1 AN INTERNATIONAL COMPARISON OF TRENDS IN DISABILITY-FREE LIFE EXPECTANCY

Emmanuelle Cambois and Jean-Marie Robine

1 Introduction

Given the decline in mortality experienced by most developed countries for several decades, principally at very high ages, the population structure is undergoing massive modifications. Among other things, this has a specific impact on the average state of health of the population. This point has led to the development of a new type of indicator, close to life expectancy: health expectancy. Life expectancy assesses the level of mortality by the number of years lived by the population; it gives quantitative information about the expected average length of life. Similarly, health expectancy assesses the level of health of the population, by the number of years lived in good and bad health; it combines both, quantitative information indicated through mortality and more qualitative information about health expressed by morbidity.
2 The concept of "health expectancy"

2.1 Theories of the evolution of health status

The lengthening of life was not expected and this development is disturbing; current debate focuses on whether people survive diseases only to live on poor health. During the first half of the 1980s, researchers have discussed the relationship between the evolution of mortality and the evolution of morbidity which has gradually centred around three theories [Robine/Brouard/Colvez (1987), Crimmins (1990)]. A general decline in health can be forecasted using the first [Gruenberg (1977), Kramer (1980)], an improvement in health by the second [Fries (1980), (1989)], while no change will be expected following the third [Manton (1982)].

1) According to Gruenberg and Kramer, the postponement of death will result in a worsening of the severity of chronic diseases [Gruenberg (1977), Kramer (1980)]. This is what Kramer (1980) called the "pandemic of mental disorders, chronic diseases and disabilities". In 1991, Olshansky et al. (1991) have further refined this theory, which they have called an "expansion of morbidity hypothesis".

2) The theory of the compression of morbidity was first proposed by Fries (1980). "The compression of morbidity thesis postulates that (a) if the morbid period is defined from the onset of chronic infirmity until death, and (b) if the time occurrence of such morbid events can be postponed, and (c) if adult life expectancy is relatively constant, then (d) morbidity will be compressed into a shorter period of time" [Fries (1989)].

3) Manton (1982) is responsible for the concept of "dynamic equilibrium". According to this concept, the decline in mortality leads to an increase in the prevalence of chronic diseases. These diseases will in general be milder in character.

It is important to note that all these theories concerning the present evolution of the health status of populations may be expressed as the relationship between health expectancy and life expectancy. Using disability as an example, the "pandemic" theory may be expressed as a decline in the ratio of disability-free life expectancy to life expectancy, "compression of morbidity" as an increase in the ratio of disability-free life expectancy to life expectancy (compression of morbidity may be unrelated to the rectangularisation of the survival curve). Taking into account levels of severity, the theory of "dynamic equilibrium"
means a decline in the ratio of total disability-free life expectancy to life expectancy and a leveling off or an increase in the ratio of severe disability-free life expectancy to life expectancy (see Table 1).

Table 1: Relationship between theories and health expectancies

<table>
<thead>
<tr>
<th>Situation</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pandemic of disability</td>
<td>(Disability-free life exp. / Life exp.)</td>
</tr>
<tr>
<td>Compression of morbidity</td>
<td>(Disability-free life exp. / Life exp.)</td>
</tr>
<tr>
<td>Dynamic equilibrium</td>
<td></td>
</tr>
<tr>
<td>all levels of disability</td>
<td>(Disability-free life exp. / Life exp.)</td>
</tr>
<tr>
<td>severe disability</td>
<td>(Severe disab.-free life exp. / Life exp.)</td>
</tr>
</tbody>
</table>

2.2 The methods of calculation

There are essentially three different methods of calculating health expectancies: (i) the "observed prevalence table method" or Sullivan's method; (ii) the double decrement life table method; (iii) and the multi-state life table method. All three methods are based on life table process; they all consist in estimating probabilities of being in a specific state and in building a life table in which the usual person-years become specific person-years lived in the state under consideration. The cumulation of specific person-years leads to "specific health expectancies", applied to various states. The choice of the method depends on the type of data used; transition probabilities, required to obtain specific person-years, are estimated by different processes, according to the nature of these data.

