# HEALTH PARAMETERS ESTIMATED FROM 1950 TO 2019 IN ROMANIA

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## Abstract

Thanks to the provided full Life Tables from www.mortalitytrends.org it was possible to estimate the Healthy Life Expectancy at birth (HLE) for all the years from 1950 to 2019 and for the majority of the United Nations Countries. For countries with life tables from the last centuries as Sweden (1751-2017) the life tables of the Human Mortality Database are preferred from www.mortality.org . Romania was selected for this application. The Health parameters as the Healthy Life Years Lost and the Healthy Life Expectancy were estimated for males and females for various time periods. The mean health state H(x) is estimated with a stochastic methodology, and stochastic simulations are done. The optimum pension scheme and healthy selection opportunities are studied via the appropriate functions and graphs. Romanian male and female health state presentations are done and comparisons follow. The methodology for assessing the health state provided, further to the healthy life expectancy estimation, is a valuable tool to take appropriate actions to improve health and reduce morbidity.

See at http://www.asmda.es/demographics2021.html for details and download the related program in Excel (*HLE-Template-1950-2019-Final-.zip*).

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**Key words:** Healthy Life Expectancy, Life Tables, Health Parameters, Pension Schemes, Stochastic Simulations

**JEL Code:** I15, I18, J1

## Introduction

Health parameters as the Healthy Life Expectancy (HLE) are important measures of the health state of a population. A systematic work of a large group of researchers all over the world has established and proposed to measure the HLE. A successful estimate termed as HALE is provided

by the World Health Organization (WHO) following the standard methodology proposed by Sullivan (1971). Jagger et al (2014) provide a practical guide. An application for the estimation of Life Expectancy and HLE in Japan was due to Tokudome et al (2016). The works of Weon and Je (2011, 2012) explore survival curves. Zafeiris (2019) studies the mortality differences among the Euro-zone countries. Interconnection between the Healthy Life Years Lost (HLYL or YLL) estimates and the Weibull (1951) shape parameter are observed by Matsushita et al (1992) and further explored in Skiadas and Skiadas (2020b). More information and applications in Skiadas and Skiadas (2018a, 2018b, 2020a, 2020c).

The mean health state H(x) is also calculated by a stochastic methodology for males and females providing an important measure for the optimum selection of the pension scheme. The same methodology is applied to perform stochastic simulations.

## Life Expectancy and Healthy Life Expectancy estimates

Thanks to the provided full Life Tables from www.mortalitytrends.org it was possible to estimate the Healthy Life Expectancy at birth (HLE) for all the years from 1950 to 2019 and for the majority of the United Nations Countries. For countries with life tables from the last centuries as Sweden (1751-2017) the life tables of the Human Mortality Database are selected www.mortality.org .

See at http://www.asmda.es/demographics2021.html for details and download the related program in Excel (HLE-Template-1950-2019-Final-.zip). You can easily calculate the detailed estimation for every country as follows.

The formula HLE=LE-HLYL applies, where

$$HLYL=\max\left(x m_x / \sum_0^x m_x\right).$$

Here the case of Romania is studied. The estimates were done for all years from 1950 to 2019 as presented in the following graphs.

