POPULATION AGING AND HEALTHY LIFE: LESSONS FROM THE RELATED STUDIES

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Abstract

In recent decades many qualitative and quantitative studies have explored the influence of disabilities on the health status of the population and the related financial and economic issues. This very important issue has to do with the introduction and estimation of characteristic indicators for the loss of healthy life years in every country and geographic region or in different ethnic and socio-economic groups. A large international study was conducted under the umbrella of the World Health Organization (WHO) in the framework of the Global Burden of Disease Study and the countries are classified according to their health status index while several attempts refer to the interaction of the health status and the economic level of a country or a population. The main finding is that the longer we live the more the years with poor health tend to increase. In this paper we discuss the main findings of the health state studies and propose methods and techniques for the most appropriate adaptation of the theory in order to support related applications.

Key words: Health status, WHO, Healthy life.

JEL Code: I15, I18, J1

1 Introduction

Starting from the late 80's 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. Over the course of time they succeeded in establishing an international network collecting and providing adequate information to formulate health measures under such terms as Loss of Healthy Life Years (LHLY) or Healthy Life Expectancy (HALE). The latter tends to be an important measure for the policy makers and national and international health programs. So far the process followed has been towards statistical measures including surveys and data collection using questionnaires and disability and epidemiological data as well. Researchers 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 public opinion has been 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 the present day it is clear that the observed and estimated health parameters follow a rather systematic pattern. If so why not 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 90's we have introduced and applied 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 those provided by the World Health Organization (WHO) and other agencies such as EUROSTAT or experts such as the REVES group. However, our method based on a difficult stochastic analysis technique is not easy to use especially by practitioners.

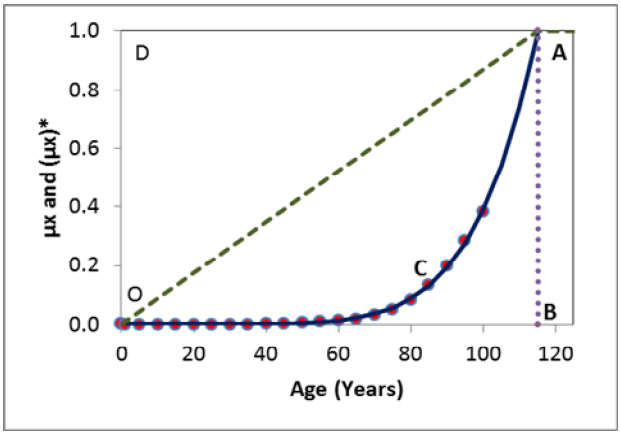
The last four centuries demography and demographers are based on the classical Life Tables. Thus, here we propose a very simple model based on the mortality μ_x of a population provided in a classical life table. To compare our results with those provided by WHO we use the μ_x included in the WHO abridged life tables. Our estimates are compared with the HALE estimates for WHO countries. Furthermore, 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 a fair WHO estimate for many of the countries. There are few countries' results differing from the model and need further study.

2 The Simplest Model

Although the Gompertz model is the classical approach in expressing mortality, its form is not so convenient for expressing the health state estimates as are presented below. We need a simpler 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 and with similar properties of the Gompertz of the form:

Fig. 1. The mortality diagram



$$\mu_x = \left(\frac{x}{T}\right)^b$$

The parameter T represents the age at which μ_x=1 and b is a crucial parameter expressing the curvature of μ_x. As the health state is improved μ_x gets higher. The main task is to find the area Ex under the curve OCABO in the mortality diagram which is a measure of the mortality effect. This is done by estimating the integral

$$E_x = \int_0^T \left(\frac{x}{T}\right)^b dx = \frac{T}{(b+1)}\left(\frac{x}{T}\right)^b$$

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

$$E_{mortality} = \frac{T}{(b+1)}$$

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

$$E_{health} = T - E_{mortality} = T - \frac{T}{(b+1)} = \frac{bT}{b+1}$$

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

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

This is the simplest indicator for the loss of health status of a population. As we have estimated by another method it is closer to the severe disability causes indicator as it is a

measure of health versus mortality. The relation $E_{total}/E_{mortality}$ provides another interesting indicator of the form:

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

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 which means that as we live longer the disability period becomes larger.

