ESTIMATING THE HEALTHY LIFE EXPECTANCY (HLE) IN THE FAR PAST. THE CASE OF FRANCE (1816-2017) AND COMPARISONS WITH HALE FROM WHO AND PROJECTIONS TO 2060

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Abstract

Healthy Life Expectancy (HLE) is an important measure of the health state of a population. It was proposed and calculated after the systematic work of a large group of researchers all over the world. Several estimates where proposed and tested during last decades. The most successful estimate was termed as HALE and is provided by the World Health Organization (WHO) in the related website. However, it remains an unexplored period of the last few centuries where, LE data exists along with the appropriate life tables, but not enough information for HLE estimates is collected and stored. The simplest solution could come from the existing life table data sets following an appropriate method. The problem is now solved following a methodology of estimating the HLE from the life tables after the Healthy Life Years Lost (HLYL) estimation. The case of females in France from 1816 to 2017 is explored along with a projection to 2060.

We apply a Direct HLYL estimation methodology from Life Tables, verified also via a series of additional methods as a Weibull and a Gompertz parameter test and a comparison with the HALE estimates from WHO. The complete methodology and estimation methods are published in the book on “Demography of Population Health, Aging and Health Expenditures” of Volume 50 of the Springer Series on Demographic Methods and Population Analysis.

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Key words: Life Expectancy, Healthy Life Expectancy, HALE, Logistic model, forecasts, Life Tables.

JEL Code: I15, I18, J1

Introduction

Healthy Life Expectancy (HLE) is an important measure of the health state of a population. It was proposed and calculated after the systematic work of a large group of researchers all over the world. Several estimates where proposed and tested during last decades. The most successful estimate was termed as HALE and is provided by the World Health Organization (WHO) in the related website. The standard methodology for estimating the HLE was proposed by Sullivan (1971). A practical guide is proposed by Jagger et al (2014). See also an application for the estimation of Life Expectancy and HLE in Japan from Tokudome et al (2016). Important are the works of Weon and Je (2011, 2012) on the form of survival curves. Zafeiris (2019) explores the mortality differences among the Euro-zone countries. The interconnection between the Healthy Life Years Lost (HLYL) estimates and the Weibull (1951) shape parameter is observed by Matsushita et al (1992) and further explored in Skiadas and Skiadas (2020b).

Life Expectancy and Healthy Life Expectancy estimates

Based on the data series from 1900 to 2017 for males and females in France, estimates until 2017 and forecasts to 2060 are done. For fitting and long-range forecasts, the Logistic model is applied to data series to calculate the three parameters of the model. Then forecasts to 2060 are done.

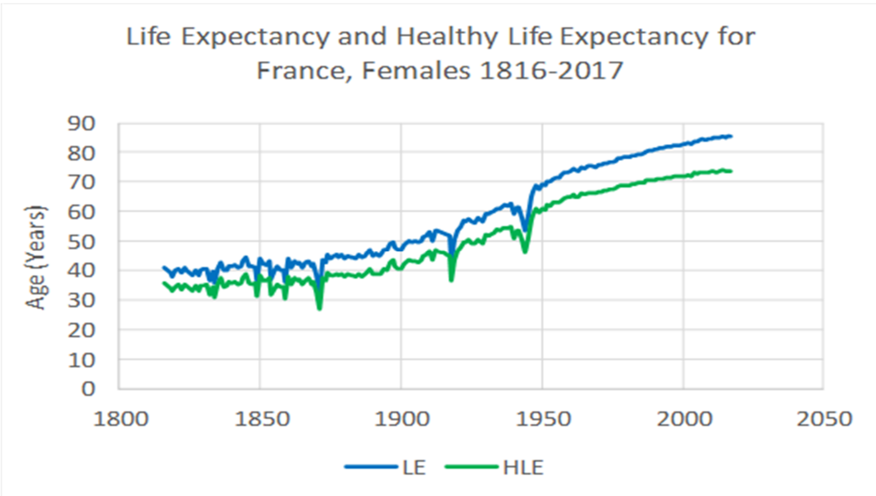
As 1900 was a milestone in health improvement in many countries, this date was selected as the starting point for the estimates. The identification of bacteria the last part of the 19th century followed by immunization and water purification techniques succeeded of controlling the spread of disease or preventing disease. Whereas, the germ theory of disease set a sound scientific basis for public health leading to a smooth growth of Life Expectancy.