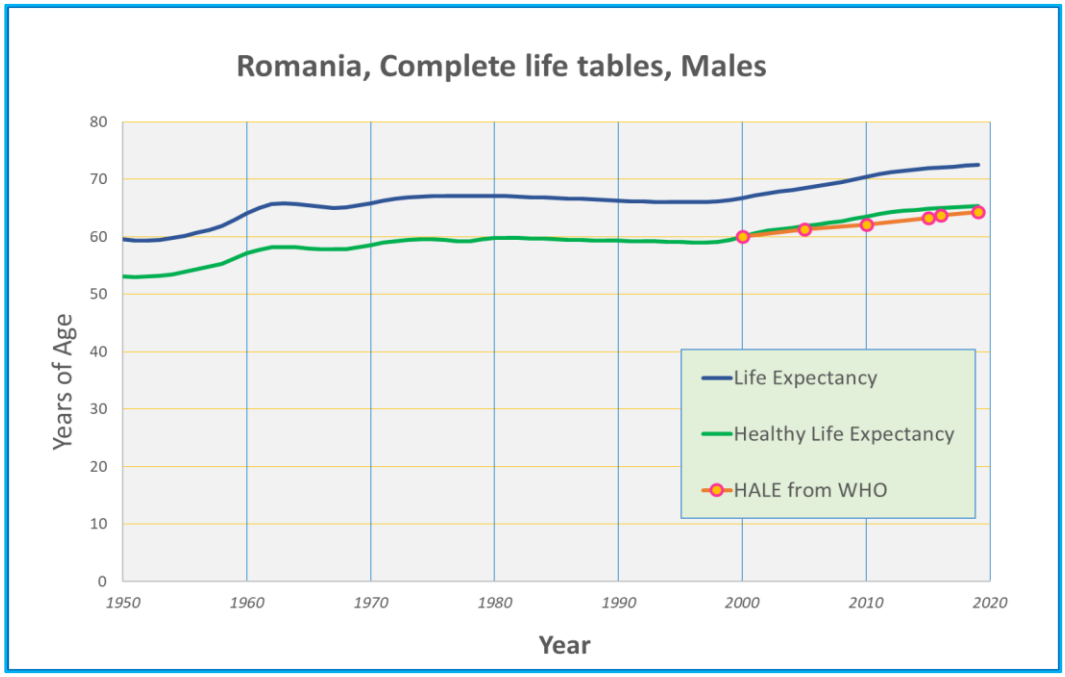
The Tables here include only partial information. To obtain the full information for this and other countries download the Excel program from http://www.asmda.es/demographics2021.html .

The Male Healthy Life Expectancy in 2019 was 65.31 years of age. It was only 53.15 years in 1950 and then followed a characteristic growth (Figure 1 and Table 1).

Female Healthy Life Expectancy was 56.41 years of age in 1950 and 69.84 years in 2019 (Figure 2 and Table 2).

Both male and female HLE from our Direct estimates from the Life Tables are close to the HALE estimates from World Health Organization at least for the period 2000-2019 when the WHO data are provided. Our method permits the HLE estimates in the far-past as life table data are available. The same holds for present estimates and future projections.

