the human life further than the limits set by the deterioration mechanisms the percentage of the non-healthy life years becomes higher. This means that we need to divide the total rectangle area by that of the deterioration area to find an estimate for the lost healthy life years. It is clear that if we dont correct the deterioration mechanisms the loss of healthy years will become higher as the expectation of life becomes larger. This is already observed in the estimates of the World Health Organization (WHO) in the World Health Report for 2000 where the lost healthy years for females are higher than the corresponding values for males. The females show higher life expectancy than males but also higher values for the lost healthy years. The proposed loss of healthy life years indicator is given by:

$$LHLY_1 = \lambda \frac{OABC}{THD_{ideal}} . \frac{THD_{ideal}}{MBCM} = \lambda \frac{OABC}{MBCM}$$

Where THD_{ideal} is ideal total health dynamics of the population and the parameter l expresses years and should be estimated according to the specific case. For comparing the related results in various countries we can set $\lambda = 1$. When OABC approaches the THD_{ideal} as is the case of several countries in nowadays the loss of healthy life years indicator LHLY can be expressed by other forms. Another point is the use of the (ECD) area in improving forecasts especially when using the

5-year life tables as is the case of the data for all the WHO Countries. In this case the expanded loss of healthy life years indicator LHLY will take the following two forms:

$$LHLY_2 = \lambda \frac{OMCO + ECD}{MBCM}$$

$$LHLY_3 = \lambda \frac{OABC + ECD}{MBCM}$$

It is clear that the last form will give higher values than the previous one. The following scheme applies: $LHLY1 < LHLY2 < LHLY3$. It remains to explore the forecasting ability of the three forms of the loss of healthy life years indicator by applying LHLY to life tables provided by WHO or by the Human Mortality Database or by other sources.

As for the previous case here important is the loss of health state area MBCM whereas the total area including the healthy and non-healthy part is included in OABC+ECD.

$$LHLY_2 = \lambda \frac{OABC + ECD}{MBCM}$$

Details and applications are included in the book on The Health State Function of a Population, the supplement of this book and other publications (see Skiadas 2011a,b,c, 2012 and Skiadas and Skiadas 2008, 2010a,b, 2011a,b, 2012a,b, 2013). It is important that we can explore the health state of a population by using the mortality approach with the Simple Model proposed herewith and the health state function approach as well. The latter method provides many important health measures than the simple model.

4.4 Applications

4.4.1 Comparative Application for the World and World Regions

The Table 4.3 includes our estimates for the healthy life expectancy at birth for the years 2000 and 2012 by applying the proposed mortality model and the health state model (HSM), and the estimates of WHO referred as HALE and included in the WHO websites (August 2015). Our estimates for the mortality model are based on $LHLY = b + 1 = E_{total}/E_{mortality}$. The main finding is that our models verify the WHO (HALE) estimates based on the Global Burden of Disease Study. Our results are quite close (with less to one year difference) to the estimates for the World, the High Income Countries, the African region, the European region and Western Pacific and differ by 1–2 years for the Eastern Mediterranean region and

Table 4.3 Comparison of model and HSM estimates with WHO (HALE) results

	Healthy Life Exp						Life Exp (LE)			
	2000			2012			2000		2012	
Sex/Region	HALE	Model	HSM	HALE	Model	HSM	HALE	Model	HALE	Model
Both sexes combined										
World	58.0	58.4	58.2	61.7	62.5	61.9	66.2	66.2	70.3	70.3
High income countries	67.3	67.1	67	69.8	69.6	69.2	76.0	76.0	78.9	78.9
African Region	43.1	42.8	42.8	49.6	49.9	49.6	50.2	50.2	57.7	57.7
Region of the Americas	64.9	65.7	65.4	67.1	67.7	67.2	73.9	73.9	76.4	76.3
Eastern Mediterranean	55.4	56.9	56.6	58.3	59.7	59.4	64.9	64.9	67.8	67.8
European Region	63.9	63.9	63.9	66.9	67.2	67.0	72.4	72.4	76.1	76.0
South East Asian Region	54.2	56.3	55.6	58.5	60.6	60.0	62.9	63.0	67.5	67.5
Western Pacific Region	64.8	63.9	64.2	68.1	67.3	67.5	72.3	72.3	75.9	75.9
Males										
World	56.4	56.6	56.2	60.1	60.4	60.0	63.9	63.9	68.1	68.0
High income countries	64.7	64.1	64.2	67.5	67	67	72.4	72.3	75.8	75.7
African Region	42.4	41.6	42.3	48.8	48.6	48.6	49.0	49.0	56.3	56.3
Region of the Americas	62.7	63.1	62.5	64.9	65.1	64.6	70.8	70.8	73.5	73.5
Eastern Mediterranean	54.8	55.7	55.6	57.4	58.2	57.9	63.6	63.6	66.1	66.1
European Region	60.7	60.4	61.1	64.2	64.3	64.5	68.2	68.2	72.4	72.4
South East Asian Region	53.5	55.4	54.6	57.4	59.2	58.6	61.6	61.7	65.7	65.7
Western Pacific Region	63.0	61.8	62.0	66.6	65.2	65.7	70.0	70.0	73.9	73.9
Females										
World	59.7	60.3	59.9	63.4	64.3	64.1	68.5	68.5	72.7	72.6
High income countries	70.0	69.7	69.6	72.0	71.8	72.1	79.6	79.5	82.0	81.9
African Region	43.8	43.8	43.5	50.4	51.2	50.5	51.4	51.4	59	59.1
Region of the Americas	67.2	68.0	67.8	69.1	69.9	69.8	77.0	76.9	79.3	79.2
Eastern Mediterranean	56.1	58.2	57.8	59.2	61.3	61.0	66.4	66.4	69.7	69.6
European Region	67.1	67.6	67.3	69.6	70.0	69.7	76.7	76.6	79.6	79.6
South East Asian Region	55.0	57.2	56.4	59.7	62.0	61.7	64.3	64.4	69.4	69.4
Western Pacific Region	66.7	65.7	66.1	69.8	68.9	69.1	74.8	74.8	78.1	78.0

the South East Asian region. In the last two cases the collection of data and the accuracy of the information sources may lead to high uncertainty of the related health state estimates. This is demonstrated in the provided confidence intervals for the estimates in countries of these regions in the studies by Salomon et al. (2012) and the Report of WHO (2001) for the HLE of the member states (2000). From the Salomon et al. study we have calculated a mean confidence interval of 5.5 years for males and 6.8 for females for the year 2000. We thus propose to base the future works on the system we propose and to use it to calibrate the estimates especially for the countries providing of low accuracy data. To support future studies we have formulated an easy to use framework in Excel. The only needed is to insert data for μx in the related column of the program. The program estimates the life expectancy, the loss of healthy life years and the healthy life expectancy.

4.4.2 Application to USA 2008

Both the Gompertz and the Weibull health estimators are calculated by the appropriate computer program. The results are compared with those of the methods proposed earlier thus providing enough evidence for a successful application. The estimates of the WHO are also included in the related table. The task to find an alternative of the WHO and other estimates for the Healthy Life Years Lost is highly supported by using a series of methods leading to similar and easily reproducible results. Only few detailed publications appear in order to use for comparative applications. It is highly appreciated that one paper by Chang et al. for USA data for 2008 and of Yong and Saito (2009) on healthy life expectancy in Japan: 1986–2004, published in Demographic Research are of particular importance for our comparative applications. A very important paper by Chang et al. (2015) appeared in the Journal of Public Health. It includes calculations of the Life Expectancy (LE) and the Healthy Life Expectancy (HLE) for the United States population the year 2008 by sex and race/ethnicity. Our task was to find good estimates compared to the authors results by a different methodology than the survey data collection and the Sullivan method followed. Following the above provided models and estimation techniques, three different methods are selected to estimate the HLE from only the life table data sets (mortality data). The benefits are: Simple estimation, estimates for all the period where mortality data exist, comparison with existing estimates from other methods, fix the weights needed for other measurements, provide a simple methodology for health decision makers to organize future plans. As an example the estimates for USA (1950) are LE (68.0 years) and HLE (61.3 years). We have calculated similar results for the first part of the Table 1 of the Chang et al. paper related to all races and for both sexes, male and female (see our Table 4.4). A power model, a Weibull model and a Gompertz model are used to first estimate the Healthy Life Years Lost (HLYL) and then find the Healthy Life Expectancy (HLE) from

Table 4.4 Comparing Chang et al. estimates

Life Expectancy (LE) Healthy Life Expectancy (HLE) and Healthy Life Years Lost (HLYL) by sex for the United States population, 2008

Age	Both sexes										Male										Female									
	LE	HLE				Plausibility	HLYL				LE	HLE				Plausibility	HLYL				LE	HLE				Plausibility	HLYL			
(Years)	Pub	Pub	SK	W	G	range	Pub	SK	W	G	Pub	Pub	SK	W	G	range	Pub	SK	W	G	Pub	Pub	SK	W	G	range	Pub	SK	W	G
<1	78.1	69.3	68.9	69.7	69.8	(68.4–70.3)	8.8	9.2	8.4	8.3	75.6	67.6	66.8	67.7	67.9	(66.8–69.2)	8.0	8.8	7.9	7.7	80.6	70.9	70.7	71.2	71.4	(69.8–72.6)	9.7	9.9	9.4	9.2
1–4	77.6	68.7	68.4	69.2	69.3	(67.9–69.8)	8.9	9.2	8.4	8.3	75.1	67.1	66.3	67.2	67.4	(66.1–68.5)	8.0	8.8	7.9	7.7	80.1	70.3	70.2	70.7	70.9	(69.1–71.8)	9.8	9.9	9.4	9.2
5–9	73.7	64.9	64.6	65.3	65.5	(64.1–66.0)	8.8	9.1	8.4	8.2	71.2	63.2	62.5	63.3	63.5	(62.2–64.6)	8.0	8.7	7.9	7.7	76.1	66.5	66.2	66.8	66.9	(65.2–67.9)	9.6	9.9	9.3	9.2
10–14	68.8	60.0	59.7	60.5	60.6	(59.2–61.1)	8.8	9.1	8.3	8.2	66.3	58.4	57.6	58.5	58.7	(57.4–59.7)	7.9	8.7	7.8	7.6	71.2	61.6	61.4	61.9	62.1	(60.4–63.0)	9.6	9.8	9.3	9.1
15–19	63.8	55.1	54.8	55.6	55.7	(54.4–56.2)	8.7	9.0	8.2	8.1	61.3	53.5	52.7	53.6	53.8	(52.6–54.8)	7.8	8.6	7.7	7.5	66.2	56.7	56.5	57.1	57.2	(55.5–58.1)	9.5	9.7	9.1	9.0
20–24	59.0	50.4	50.2	50.9	51.1	(49.7–51.5)	8.6	8.8	8.1	7.9	56.6	48.8	48.2	49.0	49.2	(47.9–50.1)	7.8	8.4	7.6	7.4	61.3	52.0	51.8	52.3	52.5	(50.8–53.3)	9.3	9.5	9.0	8.8
25–29	54.3	45.9	45.7	46.4	46.6	(45.2–46.9)	8.4	8.6	7.9	7.7	52.0	44.4	43.8	44.6	44.8	(43.5–45.6)	7.6	8.2	7.4	7.2	56.5	47.3	47.2	47.8	47.9	(46.2-48.6)	9.2	9.3	8.7	8.6
30–34	49.5	41.4	41.2	41.9	42.0	(40.7–42.3)	8.1	8.3	7.6	7.5	47.3	39.9	39.4	40.2	40.3	(39.1–41.1)	7.4	7.9	7.1	7.0	51.6	42.7	42.6	43.1	43.3	(41.7–44.0)	8.9	9.0	8.5	8.3
35–39	44.8	36.8	36.8	37.5	37.6	(36.2–37.8)	8.0	8.0	7.3	7.2	42.6	35.4	35.0	35.7	35.9	(34.7–36.6)	7.2	7.6	6.9	6.7	46.8	38.2	38.2	38.7	38.8	(37.2–39.4)	8.6	8.6	8.1	8.0
40–14	40.1	32.5	32.5	33.1	33.3	(31.9–33.4)	7.6	7.6	7.0	6.8	38.0	31.0	30.7	31.4	31.6	(30.3–32.2)	7.0	7.3	6.6	6.4	42.0	33.8	33.8	34.2	34.4	(32.9–34.9)	8.2	8.2	7.8	7.6
45–49	35.5	28.3	28.3	28.9	29.0	(27.8–29.2)	7.2	7.2	6.6	6.5	33.5	26.9	26.6	27.3	27.5	(26.3–28.0)	6.6	6.9	6.2	6.0	37.3	29.6	29.5	30.0	30.1	(28.7–30.7)	7.7	7.8	7.3	7.2
50–54	31.0	24.3	24.3	24.8	24.9	(23.8–25.1)	6.7	6.7	6.2	6.1	29.1	22.9	22.7	23.3	23.4	(22.4–24.0)	6.2	6.4	5.8	5.7	32.8	25.5	25.5	25.9	26.1	(24.8–26.6)	7.3	7.3	6.9	6.7
55–59	26.8	20.6	20.6	21.1	21.2	(20.2–21.4)	6.2	6.2	5.7	5.6	25.0	19.3	19.1	19.7	19.8	(18.8–20.3)	5.7	5.9	5.3	5.2	28.4	21.8	21.7	22.1	22.2	(21.1–22.7)	6.6	6.7	6.3	6.2
60–64	22.7	17.2	17.0	17.5	17.6	(16.8–17.9)	5.5	5.7	5.2	5.1	21.0	16.0	15.6	16.1	16.3	(15.5–16.9)	5.0	5.4	4.9	4.7	24.1	18.2	18.0	18.3	18.4	(17.6–19.1)	5.9	6.1	5.8	5.7
65–69	18.8	14.0	13.8	14.2	14.3	(13.7–14.7)	4.8	5.0	4.6	4.5	17.3	13.0	12.5	13.0	13.1	(12.6–13.8)	4.3	4.8	4.3	4.2	20.0	14.9	14.6	14.9	15.0	(14.3–15.7)	5.1	5.4	5.1	5.0
70–74	15.2	11.1	10.8	11.2	11.3	(10.8–11.7)	4.1	4.4	4.0	3.9	13.9	10.2	9.8	10.1	10.2	(9.9–11.0)	3.7	4.1	3.8	3.7	16.2	11.7	11.5	11.7	11.8	(11.3–12.5)	4.5	4.7	4.5	4.4
75–79	11.8	8.4	8.1	8.4	8.5	(8.2–9.0)	3.4	3.7	3.4	3.3	10.7	7.7	7.2	7.6	7.6	(7.5–8.4)	3.0	3.5	3.1	3.1	12.6	8.9	8.7	8.9	8.9	(8.6–9.6)	3.7	3.9	3.7	3.7
80–84	8.9	6.1	6.0	6.2	6.3	(6.0–6.7)	2.8	2.9	2.7	2.6	8.0	5.5	5.3	5.5	5.6	(5.3–6.1)	2.5	2.7	2.5	2.4	9.5	6.6	6.4	6.5	6.6	(6.4–7.2)	2.9	3.1	3.0	2.9
85+	6.4	4.3	4.3	4.5	4.5	(4.3–4.8)	2.1	2.1	1.9	1.9	5.7	3.7	3.7	3.9	3.9	(3.6–4.3)	2.0	2.0	1.8	1.8	6.8	4.6	4.6	4.7	4.7	(4.5–5.1)	2.2	2.2	2.1	2.1

