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Life expectancy: complex measures of the length and the health related quality of life

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Abstract

Background: Life expectancy is one of the most frequently used indicators to assess mortality and the health of a population. It is a synthetic measure of mortality, which has the advantage of allowing for comparisons over time and between different groups, while eliminating the influence of the age structure of the population. Life expectancy has the advantage of being very easy to understand, although it needs to be interpreted within the context of the complex system of hypothesis that generates it. This is even more important for health expectancies and health gap measures, which are synthetic indicators that take into account both survival and health condition of a population.
Methods: It is given a description of the most frequently used methods to calculate life expectancy, health expectancies and health gap measures. Measures of health expectancy are disability free life expectancy and healthy life expectancy. As health gap measures, frequently are used DALYs (Disability Adjusted Life Years).
Discussion: There are various bodies and central government agencies that either have management data or carry out statistical systematic surveys and disability surveys. Statistically speaking, the worst aspect of this scenario is that it creates confusion and uncertainty among the end users of this data, namely the policy makers. At an international level the statistical data on disability is scarcely comparable among countries, despite huge efforts on the part of international organisations to harmonize classifications and definitions of disability.
Results and Conclusions: There are several methods to compute life expectancy, each of these has some advantages and some disadvantages. Usually life expectancy is used also to account for the health status of population. Actually with the growing role of chronic and degenerative diseases, the increased number of years lived are potentially independent from increase in health status of the population. Quantity and quality of live are not anymore strictly related, then a higher quantity of life does not equate to a better quality of life. For this reason are used health expectancies measures that are very useful morbidity-mortality indicators able to summarize information on quantity and quality of the years lived.

Key words: life expectancy, health expectancies, health gap measures, methodology

Introduction

In the last two centuries human survival has dramatically increased, following economic, social and sanitary developments. Scientific progress in medical and health technology, especially in the last century, has also greatly contributed to this evolution. "For thousands of years and up until the mid-18th century, human life expectancy rarely exceeded 25 or 30 years, with limited variations according to time and space" [1]. Since then, mortality has begun to decrease while the average life span has gradually increased, reaching levels that have never been attained before: in 2001, life expectancy of men reached 79 years in Australia, Iceland, Japan, Sweden and Switzerland, while, for women, it reached 86 years in Japan and 84 years in Australia, France, Italy, Spain and Switzerland. In the same year, in the Southern hemisphere, high mortality frequently persists and there are countries where life expectancy is, still today, 37 (Sierra Leone) or 38 years (Afghanistan, Guinea, Guinea-Bissau) for men, and 37 (Swaziland) or 40 years (Sierra Leone, Zambia) for women.

Then the increase has not been equally distributed all around the world with strong disadvantage for less developed countries. Moreover a growing concern arises about the quality of the years of life that have been added to the human life: are they "high quality" years, in the sense that they are healthy and without disability, or are they years to be lived in poor heath and with disability?

Life expectancy is the measure of the average length of life of a specified cohort (real or hypothetical, more frequently, when cross sectional mortality risks are used) or population. When calculated with reference to a certain age, it represents the expected number of years remaining to live. Being a very clear and easy to interpret indicator, it is widely used both to follow the evolution of mortality over time in a single country or human group and to compare different countries and populations. In fact it has the great advantage to give a summary measure of mortality risks which is not influenced by the age structure of the population, highly affecting other synthetic measures.

The need to be interpreted with explicit reference to its conceptual framework is even more important for health expectancies, that are synthetic indicators taking into account both survival and health condition of the population. Many complex health indicators have been proposed in the last years, giving information about survival by health status, its differences between groups and its evolution over time. Some indicators specify the health quality of lived years (health expectancy measures), others consider the years of life lost (total and healthy) with reference to actual or ideal survival goals (health gap measures).

This paper aims to give a description of the possible ways to compute life expectancy, health expectancies and health gaps, discussing the main issues in interpreting their values.

Measures of life expectancy

Life expectancy

Life expectancy is a synthetic indicator of the life table, expressing the average length of life of an individual belonging to a (real or hypothetical) cohort exposed during all its life to the mortality risks observed for that cohort (cohort life table) or observed in a specific year (period life table). For the period life expectancy, it is assumed that a hypothetical cohort born in a certain year is exposed to the same mortality risks observed in the real population at different ages in the same year (so belonging to different cohorts) [2].

Life expectancy at age x, is calculated by adding up the years lived by the real or hypothetical cohort since age x up to the extreme age and equally distributing them among survivors at that age. It represents the expected number of remaining years to be lived.

$$e_x = \sum_{y=x}^{\omega-1} L_y / l_x$$

with y = age varying from x to ω-1 (the highest age reached by a component of the cohort or the population)

L_y = years lived between ages y and y+1 by the real or the fictitious cohort in the life table

l_x = survivors at age x from the real or the fictitious cohort in the life table

The most suitable and natural way to compute life expectancy should be monitoring a birth cohort up to its complete extinction through a cohort life table. This would require around 100-120 years, allowing the estimation of the indicator only for cohorts born more than a century ago.