(i) The principle of the calculation of disability-free life expectancy was postulated as early as 1964 [see Sanders (1964)] and a first method of calculation was proposed later by Sullivan (1971). It constitutes the simplest method: in the standard life table, the "person years" are multiplied by the probability of being disabled, estimated by age-specific observed rates of disability. These data are collected by cross-sectional surveys on health which are often regularly run. Once the table is modified, the specific health expectancy is calculated in the traditional manner, according to various states of functional disability under consideration. Thus, one can get, among others, the value of disability-free life expectancy.

(ii) Katz et al. (1983) proposed an indicator, computed with the multiple decrement life table, previously used during the 50's in the field of insurances, for the calculation of benefits [see Jordan (1952) and Spiegelman (1957)]. This
method is based on a life table which considers a multiple attrition phenomenon. Death is no longer the only absorbing state: any event that provokes the loss of the original characteristic known by the initial cohort, is considered as a decrementing event. In this model, the attrition phenomenon is constituted by both mortality and disability, represented here by loss of independence in "activities of daily living" [Katz et al. (1983)] and institutionalization. A sample of healthy individuals is studied twice (two waves longitudinal survey); Katz et al. (1983) estimate the probability of remaining in the initial cohort (being independent in daily life) rather than the probability of separating from it (dying or entering disability). The "disability-free person years" are directly obtained by applying probabilities of remaining healthy to an hypothetical cohort of new-borns. The resultant indicator gives an estimation of the average period of life lived in good health, before dying or becoming disabled. This method does not give an opportunity for recovering from the disabling event. Thus, it constitutes a perfect model, for example, for calculating financed and financing periods of life, for insured states (good and bad health), but it becomes a little bit limited when computing a general healthy life expectancy which should consider potential recoveries, in order to take into account all periods of time spent in good and bad health, either if they are continuous or discontinuous.

(iii) The third method of calculation is based on the so-called increment-decrement life table: the model does not only consider several events that decrease the initial cohort, as in the previous model, but also events that increase the cohort from age to age, principally represented by recoveries. In the field of public health, the first application of such a model has been presented in 1989 (Rogers et al.), with the intention of improving Katz et al.'s method, as recoveries from disabling diseases were revealed not to be negligible [Rogers/Rogers/Belanger (1989)]. Data from longitudinal surveys are required in order to calculate probabilities of transitions between all states under consideration. When probabilities of becoming disabled and of recovering are available, the disability-free person-years, can be calculated: a fictitious cohort of initially healthy individuals is developed, from the starting age of the simulation to the extinction of the cohort, according to age-specific probabilities of becoming disabled and of recovering. The simulation can also be done to obtain the disability-free person-years, for a cohort of initially disabled individuals.

Both latter methods lead to precise indicators but require data collected by longitudinal surveys. Indeed the resultant flow data are necessary for estimating the probabilities of transition between states. Such data are not regularly available, and result from expensive and laborious surveys specifically run for this kind of studies. On the opposite, the observed prevalence of table method is
based on the separate collection of mortality and disability data and in the availability of the data that are necessary for the calculation. Basic cross-sectional surveys are sufficient to collect the data of observed prevalence of disability within the population (stock data). However the indicator obtained is not really a period indicator. The problem with this method lies in approximating the period prevalence by the observed prevalence of disability: the period value is under- or over-estimated by "Sullivan's value" according to the bias carried by the observed prevalence, but the trend in the period values is properly represented by the trend in "Sullivan's values" [Cambois/Robine (1994)].

The choice of the method depends essentially on the availability of data and on the objectives of the study. The general goal associated with health expectancies is to confirm or invalidate the mentioned theories debating on the modification of the average health level of ageing populations. For this purpose repeated and international studies must be carried out in order to produce homogeneous indicators meant to be compared and studied over large periods. Thus, as flow data are accessible regularly for most countries, the "observed prevalence tables" method seems to be the most appropriate for international trends studies.

3 International review

3.1 The place of health expectancy in the world

Today, a first calculation of health expectancy has been carried out for more than 30 countries [REVES (1993)], principally using the "observed prevalence tables" method. The limits of this method are increasingly well understood. Simulations provide a better means of assessing its imprecision [see Robine/Mathers (1993)]. Beside methodological choices and despite increasing efforts to standardize health surveys at an international level, direct geographic comparisons are impossible as wide differences still persist.