Pub Chang et al. estimates, *SK* Skiadas model estimates, *W* Weibull estimates, *HLE-G* Gompertz estimates the simple relation HLE=LE-HLYL. We have verified that our results are within the provided plausibility range suggested by Chang et al. and very close to their estimates for all the life period. Instead for the second part of Table 1 of the authors our estimates differ considerably from the related figures provided. Specifically for Hispanic we have estimated 8.9 HLYL corresponding to 72.1 HLE instead of 13.4 (67.6 HLE) of the authors and for Non-Hispanic black we estimated 7.0 HLYL (66.7 HLE) instead of 12.3 (61.4 HLE) of the authors. The other estimates for Non-Hispanic white 7.9 HLYL (70.5 HLE) of the authors is in agreement with our estimates of 8.3 HLYL (70.1 HLE). It is important to clarify the cause of the differences as the perfect agreement between both methods will straighten the HLE estimators. We have provided the related estimation programs in the webpage http://www.smtda.net/demographics2016.html to support comparative applications.

4.4.3 Application in Japan 1986–2004

The results from Yong and Saito (2009) on healthy life expectancy in Japan: 1986–2004, published in Demographic Research are used for our comparative applications. The authors applied the Sullivan method to data collected from a large national survey in Japan. The number of responders and the methodology applied assures relatively good results adequate for a comparative study. Especially the part of the study related to not so poor and poor state of health was selected for our comparisons. This is because our theory presented above suggests the estimation of the health state as a fraction of areas related to mortality and health as it is presented in Fig. 4.1 and the related theory. The impact on the public opinion regarding the health state is due to the E_{health}, the $E_{mortality}$ and the total Health-Mortality area E_{total}. The impact is expressed by the exponent b or b+1 depending on the form of the social status of the society and the male-female differentiation regarding the adoption and spread of the information for health, disability and mortality. We apply the Direct Estimation as presented above in Japan from 1947 to 2012 for m_x and q_x data included in the full life tables provided by the Human mortality Database (HMD) thus estimating the parameters b and $b + 1$ as is illustrated in Fig. 4.18 for Japan (males). In the same Figures we also have included the Healthy Life Years Lost (HLYL) from the HALE estimates of the World Health Organization. Although the results for the years 1990, 2000a, 2010, 2012 and 2013 are within the region defined by the four curves, there are significant differences in the estimates in 2000b, 2001, 2002 and 2007 underestimating the HLYL due to improvements in the methodology and the use of new epidemiological data. In the Annex Table of the World Health Report 2001 (WHO 2001) and the related of 2002 (WHO 2002) write:

> Healthy life expectancy estimates published here are not directly comparable to those published in the World Health Report 2000, due to improvements in survey methodology and the use of new epidemiological data for some diseases. See Statistical Annex notes (pp.130–135). The figures reported in this Table along with the data collection and estimation methods have been largely developed by WHO and do not necessarily reflect

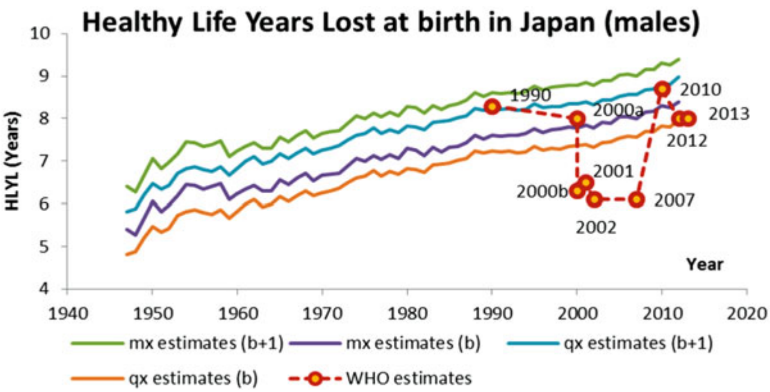

Fig. 4.18 Comparing the HLYL with a direct method to the WHO estimates (Japan, males)

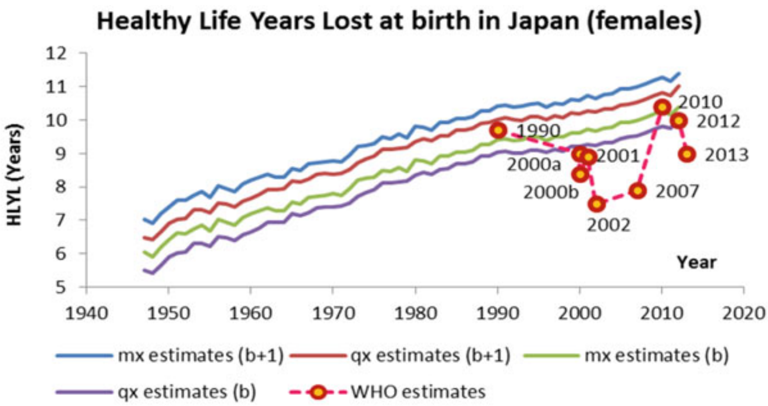

Fig. 4.19 Comparing the HLYL with a direct method to the WHO estimates (Japan, females)

official statistics of Member States. Further development in collaboration with Member States is underway for improved data collection and estimation methods (WHO 2001).

Healthy life expectancy estimates published here are not directly comparable to those published in The World Health Report 2001, because of improvements in survey methodology and the use of new epidemiological data for some diseases and revisions of life tables for 2000 for many Member States to take new data into account (see Statistical Annex explanatory notes). The figures reported in this Table along with the data collection and estimation methods have been largely developed by WHO and do not necessarily reflect official statistics of Member States. Further development in collaboration with Member States is under way for improved data collection and estimation methods (WHO 2002).

Figure 4.19 illustrates the healthy life years lost for females in Japan following the same procedure as for males. As before significant differences appear especially for the years 2002 and 2007. Even more it is clear that the differences not following a clear trend are due to the ongoing process of the estimation team of WHO to arrive in a best estimate method. To this end the recently provided estimates for 2000a, 2012 and 2013 (presented without decimal points) for males and females are closer to the results from our methodology.

Figure 4.20a–h illustrate the expected number of years in poor health for 25, 45, 65 and 85 years men and women following the Yong-Saito findings and the direct application results based on m_x and q_x estimates included in Tables 4.5 and 4.6 (see end of the paper for these Tables and Fig. 4.20a–h). For both cases (men and women) the majority of the Yong-Saito estimates are within the interval suggested with our calculations. As for both men and women the Yong-Saito findings suggest a declining pattern for the healthy life years lost until 1995, followed by an increasing trend not explained by significant variations of the mortality trends or of the life expectancy, we have to explore socioeconomic factors influencing the responses to questionnaires and in a second stage the changes in the health state of a population. So, huge changes in LHLY could be expected to arise in very special morbidity cases as from the spread of epidemics. Instead the growing unemployment rate in Japan leading to a maximum in 2004 along with the slowdown of the economy and the related economic indicators can explain the relative changes in the public opinion regarding the health state. After all as the surveys cover 280,000 households and data on over 750,000 individuals were collected, the uncertainty degree should be very low. Specific sociological surveys are needed to explore the influence of socioeconomic and political factors not only to the health state but to the way the responders reply to a specific questionnaire.

4.4.4 Application in the World

Another application is presented in Table 4.7 where the mortality model and the WHO (HALE) results from 1990 to 2013 are compared for the WHO member countries.

Figure 4.21 illustrates the estimates of the arithmetic mean for the loss of healthy life years (LHLY) for various time periods with the proposed mortality model (circles) versus the HALE method (rhombus) for the countries of WHO (males). The model estimates and the HALE differ by 1.0 years in 1990, 0.4 years in 2000, 0.6 years in 2012 and 0.6 years in 2013. Several options of the related figures for HALE are included starting from the first estimates in 1990 until the estimates of 2013. The estimates for 1990, 2000, 2012 and 2013 are provided in the last WHO websites and can be accepted as the official estimates whereas the HALE estimates for 2001, 2002 and 2010 are also included.