Actually life expectancy computed using the period life table is the most used mortality indicator. It is the result of a theoretical model that take the risk of dying at different ages as stationary, giving no allowance for changes in mortality risks in the future: only in the hypothesis of constant risks, in fact, persons reaching age x in a calendar year could have the average lifespan estimated by the indicator. Actually, it is computed on contemporary persons (people who live today at different ages) seen as they describe the life history of a cohort (people born in the same calendar year having a certain age in a specific moment). However, life expectancy can be view, as a useful indicator, which is able to summarize the current mortality of a population, allowing for comparison among different groups without the effects of the population age structure.

An alternative way of computing life expectancy was proposed by Lee and Carter in 1992 [3]. This model accounts for the evolution of mortality in the future by extrapolating trends and age patterns of mortality. It has some advantages over other methods, but it also has the fundamental weakness to be an extrapolative method, based on the hypothesis that the observed trends will hold in the future so ignoring possible structural changes [4]. The Lee-Carter model is based on a simple representation of year-to-year variations in the set of age specific death rates in terms of a single time-varying parameter. The time series of estimated values of this parameter is then modelled and forecasted. Finally "from these forecasts, the probability distributions for forecasts of age-specific death rates and related variables such as life expectancy are calculated" [4]. The experimental analysis and forecasts within the period of data available done by Lee-Carter show that the procedure performs quite well over the period 1900–1990: age patterns have been quite stable and the trend in the fundamental time-varying parameter has been

surprisingly linear. Some problems occur for data prior to 1900.

Health expectancies

Using mortality risks as proxies of the health status of the population, life expectancy is frequently used as a health indicator. Actually, as the health transition [5] has deeply modified the structure by cause of death and, in general, the health risks in low mortality countries, this approximation is less and less satisfactory [6]. The growing role of chronic and degenerative diseases, that gradually replaced the role played by the infectious and acute diseases in the past, makes the increased number of years lived potentially independent from any substantive increase in health status of the population. "With the lengthening of life expectancy, it became progressively evident that mortality no longer sufficed for measuring the changes that had come about in health and medical care" [7]. The need for indicators able to take into account also the "quality" of the years lived became more urgent. In this context, in 1989, an International Network on Health Expectancy and the Disability Process (in French REVES, Réseau d'Espérance de Vie en Santé) has been created with the goal to foster and make easier the international cooperation for the computation of the life expectancy by health status [8].

Health expectancies are a set of summary measures of population health that capture both the "quantity" and "quality" of life dimensions of physical and mental health, combining mortality and health measures. The first point in developing health expectancies, as it is for any other health indicator, is to define the concept of health to be used. In fact, health is a multidimensional, dynamic condition moving along a continuum from good health to death by way of disease or any other form of physical or mental change or decline [7]. As a result, the task of measuring health is very difficult: many different definition of health can be adopted and, consequently, many different measures can be selected. The most general and comprehensive definition of health is that suggested in 1946 by World Health Organization (WHO) [9] which defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity", which is something much more complex than the simple absence of disease or disability. This definition, as others based on the positive concept of health, is widely satisfactory on a conceptual and theoretical point of view, but it is extremely difficult in an operative way and definition based on the negative concept are frequently adopted.

Blaxter [10] proposed three different approaches to health evaluation: 1- the medical or biologic model of the disease which defines the poor health status as a divergence from a physiologic or psychological norm; 2- the social and functional model where the poor health is defined as an inability to fulfil normal tasks; 3- the subjective model, where health is rated by the individual. From the medical, to the functional, to the subjective, any model gives rise to specific measures: morbidity free life expectancy (normally specified by disease, such as cancer free or cardiovascular free life expectancy) [11]; disability free life expectancy (DFLE, based on years free from functional limitation) and healthy life expectancy (based on health perceived as "good" and "very good").

Disability free life expectancy and healthy life expectancy are the most common health expectancies and their use has become widely spread because they take into account some dimensions that are more and more relevant in ageing society. They are generally estimated through the so called "prevalence method", assuming that the total years lived by the fictitious cohort of the life table in different ages are proportionally distributed according to the prevalence of the different health condition.

Because of the demographic transition, there is a strong increase in the proportion of the elderly, with a consequent increase of the proportion of persons suffering from loss in functional health. Disability free life expectancy (eventually weighted according to severity) is the average number of years that an individual is expected to live free from disability if current patterns of mortality and disability continue to apply. Frequently, disability is evaluated referring to the Activity of Daily Living (ADLs) [12], which summarize the basic tasks of everyday life, such as eating, showering or bathing, dressing and undressing, using the toilet and continence, moving from bed to chair. Another approach is that followed by the Instrumental Activities of Daily living (IADLs) proposed by Lawton and Brody [13] and focusing on social disabilities (doing house work, preparing meals, keeping the accounts, assuming drugs, etc.). When a person is unable to perform one or more of these activities (even though aided by medical devices) and he/she needs help in order to cope with then he/she is considered disable. Prevalence of disability is then used to estimate the years lived in the different health statuses (able, disable) by the hypothetical cohort of the period life table and, by summing up years lived in good health, the disability free life expectancy. The same procedure, called prevalence-based method (also known as Sullivan method) [14], can be used to estimate the average number of years perceived as lived in "good health"