Differences in study protocols and definitions of disability could alone explain the differences in estimates presented in Table 2 [see United Nations, Chalmie (1990b), (1990a), and (1989)].

In the case of Germany, indicators have been produced twice for international reports; as those studies were based on different data collected by different surveys, no conclusion can be drawn in terms of trend. In 1990, Brown gave an estimation of the German active life expectancy at birth for 1983 [Brown (1990)]; also in 1990 Egedi computed a life expectancy in good health at birth, for 1986 [Egedi (1990)] (see Table 3).
Table 2: Disability-free life expectancy at age 65, in developed countries

<table>
<thead>
<tr>
<th>Pays</th>
<th>Males LE*</th>
<th>DFLE**</th>
<th>DFLE/LE in %</th>
<th>Females LE*</th>
<th>DFLE**</th>
<th>DFLE/LE in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States, 1985</td>
<td>14.6</td>
<td>10.5</td>
<td>71.9</td>
<td>18.6</td>
<td>13.4</td>
<td>72.0</td>
</tr>
<tr>
<td>Japan, 1985</td>
<td>15.5</td>
<td>14.1</td>
<td>91.0</td>
<td>18.9</td>
<td>17.1</td>
<td>90.5</td>
</tr>
<tr>
<td>Spain, 1986</td>
<td>15.0</td>
<td>6.8</td>
<td>45.3</td>
<td>18.4</td>
<td>6.5</td>
<td>35.3</td>
</tr>
<tr>
<td>United Kingdom, 1988</td>
<td>13.7</td>
<td>7.6</td>
<td>55.5</td>
<td>17.6</td>
<td>8.8</td>
<td>50.0</td>
</tr>
<tr>
<td>Switzerland, 1988-1989</td>
<td>15.4</td>
<td>12.2</td>
<td>79.2</td>
<td>19.6</td>
<td>14.9</td>
<td>76.0</td>
</tr>
<tr>
<td>Netherlands, 1990</td>
<td>14.0</td>
<td>9.0</td>
<td>64.3</td>
<td>19.0</td>
<td>8.0</td>
<td>42.1</td>
</tr>
<tr>
<td>France, 1991</td>
<td>15.7</td>
<td>10.1</td>
<td>64.3</td>
<td>20.1</td>
<td>12.1</td>
<td>60.2</td>
</tr>
<tr>
<td>Canada, 1991</td>
<td>15.6</td>
<td>8.3</td>
<td>53.2</td>
<td>19.7</td>
<td>9.2</td>
<td>46.7</td>
</tr>
<tr>
<td>Australia, 1992</td>
<td>15.4</td>
<td>6.4</td>
<td>41.6</td>
<td>19.2</td>
<td>10.2</td>
<td>53.1</td>
</tr>
<tr>
<td>Austria, 1992</td>
<td>14.9</td>
<td>11.5</td>
<td>77.3</td>
<td>18.3</td>
<td>12.2</td>
<td>67.0</td>
</tr>
</tbody>
</table>

*LE: Life Expectancy; **DFLE: Disability Free Life Expectancy.


Table 3: Health Expectancy for ex-West Germany

<table>
<thead>
<tr>
<th>Brown (1990)*: for 1983</th>
<th>for males</th>
<th>for females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active life expectancy at birth</td>
<td>61.5 years</td>
<td>69.9 years</td>
</tr>
<tr>
<td>Life expectancy at birth</td>
<td>70.8 years</td>
<td>77.4 years</td>
</tr>
</tbody>
</table>

Egedi (1990)**: for 1986

| Life expectancy in good health at birth | 63.4 years | 68.4 years |
| Life expectancy at birth | 71.8 years | 78.4 years |


3.2 Trends studies in the world

For other countries, time series of disability-free life expectancies have also been produced (table 4). Chronological series consist of at least two cross-sectional health surveys using the same measures and comparable samples. When these series are juxtaposed, they cover a period that extends for some
years. While the use of comparable samples and repeated use of the same measures of disability permit comparisons over time for any study, the strongly different measures of disability used, and differences in the sampling frames, do not allow comparisons between countries, not even to align the American studies one after the other in order to observe a longer time interval [see Robine/Bucquet/Ritchie (1991)].