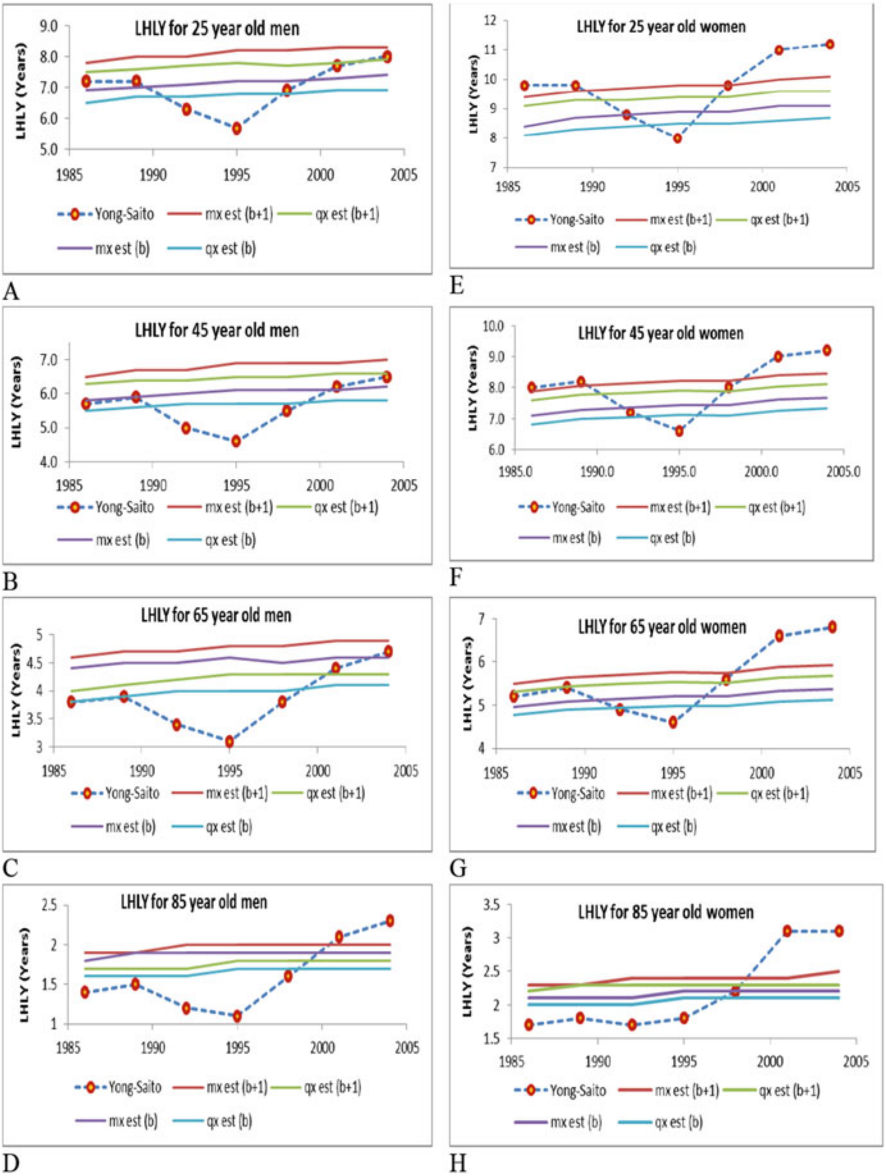

Fig. 4.20 Expected number of years in poor health for 25, 45, 65 and 85 years men and women (Yong-Saito findings and direct application results based on m_x and q_x)

Table 4.5 Life expectancy and healthy life expectancy of Japanese men, 1986–2004

Life expectancy and healthy life expectancy for Japanese men, 1986–2004						
		Expected number of years in poor health				
Year	Life expectancy	Yong-Saito	$m_x(b+1)$	$q_x(b+1)$	$m_x(b)$	$q_x(b)$
At birth men						
1986	**75.3**		8.3	8.0	7.3	7.0
1989	**76.0**		8.5	8.2	7.5	7.2
1992	**76.1**		8.6	8.2	7.6	7.2
1995	**76.4**		8.8	8.3	7.8	7.3
1998	**77.2**		8.8	8.3	7.8	7.3
2001	**78.0**		8.8	8.4	7.8	7.4
2004	**78.6**		8.9	8.4	7.9	7.4
25 year old men						
1986	**51.4**	**7.2**	7.8	7.5	6.9	6.5
1989	**52.0**	**7.2**	8.0	7.6	7.0	6.7
1992	**52.1**	**6.3**	8.0	7.7	7.1	6.7
1995	**52.3**	**5.7**	8.2	7.8	7.2	6.8
1998	**53.0**	**6.9**	8.2	7.7	7.2	6.8
2001	**53.8**	**7.7**	8.3	7.8	7.3	6.9
2004	**54.3**	**8.0**	8.3	7.9	7.4	6.9
45 year old men						
1986	**32.4**	**5.7**	6.5	6.3	5.8	5.5
1989	**32.9**	**5.9**	6.7	6.4	5.9	5.6
1992	**33.0**	**5.0**	6.7	6.4	6.0	5.7
1995	**33.3**	**4.6**	6.9	6.5	6.1	5.7
1998	**34.0**	**5.5**	6.9	6.5	6.1	5.7
2001	**34.8**	**6.2**	6.9	6.6	6.1	5.8
2004	**35.3**	**6.5**	7.0	6.6	6.2	5.8
65 year old men						
1986	**15.9**	**3.8**	4.6	4.0	4.4	3.8
1989	**16.2**	**3.9**	4.7	4.1	4.5	3.9
1992	**16.3**	**3.4**	4.7	4.2	4.5	4.0
1995	**16.5**	**3.1**	4.8	4.3	4.6	4.0
1998	**17.1**	**3.8**	4.8	4.3	4.5	4.0
2001	**17.8**	**4.4**	4.9	4.3	4.6	4.1
2004	**18.2**	**4.7**	4.9	4.3	4.6	4.1
85 year old men						
1986	**4.8**	**1.4**	1.9	1.7	1.8	1.6
1989	**4.9**	**1.5**	1.9	1.7	1.9	1.6
1992	**4.9**	**1.2**	2.0	1.7	1.9	1.6
1995	**5.1**	**1.1**	2.0	1.8	1.9	1.7
1998	**5.5**	**1.6**	2.0	1.8	1.9	1.7
2001	**5.9**	**2.1**	2.0	1.8	1.9	1.7
2004	**6.1**	**2.3**	2.0	1.8	1.9	1.7

Table 4.6 Life expectancy and healthy life expectancy of Japanese women, 1986–2004

Life expectancy and healthy life expectancy for Japanese men, 1986–2004						
		Expected number of years in poor health				
Year	Life expectancy	Yong-Saito	$m_x(b+1)$	$q_x(b+1)$	$m_x(b)$	$q_x(b)$
At birth men						
1986	**81.0**		10.0	9.7	9.0	8.7
1989	**81.8**		10.3	9.9	9.3	8.9
1992	**82.3**		10.4	10.0	9.4	9.0
1995	**82.8**		10.5	10.1	9.5	9.1
1998	**83.9**		10.5	10.1	9.5	9.1
2001	**84.9**		10.7	10.3	9.7	9.3
2004	**85.5**		10.8	10.3	9.8	9.3
25 year old women						
1986	**56.7**	**9.8**	9.4	9.1	8.4	8.1
1989	**57.5**	**9.8**	9.6	9.3	8.7	8.3
1992	**57.9**	**8.8**	9.7	9.3	8.8	8.4
1995	**58.6**	**8.0**	9.8	9.4	8.9	8.5
1998	**59.6**	**9.8**	9.8	9.4	8.9	8.5
2001	**60.5**	**11.0**	10.0	9.6	9.1	8.6
2004	**61.1**	**11.2**	10.1	9.6	9.1	8.7
45 year old women						
1986.0	**37.4**	**8.0**	7.9	7.6	7.1	6.8
1989.0	**38.1**	**8.2**	8.1	7.8	7.3	7.0
1992.0	**38.5**	**7.2**	8.1	7.8	7.4	7.1
1995.0	**39.1**	**6.6**	8.2	7.9	7.4	7.1
1998.0	**40.2**	**8.0**	8.2	7.9	7.4	7.1
2001.0	**41.0**	**9.0**	8.4	8.0	7.6	7.3
2004.0	**41.6**	**9.2**	8.5	8.1	7.7	7.3
65 year old women						
1986	**19.3**	**5.2**	5.5	5.3	5.0	4.8
1989	**20.0**	**5.4**	5.6	5.4	5.1	4.9
1992	**20.3**	**4.9**	5.7	5.5	5.1	4.9
1995	**20.9**	**4.6**	5.7	5.5	5.2	5.0
1998	**22.0**	**5.6**	5.7	5.5	5.2	5.0
2001	**22.7**	**6.6**	5.9	5.6	5.3	5.1
2004	**23.3**	**6.8**	5.9	5.7	5.4	5.1
85 year old women						
1986	**5.7**	**1.7**	2.3	2.2	2.1	2.0
1989	**6.0**	**1.8**	2.3	2.3	2.1	2.0
1992	**6.1**	**1.7**	2.4	2.3	2.1	2.0
1995	**6.7**	**1.8**	2.4	2.3	2.2	2.1
1998	**7.4**	**2.2**	2.4	2.3	2.2	2.1
2001	**7.8**	**3.1**	2.4	2.3	2.2	2.1
2004	**8.1**	**3.1**	2.5	2.3	2.2	2.1

Table 4.7 Mortality model and the WHO (HALE) results compared

Mean values of the mortality model for the Loss of Healthy Life Years (LHLY) and the related results from the HALE method for the WHO countries

Type	HALE	MODEL	HALEb	HALE	MODEL	HALE	HALE	HALE	HALE	MODEL	HALE	MODEL
Year	1990	1990	2000	2000	2000	2001	2002	2010	2012	2012	2013	2013
Males	8.7	7.7	8.4	8.2	7.8	9.7	7.2	9.3	8.8	8.2	8.9	8.3
Females	10.3	8.6	11.0	9.5	8.8	10.0	8.9	10.8	10.2	9.3	10.1	9.3

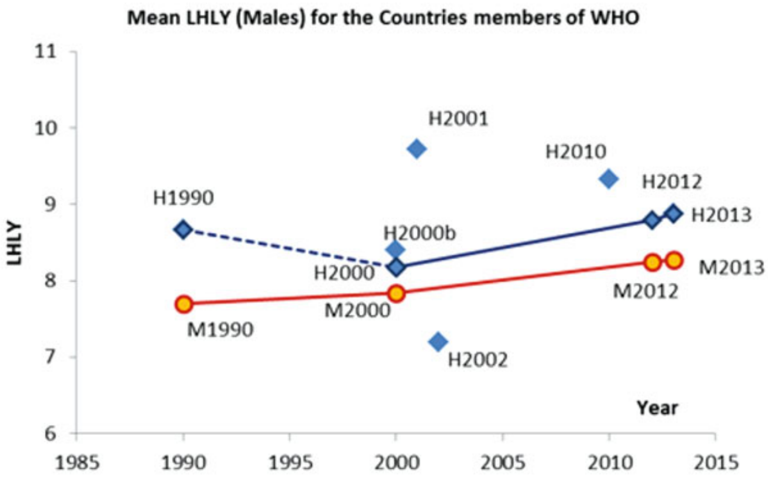

Fig. 4.21 Mean estimates for the healthy life years lost for the Model and HALE (males)

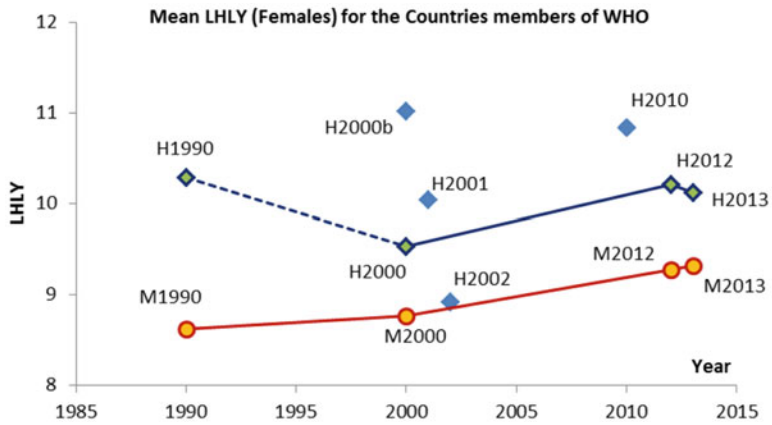

Fig. 4.22 Mean estimates for the healthy life years lost for the Model and HALE (females)

Figure 4.22 summarizes the estimates of the mean of the loss of healthy life years (LHLY) for various time periods with the proposed model (circles) versus the HALE method (rhombus) for the countries of WHO (females). The model estimates (females) and the HALE differ by 1.7 years in 1990, 0.7 years in 2000, 0.9 years in 2012 and 0.8 years in 2013. For females as for males the estimated differences between model and HALE are higher in 1990 than for the following years due to the higher values of the HALE estimates.

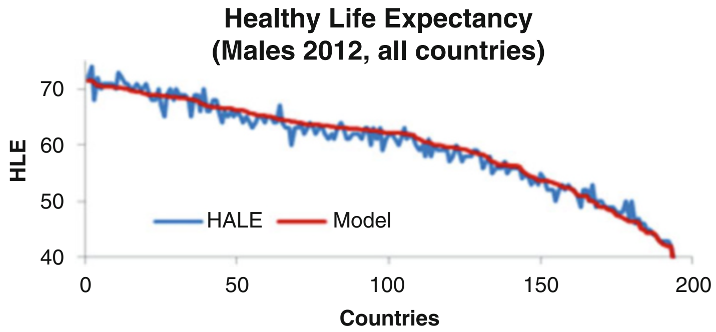

Fig. 4.23 Healthy life expectancy (HLE) for males (2012) for all the WHO countries. Model and HALE

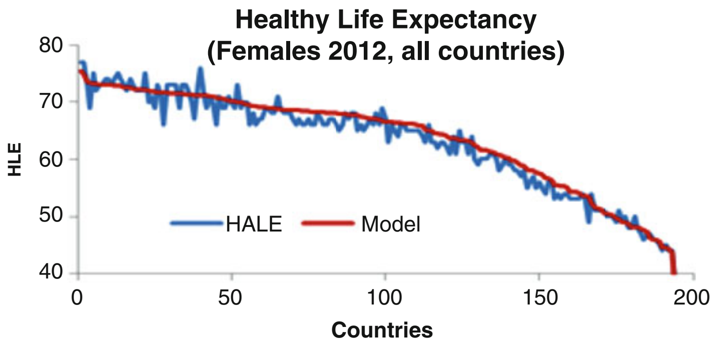

Fig. 4.24 Healthy life expectancy (HLE) for females (2012) for all the WHO countries. Model and HALE

Figure 4.23 illustrates the Healthy life expectancy (HLE) for males (2012) for all the WHO countries, estimated by the Model (red line) and HALE estimates (Blue line). The mean value is 59.6 for HALE and 60.2 years for the model.