***Fig. 1*: Life Expectancy (LE), Healthy Life Expectancy (HLE) and HALE in Romania, males (1950-2019).**

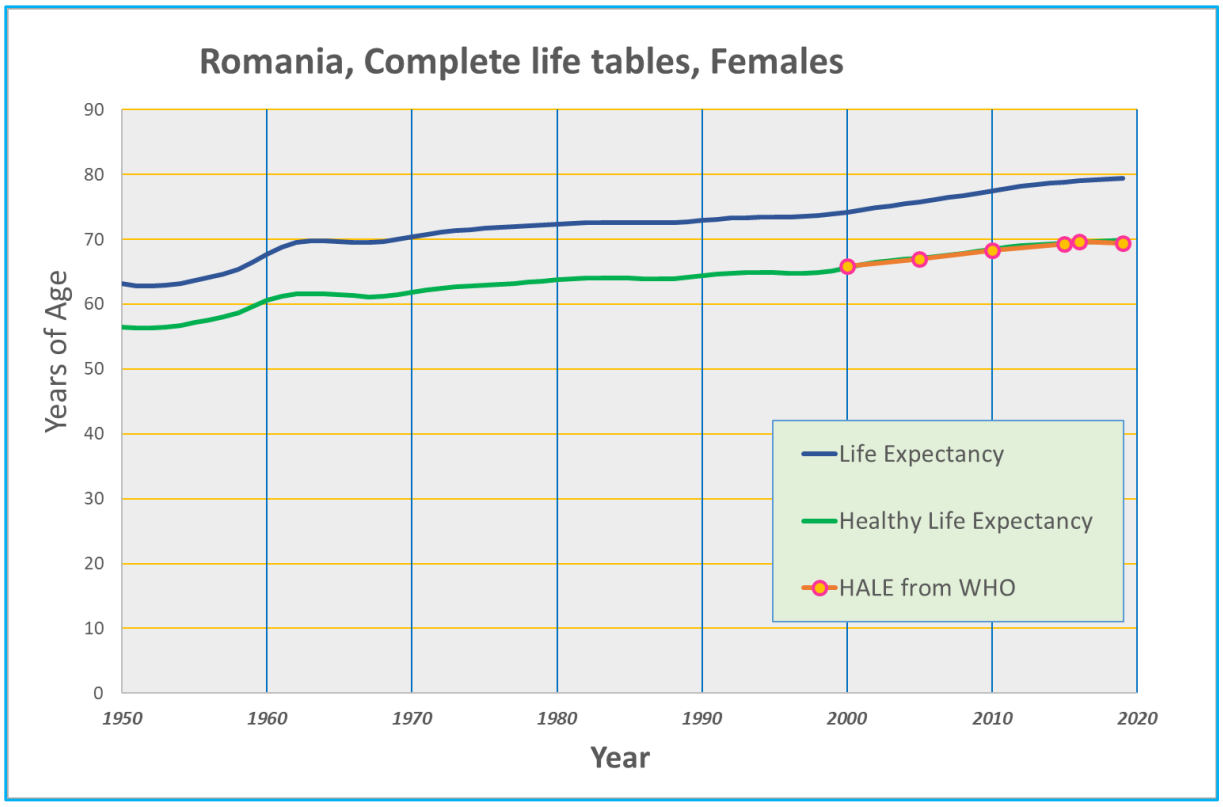



*Our calculations*

***Tab. 1*: Life Expectancy (LE), Healthy Life Expectancy (HLE) and HALE in Romania, males (1950-2019).**

| Romania: Health State, Males | | | |
|---|---|---|---|
| *Year* | *LE* | *HLE* | *HALE* |
| *1950* | **59.62** | **53.15** | |
| *1960* | **64.04** | **57.09** | |
| *1970* | **65.85** | **58.53** | |
| *1980* | **67.10** | **59.77** | |
| *1990* | **66.28** | **59.29** | |
| *2000* | **66.75** | **60.01** | **60.07** |
| *2005* | **68.51** | **61.86** | **61.30** |
| *2010* | **70.46** | **63.55** | **62.16** |
| *2015* | **71.91** | **64.84** | **63.32** |
| *2016* | **72.07** | **64.97** | **63.71** |
| *2019* | **72.50** | **65.31** | **64.30** |

***Fig. 2*: Life Expectancy (LE), Healthy Life Expectancy (HLE) and HALE in Romania, females (1950-2019).**




*Our calculations*

***Tab. 2*: Life Expectancy (LE), Healthy Life Expectancy (HLE) and HALE in Romania, females (1950-2019).**

| Romania: Health State, Females | | | |
|---|---|---|---|
| *Year* | *LE* | *HLE* | *HALE* |
| *1950* | **63.12** | **56.41** | |
| *1960* | **67.75** | **60.58** | |
| *1970* | **70.37** | **61.80** | |
| *1980* | **72.37** | **63.76** | |
| *1990* | **72.92** | **64.37** | |
| *2000* | **74.18** | **65.60** | **65.81** |
| *2005* | **75.80** | **67.14** | **66.94** |
| *2010* | **77.52** | **68.47** | **68.25** |
| *2015* | **78.85** | **69.46** | **69.30** |
| *2016* | **79.03** | **69.56** | **69.70** |
| *2019* | **79.44** | **69.84** | **69.44** |