(healthy life expectancy) or in "poor health" that is a very useful "subjective measure that conveys the way in which individuals perceive their health status. It reflects the feeling, ideas, and beliefs held by the individuals concerning their health, and it does not necessarily represent the objective state of health" [7]. The most frequently used question to ask for perceived health in surveys is that suggested by the European Office of the WHO: "How is your health in general?" with five levels of response (very good, good, fair, bad, very bad) [15]. Reflecting the very general reference framework of the question, the rating of health widely varies among persons and groups, and person with the same state can rate their health differently according to socio-demographic and economic features. Nevertheless, indicators based on subjective health, especially on poor and very poor rating, were demonstrated to be the most efficient predictors of mortality in old age [16, 17] and health expectancy in poor perceived health a summary indicator more and more widely used.

The health gap measures

Extending the concept of the years of life lost due to premature mortality in the population (YLL), health gap measures consider the years lost due to poor health (frequently disability) (YLD), referring to equivalent years of "healthy" life lost by being in states of less than full health. The most known indicator of this family are the DALYs (Disability Adjusted Life Years) elaborated by the WHO for 112 countries and 21 main causes of death.

"The DALY combines in one measure the time lived with disability and the time lost due to premature mortality. One DALY can be thought of as one lost year of "healthy" life and the burden of disease as a measurement of the gap between current health status and an ideal situation where everyone lives into old age free of disease and disability" [18]. For a certain time period and a specific disease or condition, they are calculated as the sum of the YLL (estimated as the number of deaths at age x multiplied by the remaining life expectancy at that age extracted from the life table assumed as target) and YLD (estimated as the number of incident cases in that period multiplied by the average duration of the disease) and a weight factor that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (dead). The well known Global Burden of Disease exercise [19] is based on those indicators estimated by adopting, for all countries, the same weight for every person living a year in a specific health state. Moreover, a 3% time discounting is used to evaluate the current value of the time that will be spent in different health conditions during the life history of individuals, as well as non-uniform age weights, which gives less weight to years lived at younger and older ages and higher weight at adult ages [20].

Levels of life expectancy and health expectancies today

Usually women have a higher life expectancy then men but a lower proportion of years lived without disability or in good health. This confirms the fact that higher life expectancy (then a higher quantity of life) does not equate to a better quality of life. It is possible among countries, in some cases, to find the same behaviour. In 2004, among some selected European countries, France had the highest life expectancy of 65 years of age both for men and women (17.7 and 22.1 years, respectively) but not the highest number of years lived in good health or without disability. Denmark, for example, had for men, the lowest life expectancy (15.9 years) but the highest healthy life expectancy and disability free life expectancy (10.1 and 13.2 years, respectively). For women, Denmark was the second last country for number of years expected to live at 65 years of age, but still the first for healthy life expectancy and DFLE. Concerning Italy, both men and women have a high life expectancy, but a low healthy life expectancy. As shown before, this measure is affected by the self-perception of health condition

Table 1. Life expectancy, healthy life expectancy and disability free life expectancy at age 65 in some European countries by gender. Year 2004

Gender/Countries	Life expectancy [a]	Healthy life expectancy [b]	Disability free life expectancy [a,c]
Men			
France	17.7	9.0	8.3
Italy	17.5	7.4	10.9
Spain	17.3	7.9	9.7
Greece	16.9	8.3	9.4
Denmark	15.9	10.1	13.2
Women			
France	22.1	10.3	9.9
Italy	21.5	6.6	11.8
Spain	21.5	6.3	9.5
Greece	18.9	7.1	9.4
Denmark	19.0	11.2	13.5

Source: [a] Statistical Office of the European Communities [22]; [b] EHEMU [23]

[c] Provisional value

given by the individual, therefore the reason for the low position of Italy can be accounted for by the worse perception of subjective health.

Conclusions

Life expectancy is a widely used indicator that accounts for mortality risks and, indirectly, for the health status of populations. There are several ways to compute it and each method has its advantages and disadvantages. As seen, the most used is that derived from the period life table which assumes a constant mortality to simulate the elimination of a fictitious cohort born in the year being considered. As the health transition deeply modified the mortality structure and cause of death and chronic disease became the leading causes, new indicators which combine survival and health are becoming more and more widespread. Health expectancies are very useful morbidity-mortality indicators that are able to summarize information on quantity and quality of the years lived. But, to correctly interpret them it is necessary to remember that they assume constant risks both of dying and of being healthy (following the different concept assumed). In particular, if the prevalence-based method is used to construct the period life table, it means that prevalence rates have to be assumed as being constant across time: a very strong hypothesis considered that to produce constant prevalence rates, all morbidity risks have to remain constant (incidence, recovery, differential mortality of ill persons). Moreover, in comparing health expectancies of different countries having different life expectancies - and then stationary populations associated to the life tables with different proportions of the elderly - the confounding effect of the age structure (of the stationary populations) has to be considered. Despite all these difficulties, health expectancies are increasingly used and the disability free life expectancy and the healthy life expectancy have become the most frequently reported health indicators in all countries where health surveys provide this information.

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