Figure 4.24 illustrates the Healthy life expectancy (HLE) for females (2012) for all the WHO countries, estimated by the Model (red line) and HALE estimates (Blue line). The mean value is 63.1 for HALE and 63.8 years for the model. The full estimated figures are included in Tables 4.8, 4.9 and 4.10 in the end of the paper.

Table 4.8 Mortality model and the WHO (HALE) results compared

Country – 2012 – Females	HALE	MODEL	Country – 2012 – Males	HALE	MODEL
Afghanistan	49	53.4	Afghanistan	49	51.0
Albania	66	65.1	Albania	64	63.9
Algeria	63	64.4	Algeria	62	61.9
Andorra	74	73.0	Andorra	70	68.6
Angola	45	44.5	Angola	43	42.2
Antigua and Barbuda	66	67.4	Antigua and Barbuda	63	64.0
Argentina	69	69.9	Argentina	64	65.2
Armenia	66	66.2	Armenia	60	59.9
Australia	74	72.8	Australia	71	70.4
Austria	73	71.5	Austria	69	68.3
Azerbaijan	65	66.4	Azerbaijan	61	62.2
Bahamas	67	67.1	Bahamas	62	62.9
Bahrain	66	68.5	Bahrain	66	66.9
Bangladesh	61	63.7	Bangladesh	60	62.5
Barbados	69	70.5	Barbados	64	66.2
Belarus	68	68.6	Belarus	59	59.9
Belgium	73	71.4	Belgium	69	67.9
Belize	66	68.1	Belize	61	62.2
Benin	51	51.4	Benin	50	49.1
Bhutan	59	62.1	Bhutan	58	60.3
Bolivia (Plurinational State of)	61	61.2	Bolivia (Plurinational State of)	58	57.5
Bosnia and Herzegovina	70	70.2	Bosnia and Herzegovina	66	66.7
Botswana	53	55.3	Botswana	52	53.4
Brazil	67	69.2	Brazil	62	63.3
Brunei Darussalam	69	69.0	Brunei Darussalam	68	66.8

(continued)

Table 4.8 (continued)

Country – 2012 – Females	HALE	MODEL	Country – 2012 – Males	HALE	MODEL
Bulgaria	68	67.7	Bulgaria	63	63.0
Burkina Faso	51	50.5	Burkina Faso	50	49.0
Burundi	49	49.7	Burundi	46	46.4
Cabo Verde	66	68.2	Cabo Verde	61	62.4
Cambodia	63	66.5	Cambodia	59	62.3
Cameroon	49	49.1	Cameroon	48	47.3
Canada	73	73.0	Canada	71	70.0
Central African Republic	44	43.7	Central African Republic	43	42.1
Chad	44	44.4	Chad	43	42.9
Chile	72	73.2	Chile	68	68.9
China	69	66.7	China	67	64.6
Colombia	70	72.0	Colombia	66	66.6
Comoros	54	55.2	Comoros	53	52.7
Congo	51	51.5	Congo	49	49.0
Cook Islands	66	67.9	Cook Islands	63	65.6
Costa Rica	71	71.9	Costa Rica	68	68.9
Côte d'Ivoire	46	45.9	Côte d'Ivoire	45	44.4
Croatia	70	71.0	Croatia	65	66.5
Cuba	69	71.9	Cuba	65	68.7
Cyprus	76	71.1	Cyprus	73	70.2
Czech Republic	71	70.4	Czech Republic	66	66.2
Democratic People's Republic of Korea	65	63.4	Democratic People's Republic of Korea	59	58.4
Democratic Republic of the Congo	45	45.6	Democratic Republic of the Congo	43	42.4
Denmark	72	72.2	Denmark	69	68.9
Djibouti	53	54.3	Djibouti	52	51.8

Dominica	65	68.0	Dominica	61	63.2
Dominican Republic	67	69.2	Dominican Republic	65	68.1
Ecuador	68	67.7	Ecuador	64	63.1
Egypt	63	65.2	Egypt	60	61.2
El Salvador	66	69.3	El Salvador	59	61.0
Equatorial Guinea	48	48.7	Equatorial Guinea	47	46.2
Eritrea	55	58.1	Eritrea	53	54.4
Estonia	71	71.0	Estonia	63	63.5
Ethiopia	56	56.2	Ethiopia	54	53.7
Fiji	62	64.4	Fiji	58	59.6
Finland	73	71.6	Finland	69	67.7
France	74	72.5	France	69	68.3
Gabon	54	55.1	Gabon	53	53.8
Gambia	53	53.7	Gambia	52	50.9
Georgia	68	68.6	Georgia	62	62.8
Germany	73	71.5	Germany	70	68.5
Ghana	54	52.5	Ghana	53	50.1
Greece	73	71.1	Greece	69	68.7
Grenada	66	67.3	Grenada	60	62.1
Guatemala	65	65.9	Guatemala	60	59.5
Guinea	50	50.3	Guinea	49	48.6
Guinea-Bissau	47	47.4	Guinea-Bissau	46	45.1
Guyana	57	58.9	Guyana	52	52.5
Haiti	53	55.5	Haiti	50	53.1
Honduras	65	67.4	Honduras	62	63.6
Hungary	69	69.1	Hungary	63	64.2
Iceland	73	71.5	Iceland	72	70.2

(continued)

Table 4.8 (continued)

Country – 2012 – Females	HALE	MODEL	Country – 2012 – Males	HALE	MODEL
India	58	60.8	India	56	58.2
Indonesia	64	63.7	Indonesia	61	60.4
Iran (Islamic Republic of)	65	66.1	Iran (Islamic Republic of)	63	63.7
Iraq	63	64.4	Iraq	58	58.4
Ireland	73	73.0	Ireland	70	69.7
Israel	73	72.5	Israel	71	70.3
Italy	74	73.0	Italy	71	70.3
Jamaica	66	66.9	Jamaica	62	62.2
Japan	77	75.0	Japan	72	70.5
Jordan	65	66.2	Jordan	64	63.6
Kazakhstan	64	63.0	Kazakhstan	56	56.5
Kenya	54	53.7	Kenya	52	51.0
Kiribati	60	60.3	Kiribati	56	56.4
Kuwait	67	68.5	Kuwait	68	68.5
Kyrgyzstan	63	64.6	Kyrgyzstan	58	58.7
Lao People's Democratic Republic	58	58.9	Lao People's Democratic Republic	56	56.5
Latvia	68	68.9	Latvia	61	62.0
Lebanon	71	71.7	Lebanon	68	68.3
Lesotho	44	44.5	Lesotho	42	42.0
Liberia	53	54.1	Liberia	52	52.2
Libya	65	67.7	Libya	64	64.5
Lithuania	70	69.6	Lithuania	61	61.8
Luxembourg	73	73.5	Luxembourg	70	70.5
Madagascar	56	58.0	Madagascar	54	55.5
Malawi	51	49.6	Malawi	50	46.8

Malaysia	66	67.1	Malaysia	63	64.3
Maldives	67	68.1	Maldives	66	67.0
Mali	48	48.1	Mali	49	48.4
Malta	72	71.4	Malta	70	69.3
Marshall Islands	61	63.2	Marshall Islands	57	59.6
Mauritania	54	55.5	Mauritania	52	52.9
Mauritius	68	68.3	Mauritius	62	62.2
Mexico	69	70.2	Mexico	65	65.1
Micronesia (Federated States of)	60	61.6	Micronesia (Federated States of)	59	59.7
Monaco	75	72.1	Monaco	70	67.2
Mongolia	63	63.3	Mongolia	56	56.2
Montenegro	67	68.6	Montenegro	65	65.3
Morocco	61	63.6	Morocco	60	60.7
Mozambique	46	45.9	Mozambique	45	44.4
Myanmar	58	59.3	Myanmar	56	56.1
Namibia	59	60.5	Namibia	55	56.4
Nauru	69	73.3	Nauru	64	66.6
Nepal	60	60.9	Nepal	58	59.0
Netherlands	72	72.2	Netherlands	70	70.3
New Zealand	73	71.4	New Zealand	71	69.1
Nicaragua	66	68.6	Nicaragua	61	63.0
Niger	50	50.4	Niger	50	50.2
Nigeria	47	46.3	Nigeria	46	44.9
Niue	66	68.3	Niue	62	63.4
Norway	72	72.2	Norway	70	69.4
Oman	67	71.2	Oman	65	66.4
Pakistan	57	57.9	Pakistan	56	56.4

(continued)

Table 4.8 (continued)

Country – 2012 – Females	HALE	MODEL	Country – 2012 – Males	HALE	MODEL
Palau	64	65.8	Palau	61	62.7
Panama	69	71.1	Panama	65	66.0
Papua New Guinea	55	57.7	Papua New Guinea	52	53.6
Paraguay	67	68.0	Paraguay	63	63.1
Peru	68	69.4	Peru	66	66.5
Philippines	63	63.4	Philippines	57	57.9
Poland	71	71.1	Poland	64	65.5
Portugal	73	73.0	Portugal	69	68.4
Qatar	66	71.6	Qatar	68	71.1
Republic of Korea	75	72.8	Republic of Korea	70	68.8
Republic of Moldova	66	66.5	Republic of Moldova	59	59.9
Romania	69	68.8	Romania	63	62.6
Russian Federation	66	66.3	Russian Federation	57	56.4
Rwanda	56	57.6	Rwanda	55	55.1
Saint Kitts and Nevis	66	68.0	Saint Kitts and Nevis	61	62.9
Saint Lucia	66	70.8	Saint Lucia	60	64.2
Saint Vincent and the Grenadines	65	66.1	Saint Vincent and the Grenadines	61	63.4
Samoa	66	68.4	Samoa	62	62.9
San Marino	73	69.9	San Marino	72	71.5
Sao Tome and Principe	59	60.2	Sao Tome and Principe	56	56.8
Saudi Arabia	66	68.3	Saudi Arabia	64	64.8
Senegal	56	56.6	Senegal	54	54.3
Serbia	67	68.2	Serbia	63	64.3

Seychelles	71	68.8	Seychelles	63	62.0
Sierra Leone	39	38.2	Sierra Leone	39	38.1
Singapore	77	75.3	Singapore	74	71.4
Slovakia	70	69.8	Slovakia	64	64.9
Slovenia	73	72.3	Slovenia	67	68.7
Solomon Islands	60	61.6	Solomon Islands	58	59.2
Somalia	46	47.6	Somalia	44	43.8
South Africa	53	54.3	South Africa	49	49.6
South Sudan	48	48.2	South Sudan	47	46.4
Spain	75	73.3	Spain	71	70.0
Sri Lanka	68	68.6	Sri Lanka	63	63.5
Sudan	54	56.7	Sudan	52	53.6
Suriname	68	67.1	Suriname	63	63.6
Swaziland	47	47.8	Swaziland	44	44.3
Sweden	73	71.7	Sweden	71	69.5
Switzerland	74	72.8	Switzerland	71	70.3
Syrian Arab Republic	65	66.1	Syrian Arab Republic	55	53.7
Tajikistan	60	61.7	Tajikistan	59	59.6
Thailand	68	69.0	Thailand	63	62.5
The FYROM	68	67.9	The FYROM	65	65.3
Timor-Leste	58	59.7	Timor-Leste	55	57.0
Togo	50	48.1	Togo	50	46.4
Tonga	61	61.3	Tonga	64	65.7
Trinidad and Tobago	64	66.3	Trinidad and Tobago	58	60.4
Tunisia	67	68.4	Tunisia	65	65.1

(continued)

Table 4.8 (continued)