## Health State and the Optimum Pension Schemes

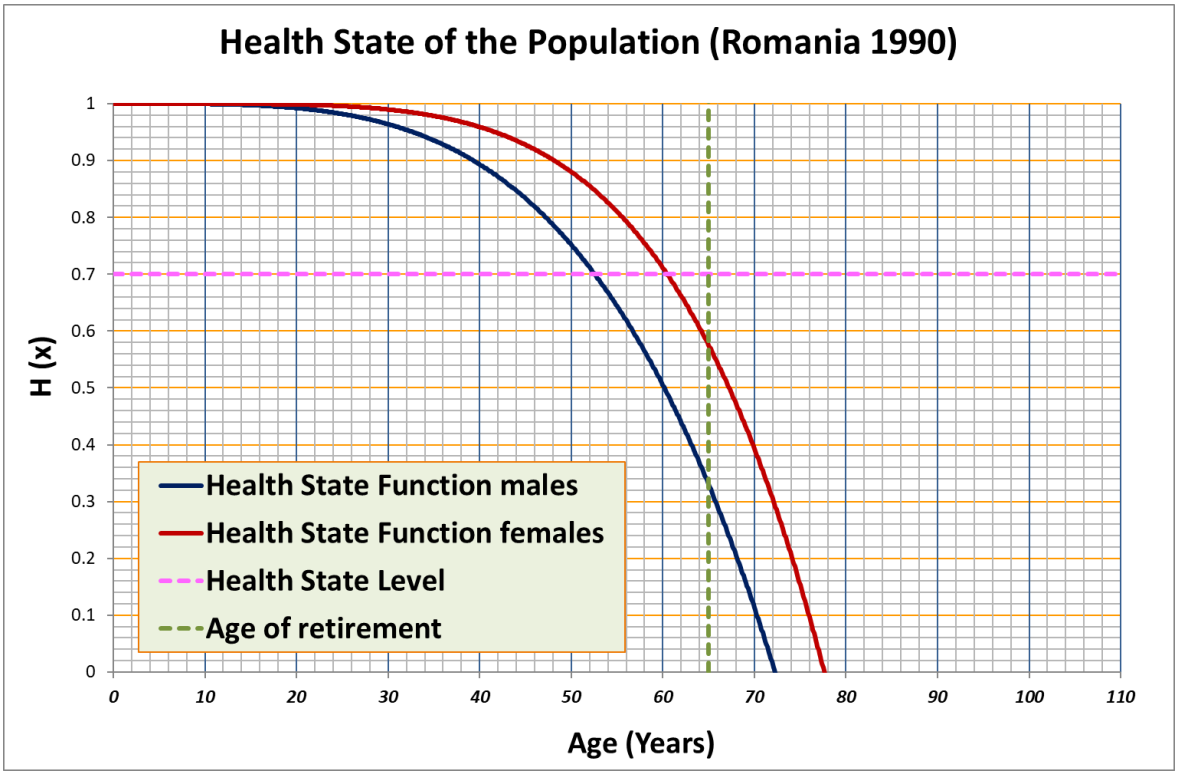
An interesting comparison between male and female healthy life expectancy in 1990 and 2019 is presented in the next two graphs. In these graphs the Health State of the Population is presented as is calculated by the stochastic modeling methodology for the Health State $H(x)=1-(bx)^c$. The death probability density g(x) at age x is given by

$$g(x) = (1 + (c-1)(bx)^c) / \sqrt{2\sigma^2 \pi x^3}\, e^{-\frac{(1-(bx)^c)^2}{2\sigma^2 x}}$$

Following this methodology, the mean health state H(x) starts at 1 or 100% health level at birth and gradually reduces to a mean state at zero level. Download the related program 1Health_State_Model-Solver from http://www.asmda.es/demographics2021.html .