This method suggests a simple 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:

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

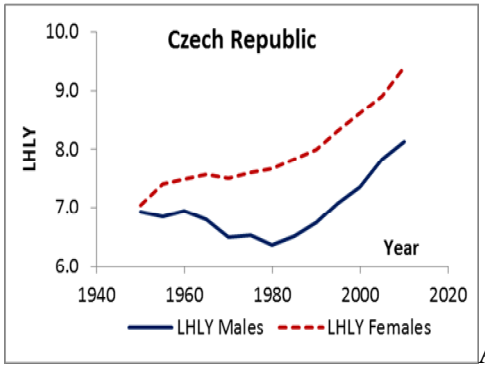
However, for comparisons between countries it is sufficient to select λ=1.

To our great surprise selecting λ=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 2010, 2012, 2015) where more health estimators are found.

3 Application

As we have established a relatively good method to estimate the loss of healthy life years (LHLY) and the healthy life expectancy (HLE) we can explore the main and very important finding of the health state research - in other words how many years are expected to be lived in good health and how much the loss of healthy life years grows as we live longer. As Switzerland is a country not affected by wars and serious changes for a long time it selected for our applications. Data from 1880 until 2010 for males and females were selected from the human mortality database and the simple model proposed was used. Data from the Czech Republic are also explored in this study. The Excel program and related material can be downloaded from the demographics2016 Conference website at: http://www.smtda.net/demographics2016.html



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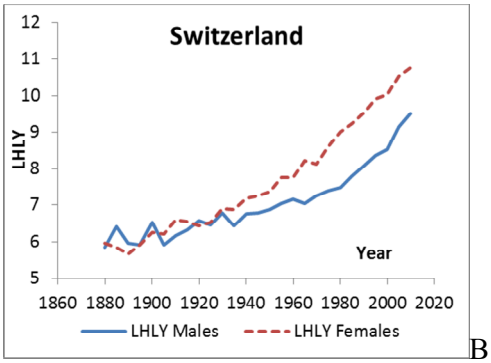

B

Fig. 2A. Loss of Healthy Life Years in Czech Republic (1950-2010)

Fig. 2B. Loss of Healthy Life Years in Switzerland (1880-2010)

The Loss of Healthy Life Years (LHLY) in the Czech Republic has two different patterns for males and females. For both cases the estimates are similar in the starting point of our estimates the year 1950. Then the LHLY for females is growing whereas the LHLY for males declines until the year 1980 and then increases while the gap between females and males remains at a level 1.2-1.3 years from 1980 until 2012 (Figure 2A). In Figures 3 and 4A we have also included the related results from WHO estimates. It should be noted that these estimates started from 1990 and continued for several years but under different assumptions and methodology. However, the WHO figures are close to our model estimates providing an interesting approach to use both methods when doing health state calculations. Our method needs only mortality data (μ_x) for the calculations so that it can be applied as far as life tables are available. For the Czech Republic we use the mortality data from the Human Mortality Database (HMD) from 1950 to 2010 whereas for Switzerland we use the HMD data from 1880 to 2010 (see Figures 2B, 4B and Tables II and IV). For both cases the estimates from WHO are also included (see Figures 3, 4A and 4B). From these graphs we see that WHO estimates are closely related to our estimates (see also Tables I, II, III and IV). Of course it is clear that the WHO estimates show variations due to changes in the methods used. The data for 1999 are provided from a study termed as DALE (see Mathers et al, 2000) whereas the other estimates are from the HALE studies already suggested and provided by WHO (see WHO 2000, 2001, 2002, 2013, 2014, Salomon et al. 2012, Murray et al. 2015). By exploring the data for three consecutive years (2000, 2001 and 2002) we see large differences not explained by the situation in both countries (see Tables I and II). Nothing important happened during this time period to account for 3 years change for males and 2.6 years for females in the Czech Republic and 1.6 years for females in Switzerland.

TABLE I

Healthy Life Expectancy in Czech Republic							
Year	1990	1999*	2000	2001	2002	2010	2012
HALE Males, WHO	60.4	65.2	62.9	63.8	65.9	64.8	66
HALE Females, WHO	67.4	70.8	68.3	69.5	70.9	69.6	71

*DALE estimates

TABLE II

Healthy Life Expectancy in Switzerland							
Year	1990	1999*	2000	2001	2002	2010	2012
HALE Males, WHO	65.5	69.5	70.4	71.1	71.1	69.1	71
HALE Females, WHO	71.4	75.5	73.7	74.4	75.3	72.4	74