Table 4: Countries for which chronological series are available

<table>
<thead>
<tr>
<th>Countries</th>
<th>Reference</th>
<th>Available years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>McKinlay et al. (1989)</td>
<td>1964, 1974, 1985</td>
</tr>
<tr>
<td>Japan</td>
<td>OECD (1976)*</td>
<td>1966 to 1970</td>
</tr>
<tr>
<td></td>
<td>Koizumi (1985)*</td>
<td>1965 to 1979</td>
</tr>
<tr>
<td>Norway</td>
<td>Grotvedt et al. (1994)</td>
<td>1975, 1985</td>
</tr>
<tr>
<td>Austria</td>
<td>Kytir (1994)</td>
<td>1992</td>
</tr>
</tbody>
</table>

* Published data are not detailed enough to be discussed in comparison studies.


In a first attempt to assess the health status of populations in 1991 American, English and Australian studies have been divided into four levels according to severity of disability: very severe disability, severe to very severe, moderate to very severe, mild to very severe disability. This classification permits to distinguish more carefully the trend in disability according to the degree of severity
through the computation of the corresponding indicators. Most authors do not distinguish life expectancy without severe disability and life expectancy without disability, all levels combined. Most of the time, a disability free life expectancy means all levels of disability combined.


![Figure 1: Disability-free life expectancy (all levels combined), for females at birth, international comparison from 1962 to 1991](image)

Over a period of 30 years, there has been a 7 year increase in life expectancy at birth among females from the most developed countries. By contrast, there has been a stagnation at about 63 years in disability-free life expectancy, all levels combined: thus the 7 years of life expectancy gained seem to be almost equivalent to an extra 7 years of disability. The Dutch series is difficult to interpret as it is based on self-rated perceived health [Perenboom/Boshuizen/van de Water (1993)]. Only the Canadian study 1986-1991 seems to indicate a clear decrease in disability-free life expectancy [Wilkins/Chen (1995)], and the French study
1981-1991 a marked increase [Robine/Mormiche (1993)]. In these ten years, disability free life expectancy in France has increased by 3 years for men, reaching 63.8 years, and by 2.6 years for women reaching 68.5 years; meanwhile for both sexes total life expectancy only increased by 2.5 years reaching 72.9 years for males and 81.1 years for females. Gains in disability-free life expectancy are half due to decreases in mortality and half to the decrease in disability at each age. Thus, in France, the increase in disability free life expectancy exceeds the increase in life expectancy: increase in life expectancy and decrease in the prevalence of disabilities (all levels combined) are associated.

In fact most of the new series are only formed with two points whereas the shape of the British series, already covering five points, leads to more careful interpretation. Thus, the last indicator produced for the United Kingdom (1991) [see Bebbington (1994)] and for Australia (1993) [Mathers (1991)], modifies the 1981-1988 conclusions, giving a newly upward trend to the disability-free life expectancy.

Studying health expectancy considering severe and very severe disabilities for all countries yields results, that indicate a significant difference in trends: indeed, as shown in Figure 2, life expectancies without severe and very severe disabilities are on a parallel course to total life expectancy.

![Graph showing life expectancy and disability-free life expectancy](image)

**Figure 2:** Disability-free life expectancy (severe disability) for females at birth, international comparison from 1965 to 1991
3.3 Conclusion of the trends studies

As already noticed, the lack of harmonization hinders proper international comparisons and conclusion should be given very carefully and provisionally. chronological series are too short to give any definitive interpretation and to validate one of the theories on changes in the health level of population. Anyway, it seems that trends are similar for most of the studied countries and an important information is given by these figures.