The development of the first healthcare system of modern history, started with policies introduced by the Otto von Bismarck's social legislation (1883-1911). The introduction of such systems in many countries came after important discoveries from scientists as Pasteur and Chamberland in France, Von Behring in Germany, Kitasato from Japan, Descombey from France and many others. The 1901 Nobel Prize in Physiology or Medicine, the first one in that field, awarded to Von Behring for his discovery of a diphtheria antitoxin.

It looks like the health care systems and methodologies already set in 1900 follow a rather systematic trend until today. See figure 1 where Life Expectancy (LE) data series is provided by the Human Mortality Database (HMD) and Healthy Life Expectancy (HLE) is estimated with our

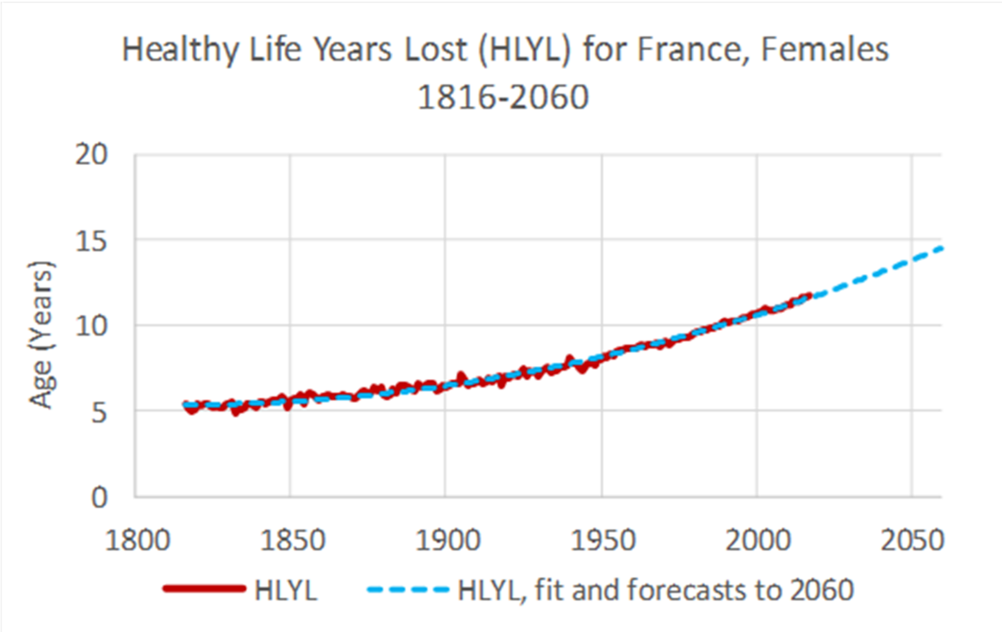
Direct methodology (Skiadas & Skiadas 2018a,b and 2020a,b,c). The LE series from 1816-1875 is strongly fluctuating mainly due to health causes. The fluctuations become smaller after this period with a clear stabilization from 1900 until now except the strong declining during the 1918 influenza pandemic followed with a fast recovery later on. The period starting from 1950 is followed with a rather smooth trend as a result of the improvement of the health systems structure, financing, technology and pharmaceutical discoveries and production.

Fig. 1: Life Expectancy (LE) and Healthy Life Expectancy (HLE) in France, females (1816-2017).



Source: Our calculations

Fig. 2: Healthy Life Years Lost (HLYL) in France, females (1816-2060).



Source: Our calculations

The Healthy Life Years Lost (HLYL) calculated data series from 1816 to 2017 is illustrated in figure 2. The HLYL trend is growing following an exponential-like pattern. A quadratic formula of the form

$$HLYL(t)=a(t-1816)^2+b(t-1816)+c,$$

is the more appropriate; where the parameters estimated are a=0.000152, b=0.000454 and c=5.375. The projection provides a HLYL=14.55 years of age to 2060.