Country – 2012 – Females	HALE	MODEL	Country – 2012 – Males	HALE	MODEL
Turkey	67	67.8	Turkey	63	62.4
Turkmenistan	59	59.8	Turkmenistan	53	52.4
Tuvalu	60	62.4	Tuvalu	57	59.3
Uganda	50	50.4	Uganda	49	48.2
Ukraine	67	66.6	Ukraine	59	58.6
United Arab Emirates	66	69.4	United Arab Emirates	66	67.4
United Kingdom	72	72.5	United Kingdom	70	69.6
United Republic of Tanzania	53	54.3	United Republic of Tanzania	51	51.1
United States of America	71	70.7	United States of America	68	66.8
Uruguay	70	71.4	Uruguay	65	66.2
Uzbekistan	62	64.0	Uzbekistan	59	59.4
Vanuatu	63	65.0	Vanuatu	61	62.1
Venezuela (Bolivarian Republic of)	69	70.6	Venezuela (Bolivarian Republic of)	63	62.7
Vietnam	69	71.5	Vietnam	62	63.8
Yemen	55	57.4	Yemen	54	54.7
Zambia	50	49.0	Zambia	48	47.5
Zimbabwe	51	51.3	Zimbabwe	48	47.2

Table 4.9 Healthy life years lost to disability: mortality model and HALE results for males

Estimates of the mortality model for the Loss of Healthy Life Years (LHLY) for males for the WHO member countries and the related results from the HALE method of the World Health Organization

	HALE	Model	HALE	HALE	Model	HALE				Model	HALE	Model
Countries/Year	1990	1990	2000b	2000	2000	2001	2002	2010	2012	2012	2013	2013
Afghanistan	8.9	6.9	9.1	9	7.2	10.0	6.6	9.7	9	7.5	11	7.5
Albania	9.3	8.6	7.9	8	8.6	10.4	7.8	9.5	9	8.6	9	8.6
Algeria	9.8	8.3	9.7	9	8.3	11.9	7.9	10.5	8	8.3	8	8.3
Andorra	10.6	8.8	7.3	9	8.7	7.4	7.0	11.5	10	10.6	9	10.6
Angola	6.4	7.2	8.1	6	7.4	8.4	6.3	8.2	7	7.7	7	7.7
Antigua and Barbuda	9.7	7.6	10.1	9	8.5	11.8	8.9	12.9	10	9.3	10	9.2
Argentina	8.5	7.1	8.4	9	7	9.5	8.3	9.0	9	7.5	9	7.5
Armenia	8.7	6.6	7.5	8	7.4	10.8	7.6	9.0	8	7.2	8	7.3
Australia	9.7	8.1	6.9	9	9.3	7.3	7.0	10.8	10	10.0	9	9.9
Austria	9.1	8.4	6.8	9	9.1	7.0	7.1	10.7	10	9.9	11	10.0
Azerbaijan	8.1	6.9	8.4	8	6.9	10.4	7.2	9.0	8	7.3	9	7.2
Bahamas	10.8	8.6	10.8	8	9.5	14.1	8.4	12.1	10	9.4	11	9.4
Bahrain	9.4	7.9	9.7	10	8	9.9	7.9	10.1	10	9.3	10	9.3
Bangladesh	9.4	7.4	9.8	10	7.2	10.2	7.3	12.4	9	6.9	10	6.9
Barbados	8.1	8.7	9.3	9	8.7	9.5	7.6	7.7	11	8.8	11	8.8
Belarus	9.2	6.9	6.6	8	6.5	9.0	6.1	10.2	9	6.7	9	6.6
Belgium	9.9	7.9	6.9	9	8.8	7.1	6.3	11.6	10	9.8	9	9.8
Belize	8.2	8.7	11.1	10	8.3	11.4	9.0	8.5	11	9.5	11	9.5
Benin	8.6	8.0	8.5	8	8	10.9	6.6	9.4	7	8.3	7	8.3
Bhutan	8.7	6.5	10.3	8	6.8	10.5	7.3	9.6	9	7.3	9	7.3
Bolivia	9.1	7.9	9.5	8	8.1	13.1	8.2	9.7	8	7.9	8	8.0
Bosnia and Herzegovina	9.3	7.1	6.6	9	6.2	9.3	7.0	11.0	10	7.8	9	7.8

(continued)

Table 4.9 (continued)

Estimates of the mortality model for the Loss of Healthy Life Years (LHLY) for males for the WHO member countries and the related results from the HALE method of the World Health Organization

	HALE	Model	HALE	HALE	Model	HALE				Model	HALE	Model
Countries/Year	1990	1990	2000b	2000	2000	2001	2002	2010	2012	2012	2013	2013
Botswana	8.8	9.7	6.5	6	6.7	6.4	4.2	9.4	9	7.7	10	8.0
Brazil	9.1	6.6	9.5	8	6.2	13.3	8.5	9.3	8	6.9	9	6.3
Brunei Darussalam	8.1	8.6	9.6	7	8.4	12.8	9.7	8.6	8	8.8	8	8.9
Bulgaria	7.6	7.5	6.3	8	7.8	7.5	6.2	7.4	9	7.7	9	7.6
Burkina Faso	7.3	7.9	7.2	7	8.1	8.3	5.6	7.5	7	8.2	8	8.2
Burundi	6.6	7.3	6.7	6	7.2	6.8	5.3	7.5	8	7.5	7	7.6
Cambodia	8.5	6.2	7.8	9	6.4	10.3	6.3	8.7	10	7.1	10	7.1
Cameroon	8.4	8.0	8.1	7	7.8	10.1	6.0	8.1	11	8.0	10	8.0
Canada	9.3	7.9	7.7	9	8.8	8.4	7.1	10.2	7	9.5	8	9.6
Cape Verde	9.2	7.7	9.6	9	7.9	13.6	7.9	10.1	10	8.3	9	8.4
Central African Republic	6.6	7.5	6.9	6	7.4	9.7	5.1	5.9	7	7.8	7	7.8
Chad	7.9	7.2	8.7	6	7.3	11.1	6.4	8.2	7	7.5	7	7.5
Chile	8.7	7.2	9	9	7.2	8.7	8.5	9.3	9	7.8	9	7.9
China	7.2	8.0	8	8	8.8	7.7	6.5	7.4	7	9.3	7	9.2
Colombia	8.9	8.4	8.6	9	7.1	11.4	9.7	9.3	11	7.8	10	9.8
Comoros	7.4	7.2	9.1	7	7.3	12.8	7.8	8.2	7	7.5	7	7.5
Congo	7.6	7.9	7.7	7	7.9	10.9	6.3	7.9	8	8.2	8	8.2
Cook Islands		7.8	8.3	10	9.3	11.6	8.6		10	7.7	11	7.7
Costa Rica	9.9	7.1	9.2	10	7.4	11.1	9.5	9.8	9	8.0	9	8.1
Cote d'Ivoire	7.9	7.7	7.2	6	7.5	8.7	5.4	7.4	7	7.9	7	7.9
Croatia	8.8	7.0	9	9	7.3	9.2	7.2	9.8	9	7.5	10	7.5
Cuba	9.5	8.6	8.6	10	7.7	10.0	7.9	12.6	11	7.6	12	8.1
Cyprus	9.9	8.9	8.4	7	10.5	9.4	8.8	10.5	8	9.4	7	9.4

Czech Republic	8.1	7.3	8.6	9	8	8.1	6.6	9.5	9	8.7	9	8.7
Democratic People's Republic of Korea	7.7	7.7	9.6	5	7.1	10.5	6.4	7.7	7	7.5	6	7.5
Democratic Republic of the Congo	8.1	7.7	7.2	7	7.7	9.8	6.0	8.1	7	7.8	8	7.8
Denmark	9.1	7.5	5.3	9	7.9	5.5	6.3	10.5	10	8.7	9	8.7
Djibouti	8.3	7.8	7.8	7	7.8	10.0	6.1	9.3	8	8.0	8	8.1
Dominica	9.4	8.3	9.4	10	8.7	12.2	9.1	11.8	11	8.8	11	8.8
Dominican Republic	9.1	8.8	10.8	9	6.7	11.1	7.7	11.2	12	7.2	11	6.4
Ecuador	9.5	6.7	9.9	9	6.7	11.1	8.1	10.0	9	9.7	9	9.7
Egypt	10.1	7.7	8.3	9	7.6	8.9	7.4	10.5	9	7.6	8	7.6
El Salvador	9.0	6.9	11	8	6	12.7	9.3	9.4	9	6.6	8	6.7
Equatorial Guinea	6.6	7.6	8.7	7	7.6	10.6	7.2	8.0	8	7.8	8	7.9
Eritrea	7.6	5.6	7.7	5	5.3	9.9	6.5	8.7	9	6.4	8	6.4
Estonia	7.6	7.1	9.3	8	6.7	7.7	6.0	8.9	9	7.8	9	7.3
Ethiopia	6.0	7.6	7.1	7	8	10.0	6.1	8.1	8	8.6	9	8.7
Fiji	8.8	7.6	8.3	9	7	11.0	7.7	8.5	9	7.0	9	7.0
Finland	10.0	7.6	7.6	8	8.5	6.8	6.1	11.8	10	9.9	10	9.8
France	9.4	8.6	6.7	8	9.2	6.6	6.7	10.5	10	10.2	10	10.2
Gabon	8.0	8.3	7.8	9	8.2	9.8	7.1	7.6	9	8.6	9	8.5
Gambia	8.1	8.3	8.6	7	8.4	11.1	6.9	8.5	7	8.5	8	8.5
Georgia	8.0	7.4	9.6	8	7.5	7.9	6.2	8.1	8	7.6	9	7.6
Germany	9.1	8.0	6.9	8	8.9	6.8	5.9	10.4	9	9.8	10	9.8
Ghana	8.9	9.9	8.5	8	10.5	10.0	7.2	8.7	8	11.2	9	10.0
Greece	9.5	8.4	5.7	9	8.7	6.5	6.7	10.1	9	9.1	10	9.5
Grenada	9.3	7.3	8.8	9	7	9.7	7.5	11.2	9	7.3	10	7.3
Guatemala	8.6	6.8	10.1	8	8.5	12.2	8.2	8.8	9	8.7	8	8.7
Guinea	7.8	8.2	8.6	7	8.2	10.1	7.0	8.6	8	8.4	8	8.4
Guinea-Bissau	7.4	7.8	7.7	8	8	9.8	6.1	8.1	7	8.0	8	8.0

(continued)

Table 4.9 (continued)

Estimates of the mortality model for the Loss of Healthy Life Years (LHLY) for males for the WHO member countries and the related results from the HALE method of the World Health Organization

	HALE	Model	HALE	HALE	Model	HALE				Model	HALE	Model
Countries/Year	1990	1990	2000b	2000	2000	2001	2002	2010	2012	2012	2013	2013
Guyana	8.5	6.0	10.1	8	6.6	9.7	8.4	10.6	8	7.5	8	7.5
Haiti	8.2	7.7	8.4	8	7.8	7.1	5.6	4.7	11	7.9	11	7.9
Honduras	9.2	8.0	10.6	10	8	12.3	7.9	9.5	10	8.2	10	8.2
Hungary	8.1	7.3	11	10	7.3	9.3	6.8	9.3	10	7.1	10	7.1
Iceland	11.5	8.5	7.3	9	9.3	7.6	6.3	13.1	9	11.0	10	10.3
India	8.0	5.9	7.6	9	6	8.4	6.8	8.3	8	6.2	9	6.2
Indonesia	8.4	7.5	6.9	8	7.8	8.3	7.5	8.4	8	8.1	8	8.1
Iran, Islamic Republic of	9.3	7.4	9.1	9	8.3	10.9	10.4	10.1	9	8.5	9	8.5
Iraq	9.6	8.1	9.2	8	8.2	11.0	10.3	9.8	8	7.7	8	7.7
Ireland	8.8	7.6	6.3	8	8.3	6.1	6.3	10.4	10	9.2	10	9.2
Israel	9.6	8.5	7.3	10	9.1	8.1	6.9	10.9	10	9.8	10	9.7
Italy	9.2	8.2	6.4	9	8.9	7.0	6.0	10.6	9	9.8	9	9.9
Jamaica	9.7	8.9	10	8	9	9.9	6.9	12.3	11	9.4	11	9.3
Japan	8.3	8.9	6.3	8	9	6.5	6.1	8.7	8	9.4	8	9.5
Jordan	9.8	8.1	10.3	8	8.3	11.4	9.0	10.9	8	8.5	8	8.6
Kazakhstan	7.5	6.0	7.5	7	6	9.8	6.1	7.4	7	6.7	7	6.6
Kenya	8.6	8.3	7	6	8	8.7	5.7	8.5	7	8.3	8	8.4
Kiribati	8.4	7.4	7.6	8	7.6	10.6	9.5	8.2	8	7.9	8	7.9
Kuwait	11.0	8.5	9.6	9	9.2	10.8	8.2	10.8	10	9.6	10	9.6
Kyrgyzstan	8.2	5.7	10.4	7	7.4	12.5	8.2	8.1	8	6.8	8	6.8
Lao People's Democratic Republic	7.3	7.1	8.6	8	7.5	11.1	7.0	8.3	8	7.9	9	7.9
Latvia	8.1	6.8	12.8	8	6.6	10.1	6.6	8.9	8	7.0	8	7.0