*DALE estimates

TABLE III

Health Estimates for Czech Republic								
	Males				Females			
Year	HLE	LHLY	T	LE	HLE	LHLY	T	LE
1950	55.1	6.9	107.1	62.0	59.8	7.0	109.2	66.9
1955	59.5	6.8	108.5	66.3	64.1	7.4	108.1	71.5
1960	60.5	7.0	107.7	67.5	65.8	7.5	108.8	73.3
1965	60.3	6.8	108.7	67.1	65.8	7.6	108.3	73.4
1970	59.5	6.5	109.2	66.0	65.5	7.5	107.5	73.0
1975	60.4	6.5	108.8	67.0	66.4	7.6	107.9	74.0
1980	60.4	6.4	109.0	66.8	66.2	7.7	106.7	73.9
1985	60.9	6.5	109.6	67.5	66.9	7.8	107.1	74.7
1990	60.8	6.8	108.7	67.5	67.4	8.0	107.4	75.4
1995	62.6	7.1	108.8	69.6	68.3	8.3	107.2	76.6
2000	64.2	7.3	109.1	71.5	69.7	8.6	107.6	78.3
2005	65.1	7.8	107.9	72.9	70.3	8.9	107.1	79.2
2010	66.2	8.1	108.1	74.4	71.2	9.4	107.1	80.6

The healthy life years lost (LHLY) for the Czech Republic increased from 6.9 years for males in 1950 to 8.1 years in 2010. The related LHLY for females was 7.0 years in 1950 and 9.4 years in 2010. In Switzerland the LHLY was 5.8 years for males the 1880 and 9.5 in 2010 whereas it was 6.0 years in 1880 and 10.8 years in 2010.

TABLE IV

Health Estimates for Switzerland								
	Males				Females			
Year	HLE	LHLY	T	LE	HLE	LHLY	T	LE
1880	35.6	5.8	109.5	41.4	38.3	6.0	109.3	44.3
1885	36.7	6.4	105.4	43.1	39.6	5.8	110.8	45.4
1890	38.0	6.0	107.1	44.0	40.9	5.7	112.0	46.6
1895	39.9	5.9	109.5	45.8	42.7	5.9	110.7	48.6
1900	40.0	6.5	104.6	46.5	42.8	6.3	106.9	49.1
1905	42.6	5.9	108.7	48.5	45.1	6.2	109.2	51.3
1910	45.3	6.2	108.9	51.4	48.1	6.6	108.0	54.8
1915	48.1	6.3	108.3	54.4	51.0	6.6	108.7	57.6

1920	46.6	6.6	105.7	53.1	49.2	6.4	108.8	55.7
1925	52.0	6.5	107.8	58.4	54.9	6.5	110.3	61.4
1930	52.5	6.8	107.4	59.3	56.6	6.9	109.0	63.5
1935	53.8	6.4	107.8	60.2	57.1	6.9	107.9	63.9
1940	54.6	6.8	105.9	61.4	58.5	7.2	106.4	65.7
1945	56.5	6.8	107.4	63.3	60.1	7.2	107.7	67.4
1950	59.8	6.9	109.7	66.6	63.7	7.4	109.3	71.1
1955	60.6	7.0	107.7	67.7	64.5	7.8	107.2	72.3
1960	61.5	7.2	108.1	68.6	64.5	7.8	107.2	72.3
1965	62.4	7.0	108.9	69.4	66.8	8.2	106.8	75.0
1970	62.7	7.2	109.1	70.0	68.0	8.1	108.7	76.1
1975	64.1	7.4	109.7	71.5	69.3	8.6	108.7	77.9
1980	64.7	7.5	109.8	72.2	69.8	9.0	107.7	78.8
1985	65.6	7.8	109.1	73.4	70.9	9.2	108.6	80.1
1990	65.8	8.1	107.8	73.9	71.1	9.5	107.6	80.6
1995	66.9	8.4	108.0	75.2	71.7	9.9	107.6	81.6
2000	68.4	8.5	108.7	76.9	72.4	10.0	107.7	82.5
2005	69.4	9.1	107.3	78.5	73.1	10.5	107.2	83.6
2010	70.5	9.5	107.3	80.0	73.5	10.8	107.3	84.3