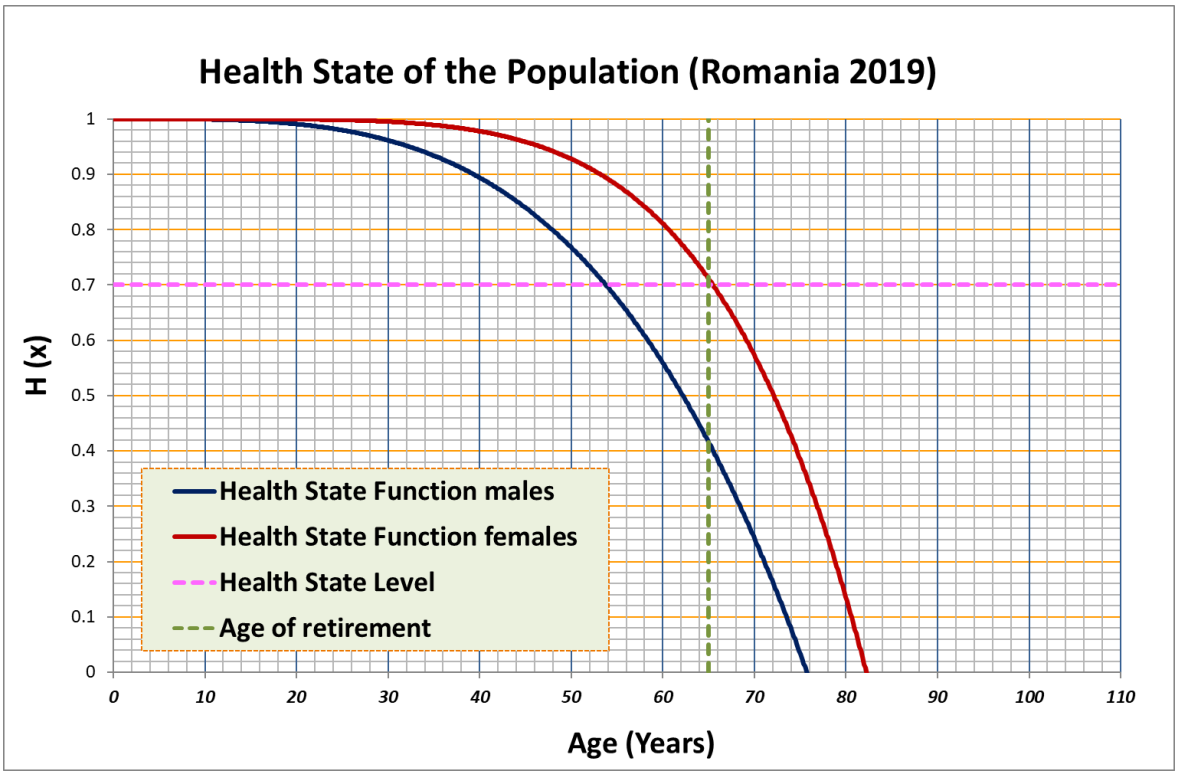
The male HLE is 59.29 years of age in 1990 compared to 64.37 years for females the same year. The age at retirement is set at 65 years of age and the optimum health state level is select at 0.7 or 70% (see Figure 3). We observe that the HLE for males is expected at 52% of the health state level at 59.29 years of age whereas the HLE for females is expected at 59% health state level at 64.37 years of age.

**Fig 3. Mean Health State Function in 1990**




*Our calculations*

**Fig 4. Mean Health State Function in 2019**




*Our calculations*

Figure 4 presenting the situation 30 years later in 2019 expresses the clear improvement for both males and females. The health state level is at 59% for females at HLE on 69.84 years. For males the HSL is at 41% at 65.31 years for the HLE.

The Health State Level at 65th year of retirement is at 32% in 1990 for males and at 58% for females.

The Health State Level at 65th year of retirement was improved in 2019 to 41% level for males and 70% for Females. Females cross the 70% threshold at 70 years of age.