Lebanon	9.1	8.0	8.9	9	8.6	11.1	8.4	10.3	10	9.3	9	9.4
Lesotho	7.6	7.1	5.9	6	6.7	6.9	3.3	6.4	7	6.9	7	6.9
Liberia	7.4	7.5	8.4	8	7.7	9.3	6.5	8.9	9	8.3	9	8.3
Libyan Arab Jamahiriya	10.5	8.0	9.2	9	8.3	11.4	8.1	10.7	9	8.7	9	8.8
Lithuania	8.4	6.6	13.3	9	6.8	10.8	7.2	8.7	8	6.6	9	6.7
Luxembourg	9.0	7.7	6.3	9	8.3	6.4	6.4	11.1	10	9.1	10	9.2
Madagascar	7.9	7.1	8.5	8	6.8	11.1	7.2	9.2	8	7.0	9	7.0
Malawi	7.2	9.3	5.8	6	9.5	6.7	4.8	7.2	9	10.8	8	11.1
Malaysia	8.9	7.1	8.6	8	7.2	11.7	8.0	8.7	9	7.2	9	7.2
Maldives	9.2	8.3	10.4	8	6.7	14.3	7.5	10.2	10	8.7	10	8.8
Mali	6.8	8.0	7.9	7	8	10.5	6.4	8.1	8	8.5	7	8.5
Malta	9.7	8.2	6.7	9	8.5	8.2	6.2	10.4	10	9.5	9	9.2
Marshall Islands	9.4	7.5	7.9	8	7.9	10.3	7.2	8.8	10	8.3	10	8.3
Mauritania	9.3	8.3	9.6	9	8.4	11.4	6.9	9.8	9	8.6	9	8.6
Mauritius	7.8	7.4	9.1	8	7.6	11.0	8.1	8.5	8	8.1	8	8.1
Mexico	7.8	8.8	7.9	8	8.9	9.0	8.3	7.8	8	7.6	8	8.8
Micronesia, Federated States of	8.4	7.9	8	9	7.9	10.6	7.9	8.2	9	8.1	9	8.1
Monaco		8.7	7.4	9	8.9	7.5	7.1		9	11.4	9	11.4
Mongolia	7.2	7.5	10.9	7	7.4	11.4	6.8	7.3	8	7.3	7	7.3
Morocco	10.3	8.1	10.8	9	8.2	12.6	9.4	10.6	9	8.2	9	8.2
Mozambique	7.2	7.3	6.4	6	7.5	9.3	4.9	7.1	7	7.9	7	7.9
Myanmar		7.3	8.5	8	7.5	8.2	6.3		8	7.7	8	7.7
Namibia	8.3	7.4	6.3	8	7.3	8.6	5.2	8.4	9	7.9	10	8.1
Nauru		7.4	8.3	11	7.8	9.9	6.9		11	8.1	11	8.1
Nepal	8.7	7.2	11	8	7.6	9.9	7.4	10.1	9	7.9	9	8.0
Netherlands	9.3	7.7	7.3	9	9.1	7.1	6.3	10.6	9	9.8	9	9.9
New Zealand	9.7	7.9	6.4	9	8.6	6.9	7.2	10.9	9	9.9	9	9.9

(continued)

Table 4.9 (continued)

Estimates of the mortality model for the Loss of Healthy Life Years (LHLY) for males for the WHO member countries and the related results from the HALE method of the World Health Organization

	HALE	Model	HALE	HALE	Model	HALE				Model	HALE	Model
Countries/Year	1990	1990	2000b	2000	2000	2001	2002	2010	2012	2012	2013	2013
Nicaragua	9.4	8.4	10.6	9	7.6	12.7	8.2	9.6	8	7.4	9	7.4
Niger	6.6	8.0	8.8	7	8.2	10.2	6.8	8.4	9	8.4	8	8.4
Nigeria	8.1	7.9	7.7	7	7.9	10.6	6.8	8.8	7	8.2	7	8.2
Niue		7.8	8.7	10	8	11.3	8.6		10	8.2	10	8.2
Norway	10.7	8.2	6.9	10	9.2	6.8	5.9	12.2	11	10.1	11	9.9
Oman	9.7	7.8	10.3	9	7.7	10.4	8.3	10.2	9	7.8	9	7.8
Pakistan	8.6	8.0	10	9	8	10.7	6.9	8.7	8	8.1	9	8.1
Palau		7.5	8.2	9	7.9	11.4	7.7		10	8.2	10	8.3
Panama	9.7	8.0	8.9	10	8	10.8	8.5	9.3	9	8.1	9	8.2
Papua New Guinea	7.9	5.7	8.5	7	5.9	10.5	7.0	7.9	8	6.2	8	6.2
Paraguay	10.3	8.9	10.3	9	7.5	12.9	9.1	9.7	9	8.6	9	8.6
Peru	9.8	9.0	8.9	9	8.4	11.5	7.9	10.4	10	8.9	10	8.9
Philippines	9.2	7.6	7.7	9	7.8	13.1	8.0	9.2	8	7.3	8	7.3
Poland	8.3	7.1	10	9	7.4	7.8	7.5	9.3	9	7.2	10	7.3
Portugal	8.9	7.9	7.8	8	8.4	8.5	6.9	9.9	9	9.0	10	9.0
Qatar	11.8	9.8	11.1	11	8	11.5	8.2	12.7	11	7.9	11	8.0
Republic of Korea	7.5	7.4	7.3	8	7.7	6.7	6.9	8.6	8	8.9	8	9.2
Republic of Moldova	7.8	6.8	7.7	7	6.6	10.0	6.8	8.0	7	6.6	7	6.7
Romania	8.2	7.5	6.8	8	7.6	9.2	7.0	8.7	8	7.9	8	7.8
Russian Federation	7.7	6.6	9.1	8	6.5	7.4	5.5	7.7	8	6.9	8	6.9
Rwanda	6.8	7.3	6.5	7	8.1	7.3	5.6	8.8	9	8.2	9	8.4
Saint Kitts and Nevis		8.2	8.4	8	9	10.2	8.7		10	8.0	11	8.0
Saint Lucia	9.5	7.8	8.5	9	7	10.7	8.6	11.9	11	7.2	12	7.2

Saint Vincent and the Grenadines	9.3	7.8	8	8	7.8	10.3	7.9	11.6	11	8.2	11	8.2
Samoa	8.7	6.3	8.5	8	6.8	11.0	7.6	8.6	8	7.2	8	7.2
San Marino		9.7	6.5	9	10.5	7.2	6.3		10	10.3	10	10.3
Sao Tome and Principe	9.0	7.9	10	8	8	14.8	7.5	9.7	9	8.2	9	8.2
Saudi Arabia	10.8	8.1	9.7	10	8.2	10.9	8.6	11.1	10	9.1	9	9.1
Senegal	7.9	8.3	8.8	8	8.3	11.3	7.3	8.7	9	8.5	8	8.5
Seychelles	7.4	6.8	9.5	6	8.7	11.3	9.6	7.1	6	7.4	7	7.5
Sierra Leone	7.2	7.1	7.3	5	7	8.6	5.1	8.9	6	7.4	7	7.5
Singapore	8.0	8.1	8.6	6	8.4	8.6	8.6	9.2	6	8.7	6	9.7
Slovakia	8.5	7.3	9.7	9	7.4	7.7	6.7	9.2	9	7.3	9	7.4
Slovenia	8.6	7.9	7.4	9	8.2	7.0	6.1	10.2	11	8.2	11	8.3
Solomon Islands	7.9	7.3	8.6	9	7.6	12.0	8.3	7.5	9	7.9	8	7.9
Somalia	7.1	6.9	8.3	7	7	8.5	6.9	7.8	7	7.1	8	7.2
South Africa	8.1	6.4	6.6	7	6.5	7.7	5.5	8.3	7	6.7	8	6.7
Spain	8.5	8.1	6.6	8	8.5	6.6	6.2	9.6	8	9.1	9	9.0
Sri Lanka	9.4	6.3	9	8	6.1	11.5	8.0	9.3	8	8.0	9	7.9
Sudan	10.1	7.2	9.8	9	7.2	11.2	7.8	11.0	9	7.4	9	7.4
Suriname	9.1	8.9	8.5	10	9.9	10.0	7.6	11.6	12	10.9	11	11.1
Swaziland	8.4	7.6	6	7	7.3	6.4	3.7	7.0	8	7.9	8	7.8
Sweden	9.9	8.6	7.2	10	9.5	7.2	6.2	11.2	10	10.4	10	10.4
Switzerland	9.1	8.8	6.2	9	9.8	6.2	6.6	10.6	11	10.3	10	10.4
Syrian Arab Republic	10.1	8.3	9.7	10	8.5	10.7	8.5	10.5	7	8.5	8	8.7
Tajikistan	8.2	7.7	10.8	7	7.7	12.8	7.9	8.7	8	7.8	8	7.8
Thailand	8.5	7.2	8.4	8	8	9.3	8.4	8.2	8	8.6	8	8.7
The FYROM	8.9	7.7	6.3	9	7.4	8.5	7.2	9.6	9	8.1	10	8.2
Togo	8.4	9.3	7.9	8	10.3	9.7	6.5	8.3	8	10.7	8	10.7
Tonga	9.7	6.9	8.1	8	7.2	11.0	8.2	8.4	10	7.9	10	8.0

(continued)

Table 4.9 (continued)

Estimates of the mortality model for the Loss of Healthy Life Years (LHLY) for males for the WHO member countries and the related results from the HALE method of the World Health Organization

	HALE	Model	HALE	HALE	Model	HALE				Model	HALE	Model
Countries/Year	1990	1990	2000b	2000	2000	2001	2002	2010	2012	2012	2013	2013
Trinidad and Tobago	8.6	6.5	8.2	8	6.5	8.4	7.3	10.5	9	6.6	9	6.6
Tunisia	9.0	8.5	8.2	8	8.5	10.1	8.2	9.5	9	8.5	9	8.6
Turkey	8.4	8.4	10	9	8.9	8.5	6.7	9.4	9	9.3	9	9.3
Turkmenistan	7.5	6.9	8.8	6	6.9	12.1	7.1	8.3	7	7.2	7	7.2
Tuvalu		6.1	7.2	9	6.3	9.9	7.0		9	6.7	9	6.7
Uganda	7.6	7.4	7.2	6	7.3	9.0	6.2	8.2	8	7.9	8	8.0
Ukraine	8.0	6.9	10.3	7	6.8	9.3	6.8	7.9	7	7.1	7	7.1
United Arab Emirates	10.1	7.6	10	9	7.9	9.0	7.8	10.6	10	8.3	9	8.4
United Kingdom	9.5	7.6	6.5	10	8.6	6.6	6.7	10.7	10	9.2	10	9.2
United Republic of Tanzania	8.3	7.8	7.2	7	7.9	9.5	5.5	9.1	8	8.3	9	8.3
United States of America	8.7	7.6	8.2	8	8.5	8.0	7.4	9.7	9	9.4	8	9.4
Uruguay	8.3	8.3	8.4	8	6.7	9.7	8.0	8.6	8	7.2	9	7.2
Uzbekistan	8.4	7.5	9.4	7	7.3	11.7	7.6	8.5	8	7.1	8	7.1
Vanuatu	8.1	7.6	8.2	9	7.9	11.0	8.0	7.9	9	8.2	10	8.2
Venezuela, Bolivarian Republic of	8.9	7.6	10.1	9	7.9	13.7	9.3	8.6	9	9.3	9	9.3
Vietnam	8.8	6.8	8.5	9	6.7	11.0	7.4	9.0	9	6.8	9	6.8
Yemen	9.5	7.4	10.4	8	7.5	12.9	10.8	10.2	8	7.6	9	7.6
Zambia	7.3	6.7	5.5	5	6.8	6.2	4.3	7.5	7	7.8	8	7.9
Zimbabwe	9.6	8.7	5.8	5	6.7	5.6	3.9	7.8	9	8.7	8	8.9
Method	HALE	Model	HALEb	HALE	Mode	HALE	HALE	HALE	HALE	Mode	HALE	Mode
Year	1990	1990	2000	2000	2000	2001	2002	2010	2012	2012	2013	2013
Mean	8.67	**7.69**	8.41	8.18	**7.83**	9.73	7.19	9.33	8.79	**8.25**	8.88	8.28

Table 4.10 Healthy life years lost to disability: mortality model and HALE results for females