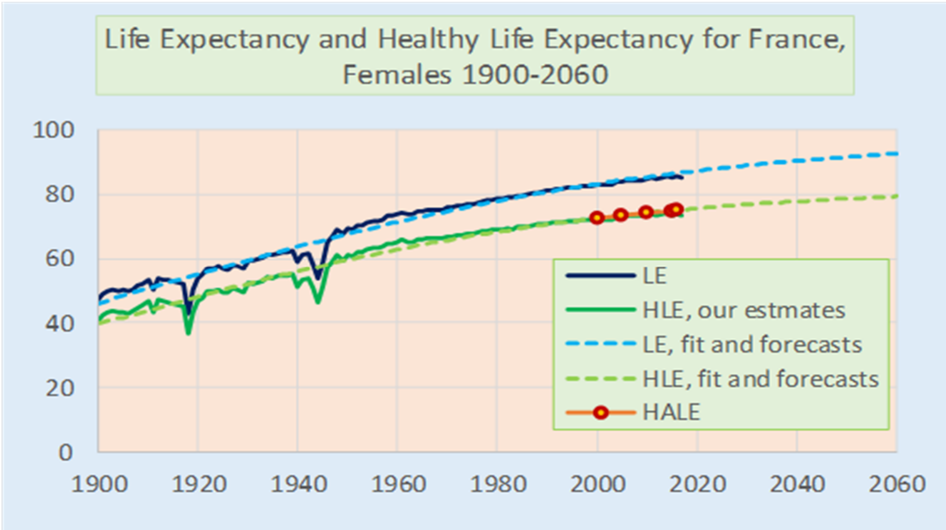
The Logistic Model

This classical model proposed by P. F. Verhulst (1838) to estimate the population of France is proven to be a successful tool for long range forecasting. In his first application, Verhulst predicted the population of France for almost 100 years. Pearl and Reed used this model to predict the growth of the United States Population. Applications in other countries have also done.

The three parameter Logistic Model equation form is the following g(t)=F/(1+(F/g(0) -1)exp(-b(t-T(0)))),

Where b is the trend or diffusion parameter and F is the upper level of the sigmoid logistic process and g(0) is the value at time T(0)=1900.

Fig. 3: Logistic model fit and forecasts to 2060 for females in France.



Source: Our calculations

The HALE estimates and our Direct calculations

The latest WHO estimates for Healthy Life Expectancy called HALE are provided for the years 2000, 2005, 2010, 2015 and 2016.

These estimates perfectly fit into our calculations for the HLE and the fit results by using the Logistic model.

Our HLE calculations are based on the Direct estimates from the Life Tables of the HLYL with a formula provided in recent publications (Skiadas & Skiadas 2020a,b,c) that is:

$$HLYL = max \frac{xm_x}{\sum_0^x m_x}$$

Where mx is the mortality at age x as provided in HMD life tables.

Then HLE=LE-HLYL.

The Logistic model is applied to data sets for LE and HLE from our estimates from 1900 to 2017. The parameters selected appear in the following Table I.

The Healthy Life Years Lost (HLYL) are 6.52 years of age in 1900, 11.47 for 2016, 13.31 in 2060 with a maximum of HLYL=15.71 years of age difference.

Tab. 1: Logistic model parameters and estimates

	Logistic Model Parameters		LE and HLE in 1900, 2016 and 2060		
	b	F	1900	2016	2060
LE	0.01820	98.05	46.07	86.46	92.53
HLE	0.02096	82.34	39.55	74.99	79.22
HLYL= LE-HLE		15.71	6.52	11.47	13.31

Source: Our calculations

Table II summarizes the three healthy life expectancy estimates from WHO (HALE), our Direct estimates and from Logistic fit. All three methodologies provide close results.

Tab. 2: HALE and Healthy Life Expectancy Direct estimates and Logistic fit

Year	2000	2005	2010	2015	2016
WHO HALE	72.61	73.35	74.06	74.77	74.93
Direct HLE	72.07	72.87	73.44	73.49	73.70
Logistic Fit	72.45	73.31	74.11	74.85	74.99

Source: Our calculations

Conclusions

We have solved the problem of finding the HLE in the far past. The case of France (1816-2017, females) with forecasts to 2060 and comparisons with HALE has explored. The selected Logistic model has a good fit while the HALE estimates from WHO compare very good to our estimates both with Direct method and the Logistic fit. The methodology presented and applied is useful for further estimates in several countries, especially when life table data are provided in a systematic form as those provided by the Human Mortality Database. Important is the Healthy Life Years Lost "Direct" estimation method we have proposed and applied to life table data sets.

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