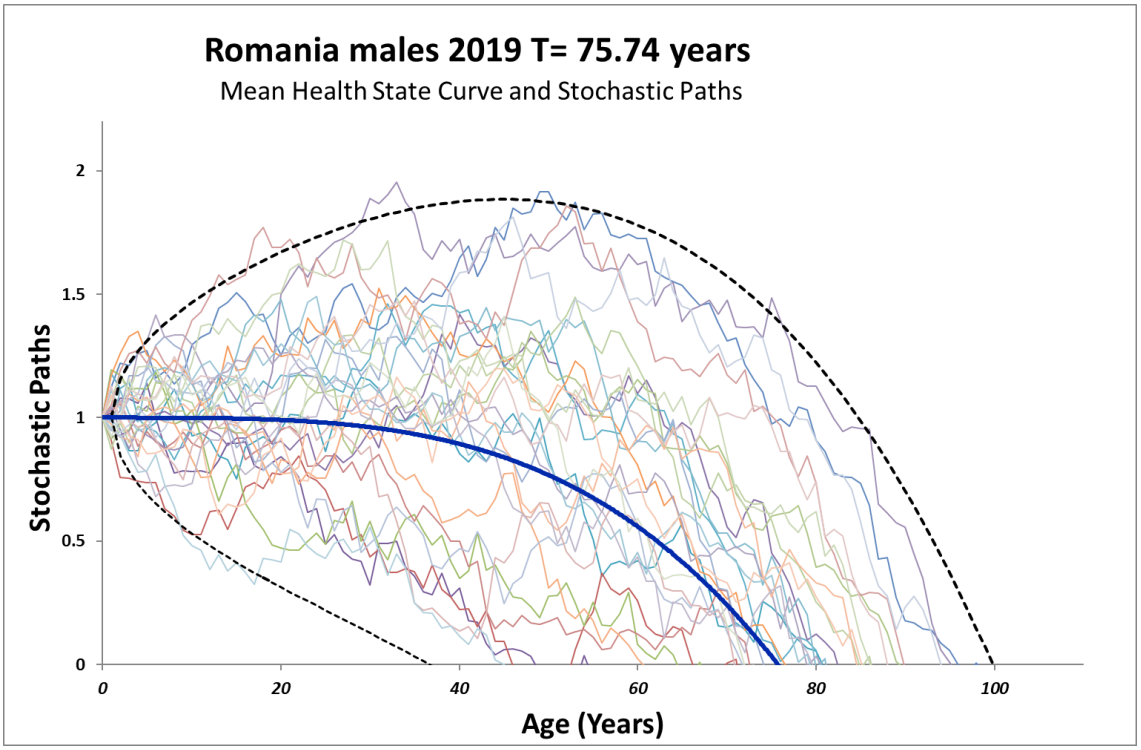
It is very important to enter in a good health state level the retirement as to be able to continue the pension period for several years in a good health. Three main measures apply. The Life Expectancy, the Healthy Life Expectancy and the Health State Level at Retirement, the latter two estimated by the methodology and Excel programs provided herewith. All methods provided are important to select the Optimum Pension Schemes and Policies selected.

## The Health State of the Population Stochastic Theory

The following assumptions are met:

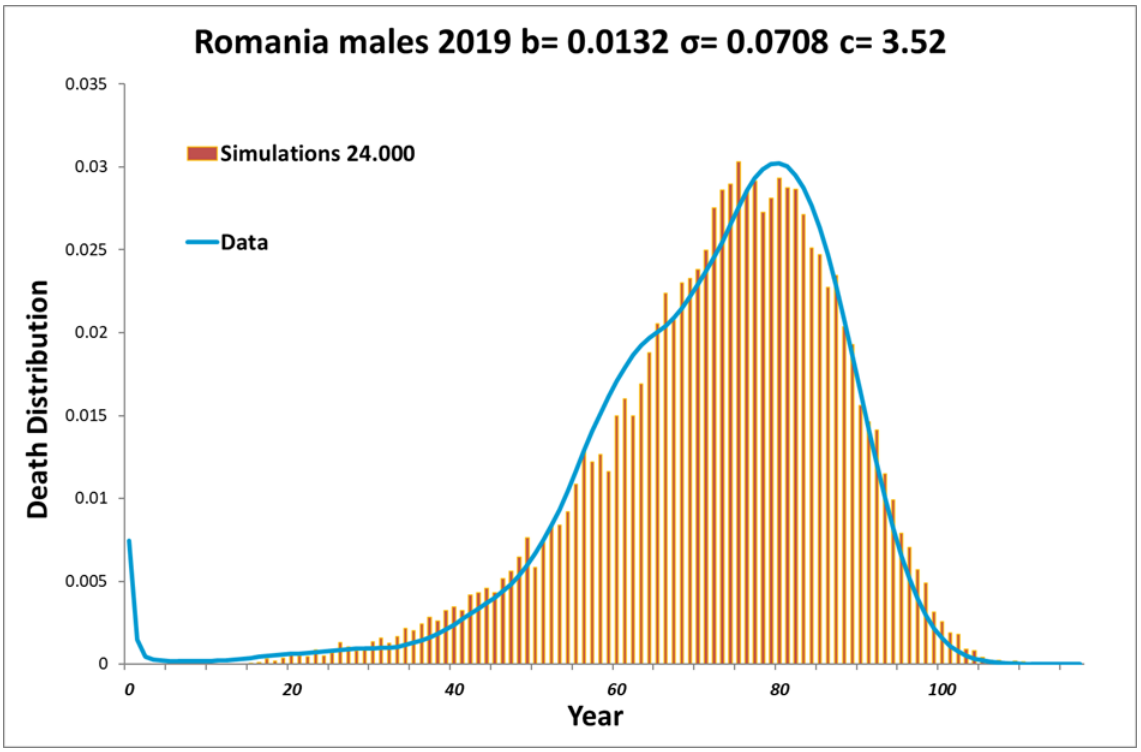
1. The Health State at Birth is 1 or 100%. It is continuously moving up and down during age following a stochastic path in a declining form until the end marked when reaching the zero health state.
2. Though it is impossible to find a specific health state path of an individual, we can estimate the Mean Health State by summing a very large number of stochastic paths which could provide a relatively smooth curve over time or age.
3. The simplest form of the Mean Health State Function (MHSF) H(x) at age x is: $H(x)=1-(bx)^c$
4. When the data for g(x) are provided via a Life Table, usually as (dx/100000), the parameters b, c and σ are easily estimated by a non-linear regression analysis.
5. Then the Death Probability Density g(x) at age x is given by: : $g(x) = \frac{|H-xH'|}{2\sqrt{2\pi x^3}} e^{-\frac{H^2}{2\sigma^2 x}}$
6. Another option is to start from $m_x$=Dx/Px data from Deaths and Population and estimate g(x) from the life table or from $g(x) = m_x e^{-\Sigma_0^x m_x}$.
7. Next step is to verify the validity of the method by generating a sufficient large number of stochastic paths using the formula h(x)=H(x)+σW(x), where h(x) is the Health State path of an individual.
8. By summing the number of hits to the zero line (X axis) where is the end of the life span of an individual and normalize to (0,1) we form the shape of the probability density function g(x).
9. The provided Excel software gives immediately the stochastic simulation graph for 24.000 stochastic paths (see related figures 5 and 6) that verify the good application of the theory.
10. The most important finding from this methodology is that the Mean Health State Function H(x) estimated provides essential information for the course of the health state of the population in many periods of the life time and especially for the health state of the population at retirement as it is presented in figures 3 and 4.

**Fig. 5. MHSC and stochastic paths**




*Our calculations*

**Fig. 6. Stochastic simulations and PDF g(x)**




*Our calculations*

The Mean Health State Curve (Blue line) and the confidence intervals (dashed lines) are illustrated in Figure 5. The point where the MHSC crosses X axis is at T=75.74 years of age and can be termed as the maximum Mean Health State Age.

Figure 6 presents the simulation bars for 24.000 stochastic realizations. The non-linear regression analysis estimates for b, c and σ are also included.

Download the related program "Stochastic_Simulations-ZIP" from
http://www.asmda.es/demographics2021.html

## Conclusions

We have solved the problem of finding the HLE in the far past. The case of Romania (1950-2019) with comparisons with HALE has explored. The HALE estimates from WHO compare very good to our estimates with the Direct method. The methodology presented and applied is useful for further estimates in several countries, especially when life table data are provided in a systematic form. Important is the Healthy Life Years Lost "Direct" estimation method we have proposed and applied to life table data sets. The mean health state H(x) is also calculated by a stochastic methodology for males and females providing an important measure for the optimum selection of the pension scheme. The same methodology is applied to perform stochastic simulations.

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