Estimates of the mortality model for the Loss of Healthy Life Years (LHLY) for females for the WHO member countries and the related results from the HALE method of the World Health Organization

Countries/Year	HALE	Model	HALE	HALE	Model	HALE				Model	HALE	Model
	1990	1990	2000b	2000	2000	2001	2002	2010	2012	2012	2013	2013
Afghanistan	10.1	7.1	12.5	11	7.5	8.1	7.7	11.1	12	7.9	12	8.0
Albania	11.0	11.3	10.6	9	10.4	11.7	10.8	11.1	9	10.1	10	10.0
Algeria	11.2	8.9	12.9	10	8.9	11.2	9.6	11.9	10	8.9	11	9.0
Andorra	12.5	11.1	10.1	11	11.3	10.0	9.1	13.0	12	12.5	12	13.0
Angola	8.3	7.4	10.8	7	7.6	6.5	6.9	9.9	7	7.9	7	8.0
Antigua and Barbuda	11.2	9.5	14.5	9	9.2	10.9	10.3	13.5	11	9.7	11	10.0
Argentina	10.2	9.0	11.9	10	8.8	12.0	10.0	10.6	10	9.5	11	10.0
Armenia	10.7	7.9	10.1	10	8.3	11.9	10.4	11.3	9	8.9	9	9.0
Australia	11.2	9.7	8.8	11	10.4	9.5	8.7	12.0	11	11.6	11	12.0
Austria	10.7	10.4	8.9	10	11.1	8.8	8.6	12.1	11	11.8	11	12.0
Azerbaijan	10.5	7.8	11.4	9	7.8	11.2	10.0	11.1	10	8.6	10	9.0
Bahamas	12.2	9.7	15.7	11	11.3	12.5	9.7	13.9	12	10.8	11	11.0
Bahrain	9.9	7.9	12.4	12	7.6	12.2	10.1	11.2	12	9.6	12	10.0
Bangladesh	11.5	7.9	12.9	10	7.8	9.2	9.3	12.3	10	7.7	10	8.0
Barbados	10.4	8.4	13.4	12	8.7	10.6	9.8	10.4	13	10.2	13	10.0
Belarus	11.2	8.4	9.2	10	8.1	11.4	9.4	11.7	10	9.1	10	9.0
Belgium	11.7	10.2	9.9	10	10.6	9.4	8.2	12.1	11	11.4	11	11.0
Belize	10.3	9.8	14.3	11	9.5	11.3	10.2	10.8	12	9.8	12	10.0
Benin	9.2	8.5	11.9	9	8.3	9.2	7.9	10.2	9	8.6	9	9.0

(continued)

Table 4.10 (continued)

Estimates of the mortality model for the Loss of Healthy Life Years (LHLY) for females for the WHO member countries and the related results from the HALE method of the World Health Organization

	HALE	Model	HALE	HALE	Model	HALE				Model	HALE	Model
Countries/Year	1990	1990	2000b	2000	2000	2001	2002	2010	2012	2012	2013	2013
Bhutan	9.4	6.0	14.3	8	6.1	9.9	9.5	10.2	10	6.4	9	6.0
Bolivia	11.1	8.5	12.1	9	8.8	10.7	9.4	10.7	9	8.6	9	9.0
Bosnia and Herzegovina	10.8	8.8	9.4	10	7.1	11.5	10.0	12.7	11	9.3	10	9.0
Botswana	10.7	7.9	7.9	6	7.4	5.9	5.2	11.1	10	7.5	10	8.0
Brazil	10.0	8.2	12.7	10	7.7	11.0	9.8	10.5	10	8.1	11	7.0
Canada	11.1	9.5	9.8	10	10.3	10.4	8.3	11.8	8	10.7	9	11.0
Cape Verde	12.0	8.4	12.3	12	9.0	11.3	10.0	12.7	11	9.7	11	10.0
Central African Republic	8.6	7.6	8.9	7	7.2	7.7	6.1	7.6	8	7.9	8	8.0
Chad	9.2	7.4	11.2	7	7.4	8.7	7.6	9.2	8	7.6	8	8.0
Chile	10.2	8.7	12.1	10	8.7	11.7	10.3	10.5	11	9.2	11	9.0
China	8.0	8.7	9.7	7	9.7	8.4	7.6	8.6	8	10.1	8	10.0
Colombia	11.0	8.7	11.8	12	7.5	12.7	10.0	11.2	14	8.4	12	11.0
Comoros	8.6	7.6	12.3	8	7.7	11.0	9.6	9.3	9	7.9	8	8.0
Congo	9.8	8.1	10.1	8	7.9	8.7	7.2	10.0	9	8.4	9	8.0
Cook Islands		7.4	11.0	11	8.1	11.4	11.5		12	10.1	12	10.0
Costa Rica	11.4	9.2	12.4	10	8.8	11.6	10.3	11.4	10	9.2	10	9.0
Cote d'Ivoire	10.1	8.0	9.5	7	7.4	7.7	6.7	9.6	8	7.8	8	8.0
Croatia	11.3	9.3	10.6	10	9.6	10.2	9.3	11.6	11	9.9	11	10.0
Cuba	11.0	10.1	10.9	11	8.2	10.8	9.8	12.9	13	8.7	12	9.0
Cyprus	11.9	11.6	12.7	8	12.6	12.0	10.6	12.3	8	12.7	8	13.0
Czech Republic	10.3	9.2	9.9	9	9.8	9.3	8.1	11.1	10	10.6	10	11.0
Democratic People's Rep. of Korea	8.7	9.8	11.2	8	9.2	10.3	7.4	8.9	8	9.6	8	10.0

Democratic Republic of the Congo	9.2	7.7	9.6	8	7.7	8.2	7.0	9.6	8	7.9	8	8.0
Denmark	10.6	9.1	8.4	9	8.9	8.7	8.4	11.5	11	9.6	11	10.0
Djibouti	9.6	8.2	10.1	9	8.2	8.1	7.4	10.3	10	8.5	9	9.0
Dominica	10.7	9.3	12.2	10	9.7	11.2	10.2	12.9	12	9.1	12	9.0
Brunei Darussalam	9.8	8.5	12.7	10	8.0	12.2	11.9	10.2	9	9.3	10	9.0
Bulgaria	8.9	9.3	9.2	9	9.5	9.6	8.5	8.8	10	10.0	10	10.0
Burkina Faso	8.5	8.2	9.5	7	8.3	7.2	6.3	9.3	8	8.4	8	8.0
Burundi	7.7	7.2	8.5	7	7.3	6.6	6.2	8.4	8	7.6	9	8.0
Cambodia	9.6	6.6	9.8	10	7.0	9.1	7.6	10.1	12	8.0	12	8.0
Cameroon	9.9	8.0	10.5	8	7.8	8.4	7.3	9.7	12	8.1	11	8.0
Dominican Republic	10.7	9.8	14.0	10	7.6	10.7	9.6	11.8	12	8.5	10	7.0
Ecuador	11.1	7.4	12.0	11	7.4	10.8	9.4	11.3	10	10.5	11	11.0
Egypt	12.0	8.2	12.0	11	8.2	10.8	8.8	12.6	11	8.3	11	8.0
El Salvador	11.2	7.9	13.9	10	7.1	11.5	10.4	11.2	11	7.1	11	7.0
Equatorial Guinea	8.7	7.6	11.4	8	7.6	9.2	8.5	10.7	10	7.9	9	8.0
Eritrea	9.1	6.2	10.4	8	6.7	9.1	8.6	10.0	11	7.5	10	8.0
Estonia	10.0	8.9	11.0	9	9.2	10.4	8.1	11.3	10	10.3	11	10.0
Ethiopia	6.9	7.6	9.6	8	8.0	8.5	7.7	8.8	9	9.1	9	9.0
Fiji	9.9	8.4	10.7	10	8.0	11.0	9.7	9.8	11	8.1	10	8.0
Finland	12.5	9.8	9.5	10	10.9	8.8	8.0	13.7	11	11.8	11	12.0
France	11.7	10.9	10.2	11	11.4	9.5	8.8	12.4	11	12.3	11	12.0
Gabon	10.6	8.6	10.4	9	8.5	9.0	8.8	10.5	10	8.8	10	9.0
Gambia	9.7	8.4	12.1	9	8.6	10.1	8.4	9.8	10	8.9	9	9.0
Georgia	10.5	8.8	11.6	10	8.9	10.2	8.4	11.0	10	9.2	10	9.0
Germany	10.9	10.0	9.2	10	10.5	8.9	7.6	11.9	10	11.6	10	12.0
Ghana	10.5	11.2	11.0	9	10.5	9.2	8.5	10.6	10	11.2	9	11.0

(continued)

Table 4.10 (continued)

Estimates of the mortality model for the Loss of Healthy Life Years (LHLY) for females for the WHO member countries and the related results from the HALE method of the World Health Organization

	HALE	Model	HALE	HALE	Model	HALE				Model	HALE	Model
Countries/Year	1990	1990	2000b	2000	2000	2001	2002	2010	2012	2012	2013	2013
Greece	11.4	10.1	8.5	10	11.0	8.9	8.1	11.7	10	12.2	11	12.0
Grenada	10.9	8.8	11.5	11	9.3	9.7	8.9	11.8	12	9.9	11	10.0
Guatemala	9.8	7.2	12.6	10	8.9	11.9	9.1	10.2	10	9.1	10	9.0
Guinea	8.9	8.3	11.9	9	8.1	9.1	8.2	9.9	9	8.5	9	9.0
Guinea-Bissau	8.7	8.2	10.5	8	8.1	8.2	7.2	9.1	9	8.2	8	8.0
Guyana	10.5	6.6	14.2	9	7.8	10.0	9.7	11.5	10	7.8	10	8.0
Haiti	8.7	8.0	11.2	8	8.3	7.4	6.9	6.5	11	8.2	11	8.0
Honduras	11.0	8.8	13.2	11	8.9	10.7	9.9	11.0	12	9.1	12	9.0
Hungary	10.4	8.8	10.7	10	9.2	10.5	8.6	11.1	11	9.5	11	10.0
Iceland	12.8	9.8	9.3	10	10.7	9.4	8.2	14.5	11	12.1	11	12.0
India	9.2	6.4	11.0	10	6.7	10.4	8.4	9.8	10	7.1	9	7.0
Indonesia	9.2	8.1	9.1	9	8.4	10.1	9.1	9.3	9	8.8	9	9.0
Iran, Islamic Republic of	11.5	7.6	11.4	10	8.9	13.2	12.5	12.5	11	9.8	11	10.0
Iraq	10.5	8.9	12.1	11	9.1	9.6	11.6	10.5	11	9.1	10	9.0
Ireland	10.4	9.1	8.8	9	9.5	8.9	8.2	11.7	10	10.1	10	10.0
Israel	10.8	9.4	10.0	10	10.2	10.0	9.0	12.0	11	11.2	10	11.0
Italy	11.2	10.2	9.6	11	10.8	9.3	7.8	12.0	11	11.9	11	12.0
Jamaica	11.0	9.3	11.5	11	9.7	10.0	8.6	12.7	11	10.1	11	10.0
Japan	9.7	10.9	8.4	9	11.1	8.9	7.5	10.4	10	11.7	9	12.0
Jordan	11.3	8.7	13.6	10	8.9	13.6	10.9	11.9	10	9.2	11	9.0
Kazakhstan	10.0	7.3	10.3	8	7.5	11.3	9.6	9.8	8	9.3	9	9.0
Kenya	9.7	8.5	9.4	7	8.4	7.5	7.1	10.1	8	8.7	9	9.0