In fact, this two-level study shows that, at the worst, the population is undergoing a pandemic of light and moderate disabilities, but not of severe disabilities. It tends to confirm, for the latter, the theory of "dynamic equilibrium". According to Manton (1982), the increase in life expectancy is partly explained by a slow down in the rate of progression of chronic diseases. Thus, although the decline in mortality leads to an increase in the prevalence of disabilities, these disabilities are less severe. The results discussed here are essentially the same for males and females at birth and at age 65.

For the specific French case, the results are even more optimistic as they seem to illustrate the theory of compression of morbidity for disabilities at all levels combined. Identical results about the diminishing of the prevalence of disabilities, have also been observed in the United States of America recently [see Crimmins/Ingegneri (1991), Manton/Corder/Stallard (1993), National Research Council (1994)]. The French results, in favour of a compression of morbidity confirmed by some isolated studies, should be verified in other countries, before concluding that, of late years, increases in life expectancy are really accompanied by a rise in disability-free life expectancy, thus leading to a compression of morbidity.

At least, by reference to the existing series, it is possible to conclude that the increase in life expectancy does not lead to a pandemic of (very) severe disabilities in the most developed countries.

Work On Harmonization In Calculations

An international harmonization in protocols, surveys and definition of concept is urgently needed in order to carry on the development of such indicators; international organizations are working on this. For this purpose, the aims of REVE [see Bone, 1992], the international Network on Health Expectancy and Disability Process, are 1. to consider the necessary conditions for a comparison of several calculations of health expectancy, with a particular view to internation
geographical comparisons; 2. to reflect on how to interpret chronological series of health expectancy; 3. to examine the possible uses of health expectancy for socio-medical planning and programs; 4. to look at the possibilities of procedural standardization of data collection and health expectancy calculation procedures.

In 1993, the European Community has decided to support the creation of EURO REVES [see Robine (1995)], in order to produce homogeneous indicators for the member countries.

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8. Social Protection for Dependence in Old Age: The Case of Germany
   *Bernd Schulte* .......................................................... 149

9. Determining the Long-Term Care Needs of Individuals Living in Private Households: Results from a Survey
   *Ulrich Schneekloth* .................................................. 171

10. The Long-Term Costs of Public Long-Term Care Insurance in Germany. Some Guesstimates
    *Winfried Schmähl and Heinz Rothgang* .......................... 181

Part Four: Theoretical Issues and Policy Recommendations

11. Long-Term Care Insurance and Trust Saving in a Two-Generation Model
    *Peter Zweifel and Wolfram Strüwe* .................................. 225

12. Long-Term Care - An Inter- and Intragenerational Decision Model
    *Roland Eisen and Hans-Christian Mager* .......................... 251

13. The Assessment and the Regulation of Quality in Long-Term Care
    *Gabriele Johne* ......................................................... 285

14. Almost Optimal Social Insurance for Long-Term Care
    *Mark V. Pauly* ......................................................... 307

Subject Index ............................................................................. 331
Contents

Contributing Authors and Participants ..................................................... vii

Introduction
Roland Eisen and Frank A. Sloan ......................................................... 1

Part One: International Comparisons

1. An International Comparison of Trends in Disability-Free
   Life Expectancy
   Emmanuelle Cambois and Jean-Marie Robine ........................................ 11

2. Possibilities and Problems in a Cross-Country Comparative Analysis
   of Long-Term Care Systems
   Trond O. Edvardsen ............................................................................ 25

Part Two: Empirical Research into the Demand and
Provision of Long-Term Care Services

3. Effects of Strategic Behavior and Public Subsidies on Families' Savings
   and Long-Term Care Decisions
   Frank A. Sloan, Thomas J. Hoerger and Gabriel Picone .......................... 45

4. Women's Role in the Provision of Long-Term Care, Financial Incentives,
   and the Future Financing of Long-Term Care
   Sandra Necera and Peter Zweifel .......................................................... 79

5. Determinants of Institutionalization in Old Age
   Thomas Klein .................................................................................... 103

6. The Impact of the Community Long-Term Care Insurance Law
   on Services for the Elderly in Israel
   Denise Naon ...................................................................................... 115

7. The Effect of Public Provision of Home Care on Living and Care
   Arrangements: Evidence from the Channeling Experiment
   Peter Kemper and Lilitana E. Pezzin ................................................... 125

v