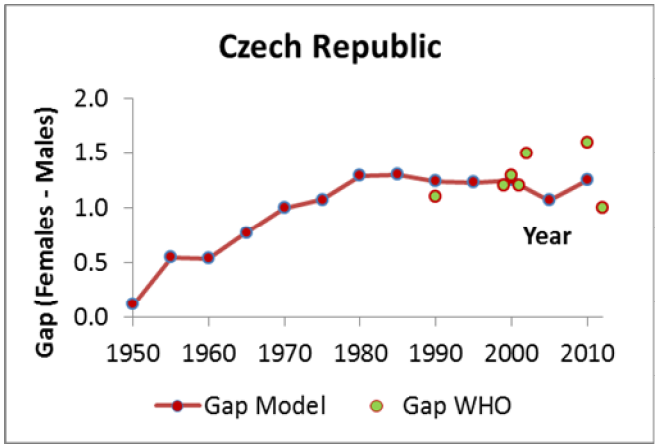

Fig. 3.The gap between males and females for Czech Republic

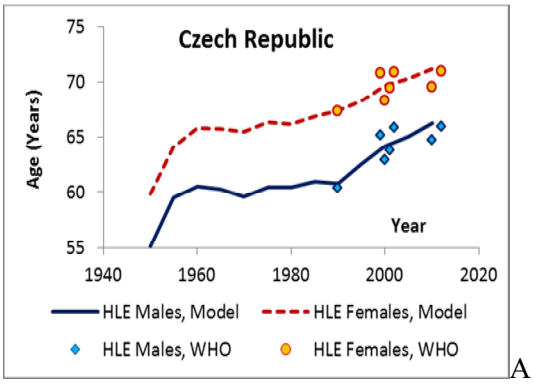

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Fig. 4A. Healthy Life Expectancy in Czech Republic (1950-2010)

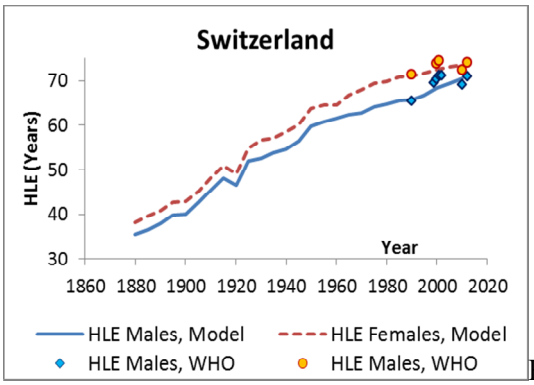

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Fig. 4B. Healthy Life Expectancy in Switzerland (1880-2010)

4 Discussion

The introduction of the healthy life expectancy indicator and the related estimations was a formidable improvement of the demographic science and related applications (see Sanders, 1964, Sullivan, 1971, Janssen and Skiadas, 1995, Murray and Lopez, 1997, McDowell, 2006, Skiadas and Skiadas, 2010, 2012, 2014, Vos et al, 2010, Hausman 2012, Murray et al., 2015). It was a step by step advancement in the way we face and measure the health state of a population from the original negative approach regarding the quantification process of what we call health (see Murray and Lopez, 2000 in a response to Williams) until the establishment of generally accepted healthy life expectancy (HLE) estimates. This was also possible with the help and support of international organizations as WHO, United Nations, World Bank, Eurostat, and many others.

1. The loss of healthy life years for females is higher thanf or males thus compensating for the extra years for females measured in life expectancy. Of course the gap of LE between the two sexes is larger than the gap for the HLE.

2. As we live longer the healthy life years lost (LHLY) are increasing. This is a serious finding from the related studies. It means that along with expanding the life span we have to find ways to reduce the number of the healthy life years lost.

3. The simple measures of the social security systems based on the life expectancy should be improved taking the LHLY into serious consideration in the related plans and programs.

4. It is a challenge for the medical systems to adapt their support to the growing segment of society which lives above the HLE age.

5. The economic estimates of a country should be adapted to the growing need for medical support due to the increasing number of LHLY. More attention should be paid to how we can reduce the healthy life years lost.

6. A surprising finding from applying our model to health state was that we find similar results with the WHO estimates without measuring any kind of diseases or disabilities. Only mortality measures are needed.

7. Following the last finding we have to reconsider the role of diseases in mortality and consider the aging process as more important than the diseases, the latter being more of an after effect of the aging mechanisms.

5 Conclusions

The post war advances in science and medicine along with the economic and social improvements in our societies led to increasing life expectancy. Special attention was paid to the improvement of the care of an aging population. However, the figures turned out to be disappointing regarding the health state of the aging population. As we live longer the disability period is increasing. This fact applies even in the more developed countries, the medical system reducing the effects of bad health but not eliminating or reducing the healthy life years lost so far. Countries should spend more on improving the social security system and of course health spending. As we live longer we need special care.

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