Kiribati	9.3	8.0	10.1	10	8.3	10.5	11.0	10.3	9	8.7	9	9.0
Kuwait	12.6	9.7	12.0	11	9.8	10.2	10.6	12.6	12	10.0	12	10.0
Kyrgyzstan	10.3	7.1	13.2	9	8.9	12.8	10.6	10.5	9	8.3	9	8.0
Lao People’s Democratic Republic	8.4	7.4	10.4	9	7.9	9.6	9.2	9.3	9	8.5	10	9.0
Latvia	10.5	8.7	11.6	10	9.2	11.1	8.3	11.3	11	9.6	10	10.0
Lebanon	10.6	8.8	12.2	10	9.3	9.8	10.4	11.4	11	10.1	11	10.0
Lesotho	10.1	7.4	7.7	6	7.2	6.3	5.0	8.1	8	7.2	8	7.0
Liberia	8.9	7.9	11.7	8	8.2	8.3	6.7	10.0	10	8.7	10	9.0
Libyan Arab Jamahiriya	12.5	8.8	12.4	12	9.1	10.8	10.5	12.9	12	9.5	12	9.0
Lithuania	10.6	9.0	14.0	10	9.5	12.6	9.9	10.9	11	9.9	9	10.0
Luxembourg	11.2	9.4	8.7	10	9.9	9.0	8.0	12.3	11	10.4	11	10.0
Madagascar	9.0	7.3	12.0	9	7.1	9.7	8.4	10.4	9	7.5	10	8.0
Malawi	8.2	8.9	7.4	6	8.6	6.3	5.8	8.5	9	10.0	9	10.0
Malaysia	10.1	8.2	10.7	10	8.9	11.2	10.0	10.1	10	9.1	10	9.0
Maldives	9.7	8.1	13.8	9	8.3	10.1	9.0	11.5	10	9.8	11	10.0
Mali	8.2	8.0	10.5	8	8.0	8.5	7.4	9.3	9	8.5	9	9.0
Malta	11.6	10.9	8.6	10	10.6	9.5	8.3	12.4	11	11.3	10	12.0
Marshall Islands	10.7	8.0	10.4	9	8.5	9.6	8.9	10.2	11	9.1	12	9.0
Mauritania	10.5	8.7	12.7	11	8.8	9.5	8.2	10.7	11	9.0	10	9.0
Mauritius	9.5	8.2	12.2	10	8.8	17.2	10.9	10.1	10	9.5	10	9.0
Mexico	9.4	9.8	10.9	9	9.9	11.8	9.3	9.3	10	8.3	9	10.0
Micronesia, Federated States of	9.3	8.3	10.3	10	8.4	10.3	9.6	9.7	10	8.6	9	9.0
Monaco		11.2	10.5	11	10.9	10.5	9.3		11	13.3	11	13.0
Mongolia	8.3	8.6	12.4	8	8.1	10.3	8.0	9.0	9	8.4	8	8.0
Morocco	12.0	8.7	16.0	11	8.8	15.5	11.9	12.5	12	8.9	11	9.0
Mozambique	9.1	7.5	8.4	8	7.6	8.3	6.4	8.8	8	7.9	8	8.0
Myanmar		7.8	10.7	9	8.0	8.5	8.4		10	8.3	9	8.0

(continued)

Table 4.10 (continued)

Estimates of the mortality model for the Loss of Healthy Life Years (LHLY) for females for the WHO member countries and the related results from the HALE method of the World Health Organization

	HALE	Model	HALE	HALE	Model	HALE				Model	HALE	Model
Countries/Year	1990	1990	2000b	2000	2000	2001	2002	2010	2012	2012	2013	2013
Namibia	10.2	8.0	7.9	8	6.7	8.0	6.7	9.8	10	8.1	10	8.0
Nauru		8.1	11.1	13	9.2	9.6	9.0		14	9.6	14	10.0
Nepal	9.1	7.4	13.8	9	7.9	8.8	9.1	10.7	9	8.5	10	9.0
Netherlands	11.6	9.1	9.7	11	10.2	9.6	8.5	12.4	11	11.3	11	11.0
New Zealand	11.0	10.3	8.9	10	10.7	9.4	9.0	12.0	11	11.4	11	11.0
Nicaragua	11.0	8.2	13.0	11	7.2	10.7	9.3	11.2	10	7.5	11	8.0
Niger	7.8	8.2	11.5	8	8.3	8.5	7.5	9.3	9	8.5	8	9.0
Nigeria	9.2	7.9	10.3	7	7.8	8.9	7.8	9.6	8	8.2	8	8.0
Niue		8.9	11.4	11	9.2	11.6	11.3		12	9.4	12	9.0
Norway	12.6	9.7	9.1	12	10.7	9.3	8.1	13.4	12	11.2	12	11.0
Oman	11.8	7.6	13.2	12	7.3	12.9	11.1	12.5	11	7.1	12	7.0
Pakistan	9.3	8.4	14.7	10	8.5	10.0	9.3	9.8	9	8.5	10	8.0
Palau		8.0	10.4	10	8.5	10.7	10.4		11	9.1	11	9.0
Panama	11.6	11.3	11.0	11	8.9	11.1	10.2	11.2	11	9.0	10	9.0
Papua New Guinea	8.3	6.5	10.4	9	6.7	9.5	9.1	8.8	10	6.9	10	7.0
Paraguay	11.5	9.6	12.3	12	8.8	11.0	10.5	11.2	11	9.7	11	10.0
Peru	10.7	9.1	11.8	10	8.6	10.8	9.6	11.0	11	9.4	11	9.0
Philippines	11.0	8.4	10.2	11	9.1	11.7	10.2	10.6	9	8.8	9	9.0
Poland	10.5	9.7	13.4	10	9.6	11.5	10.2	11.2	11	9.8	10	10.0
Portugal	10.9	9.9	10.7	10	10.4	10.7	8.8	11.6	11	10.9	11	11.0
Qatar	13.3	9.2	13.2	12	7.6	11.2	10.0	14.7	14	7.9	13	8.0

Republic of Korea	9.1	8.9	9.5	9	10.1	8.4	8.6	10.1	10	11.6	10	12.0
Republic of Moldova	9.8	7.7	8.9	9	7.7	10.9	9.2	10.0	9	8.0	9	8.0
Romania	9.8	8.7	9.5	9	8.4	11.2	9.7	10.3	9	9.3	9	9.0
Russian Federation	10.3	8.4	11.4	9	8.3	10.4	7.7	10.2	9	8.8	9	9.0
Rwanda	8.1	7.4	8.7	7	8.3	6.8	6.6	10.7	10	8.7	10	9.0
Saint Kitts and Nevis		9.5	10.5	10	10.4	10.0	9.1		12	9.5	12	10.0
Saint Lucia	11.1	7.8	10.9	12	7.2	10.6	10.2	12.4	13	8.0	13	8.0
Saint Vincent and the Grenadines	11.1	8.8	11.3	10	8.8	10.2	9.8	12.0	11	10.0	11	10.0
Samoa	9.9	7.3	11.3	10	7.8	10.4	9.4	10.2	11	8.2	10	8.0
San Marino		12.0	9.5	11	12.2	9.8	8.1		11	13.6	11	14.0
Sao Tome and Principe	10.3	8.1	12.2	10	8.2	10.3	9.0	11.5	11	8.4	10	8.0
Saudi Arabia	12.9	9.6	12.8	12	10.0	11.0	11.0	13.3	12	9.2	12	9.0
Senegal	9.9	8.7	11.6	10	8.7	9.5	8.4	10.6	10	9.0	10	9.0
Seychelles	9.6	9.0	13.8	8	10.1	13.6	12.3	9.1	7	9.6	7	10.0
Sierra Leone	8.9	7.4	9.6	6	7.4	6.9	5.8	10.2	7	7.6	6	8.0
Singapore	9.7	9.1	11.3	8	9.8	11.6	10.4	10.7	8	9.4	7	11.0
Slovakia	11.1	9.3	12.3	9	9.4	10.7	8.9	10.8	10	10.0	10	10.0
Slovenia	11.0	10.0	10.2	11	10.3	9.2	8.2	11.8	11	11.1	12	11.0
Solomon Islands	8.6	7.5	11.3	10	8.0	11.5	10.3	8.7	10	8.5	9	8.0
Somalia	8.3	7.1	11.2	8	7.3	7.9	8.1	9.0	9	7.5	9	7.0
South Africa	10.2	7.7	8.6	9	7.8	7.6	7.3	9.6	9	8.0	10	8.0
Spain	10.4	10.4	9.8	10	11.0	9.6	7.7	11.2	10	11.7	11	12.0
Sri Lanka	11.1	7.7	11.7	10	8.5	11.4	10.3	11.2	10	9.7	10	10.0
Sudan	11.4	7.5	13.4	10	7.7	9.8	9.4	12.6	11	7.9	11	8.0

(continued)

Table 4.10 (continued)

Estimates of the mortality model for the Loss of Healthy Life Years (LHLY) for females for the WHO member countries and the related results from the HALE method of the World Health Organization

	HALE	Model	HALE	HALE	Model	HALE				Model	HALE	Model
Countries/Year	1990	1990	2000b	2000	2000	2001	2002	2010	2012	2012	2013	2013
Suriname	10.7	11.5	11.9	12	13.7	10.0	10.0	12.2	12	13.1	12	13.0
Swaziland	10.2	7.1	8.0	7	7.1	6.1	5.2	8.1	8	7.6	8	8.0
Sweden	11.7	10.4	9.2	10	11.0	9.1	7.9	12.3	11	11.8	11	12.0
Switzerland	11.0	10.9	8.8	11	11.9	8.4	8.1	12.1	11	12.2	11	12.0
Syrian Arab Republic	12.1	8.7	12.9	11	9.1	12.7	10.5	12.7	11	9.5	11	10.0
Tajikistan	9.8	8.0	12.7	8	7.4	13.7	10.1	10.5	9	7.6	9	8.0
Thailand	10.0	8.4	10.5	10	8.7	11.5	10.2	9.7	11	9.5	10	10.0
The FYROM	10.5	8.4	8.9	10	8.6	11.0	10.2	10.8	10	9.7	10	10.0
Togo	10.1	9.5	10.3	9	10.5	8.2	7.7	10.1	9	10.9	9	11.0
Tonga	10.3	7.7	10.8	10	7.9	10.5	9.6	10.6	9	8.0	9	8.0
Trinidad and Tobago	10.8	7.2	10.7	10	7.6	10.6	8.6	12.0	11	7.7	11	8.0
Tunisia	10.7	10.7	11.7	10	9.8	9.8	10.3	11.4	11	9.5	10	10.0
Turkey	10.8	9.1	12.0	11	9.9	10.1	9.3	11.7	11	10.6	12	11.0
Turkmenistan	9.3	7.7	11.9	8	7.4	12.7	9.7	10.4	8	7.6	9	8.0
Tuvalu		6.9	10.0	9	1 7.0	1 9.7	8.3		10	7.3	10	7.0
Uganda	8.8	7.7	9.4	6	7.3	7.9	7.2	9.7	8	8.0		80
Ukraine	10.2	8.9	12.0	8	8.8	11.5	9.4	10.0	9	9.0	9	9.0
United Arab Emirates	11.6	7.7	12.5	11	7.9	11.5	10.9	12.4	11	8.3	11	8.0
United Kingdom	10.9	9.1	8.5	10	9.8	9.0	8.4	11.8	11	10.2	11	10.0
United Republic of Tanzania	9.3	8.0	9.6	7	8.1	7.9	6.8	10.0	10	8.7	10	9.0
United States of America	10.5	9.1	10.7	10	9.6	10.7	8.5	11.0	10	10.3	10	10.0

Uruguay	10.2	10.0	11.4		8.8	109	9.9	10.4	11	9.4	11	9.0
Uzbekistan	10.5	7.1	12.2	9	6.9	12.4	10.0	10.6	10	7.5	10	8.0
Vanuatu	9.1	8.1	10.8	11	8.5	10.8	9.8	9.5	11	9.0	10	9.0
Venezuela, Bolivarian Republic of	10.5	8.5	12.3	10	8.8	11.5	10.1	10.7	11	9.1	11	9.0
Vietnam	10.1	8.2	11.3	11	8.5	10.4	9.3	10.5	11	8.6	10	9.0
Yemen	10.3	7.8	12.7	10	7.9	10.2	11.5	11.0	10	8.0	11	8.0
Zambia	8.6	7.4	7.2	6	6.8	5.6	5.3	8.6	8	8.9	9	9.0
Zimbabwe	11.0	8.9	7.9	6	7.3	5.5	4.7	9.0	9	8.8	9	9.0
Method	HALE	MODEL	HALEb	HALE	MODE	HALE	HALE	HALE	HALE	MODE	HALE	MODE
Year	1990	1990	2000	2000	2000	2001	2002	2010	2012	2012	2013	2013
Mean	10.3	**8.6**	11	9.5	**8.8**	10	8.9	10.8	10.2	**9.3**	10.1	9.3

4.5 Discussion and Conclusions

The GBD study criticized by Williams (see Murray and Lopez 2000) whereas many comments from people from social sciences and philosophy refer to the impossibility to define health and, as a consequence, to measure it. The main problem is that we cannot have flexibility in finding an estimate of health the way we do with other measures of the human organism and related activities. So far if we measure health by collecting surveys it is clear that the uncertainty is relatively high. Even more if we decide for an accepted health state estimate (see Sanders 1964 and related studies during 1960s and 1970s) it remains the problem of accepting a unit of measure. The quantitative methods we propose overcome many of the objections posed. That we have achieved is to propose and apply several quantitative methods and techniques leading to estimates of the healthy life years lost, that more than to be close to the WHO results, provide enough evidence for estimating and quantifying the health state of a population.

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