

# Determining Health Expectancies

**Edited by**

**Jean-Marie Robine**

INSERM, Equipe Démographie et Santé, Parc Euromédecine, Montpellier, France

**Carol Jagger**

Department of Epidemiology and Public Health, University of Leicester, UK

**Colin D. Mathers**

Epidemiology and Burden of Disease, World Health Organization,  
Geneva, Switzerland

**Eileen M. Crimmins**

Andrus Gerontology Center, University of Southern California, Los Angeles, USA

**Richard M. Suzman**

Behavioral and Social Research, National Institute on Aging, Bethesda, USA



Copyright © 2003 John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester,  
West Sussex PO19 8SQ, England

Telephone (+44) 1243 779777

Email (for orders and customer service enquiries): [cs-books@wiley.co.uk](mailto:cs-books@wiley.co.uk)  
Visit our Home Page on [www.wileyeurope.com](http://www.wileyeurope.com) or [www.wiley.com](http://www.wiley.com)

All Rights Reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning or otherwise, except under the terms of the Copyright, Designs and Patents Act 1988 or under the terms of a licence issued by the Copyright Licensing Agency Ltd, 90 Tottenham Court Road, London W1T 4LP, UK, without the permission in writing of the Publisher. Requests to the Publisher should be addressed to the Permissions Department, John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England, or emailed to [permreq@wiley.co.uk](mailto:permreq@wiley.co.uk), or faxed to (+44) 1243 770620.

This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold on the understanding that the Publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

#### *Other Wiley Editorial Offices*

John Wiley & Sons Inc., 111 River Street, Hoboken, NJ 07030, USA

Jossey-Bass, 989 Market Street, San Francisco, CA 94103-1741, USA

Wiley-VCH Verlag GmbH, Boschstr. 12, D-69469 Weinheim, Germany

John Wiley & Sons Australia Ltd, 33 Park Road, Milton, Queensland 4064, Australia

John Wiley & Sons (Asia) Pte Ltd, 2 Clementi Loop #02-01, Jin Xing Distripark, Singapore 129809

John Wiley & Sons Canada Ltd, 22 Worcester Road, Etobicoke, Ontario, Canada M9W 1L1

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

#### *Library of Congress Cataloging-in-Publication Data*

Determining health expectancies / edited by Jean-Marie Robine ... [et al].  
p.cm.

Includes bibliographical references and index.

ISBN 0-470-84397-7 (alk. paper)

1. Health expectancy. 2. Health status indicators. 3. World health. I. Robine, Jean-Marie.

RA407 .D47 2002

614.4'2 dc21

2002031130

#### *British Library Cataloguing in Publication Data*

A catalogue record for this book is available from the British Library

ISBN 0 470 84397 7

Typeset by Dobbie Typesetting Ltd, Tavistock, Devon

Printed and bound in Great Britain by T.J. International, Padstow, Cornwall

This book is printed on acid-free paper responsibly manufactured from sustainable forestry in which at least two trees are planted for each one used for paper production.

# Contents

<b>List of Contributors</b> .....	ix
<b>List of Abbreviations</b> .....	xv
<b>Introduction</b> .....	1
<i>Jean-Marie Robine, Carol Jagger, Colin D. Mathers, Eileen M. Crimmins, Richard M. Suzman and Yves Péron</i>	
<b>PART I THE MAIN TRENDS IN THE EVOLUTION OF THE POPULATION'S HEALTH STATUS</b>	
<b>Introduction</b> .....	9
<i>Jean-Marie Robine</i>	
<b>1 Increase in Life Expectancy and Concentration of Ages at Death</b> . . . .	13
<i>France Meslé and Jacques Vallin</i>	
<b>2 Compression of Morbidity</b> .....	35
<i>Wilma J. Nusselder</i>	
<b>3 Patterns of Disability Change Associated with the Epidemiologic Transition</b> .....	59
<i>George C. Myers, Vicki L. Lamb and Emily M. Agree</i>	
<b>4 Trends in Health Expectancies</b> .....	75
<i>Jean-Marie Robine, Isabelle Romieu and Jean-Pierre Michel</i>	

- Popkin, B.M. (1993) 'Nutritional patterns and transitions', *Population and Development Review* 19, 138–157.
- Riley, J.C. (1993) 'Active life expectancy during the long mortality decline: the transition from brief to protracted sickness', in Robine, J-M., Mathers, C.D., Bone, M.R. and Romieu, I. (eds) *Calculation of Health Expectancies: Harmonization, Consensus Achieved and Future Perspectives*. Montrouge: John Libbey Eurotext.
- Riley, J.C. and Alter, G. (1996) 'The sick and the well: adult health in Britain during the health transition', *Health Transition Review* 6, 19–44.
- Rogers, A. (1989) 'The elderly mobility transition: growth, concentration, and tempo', *Research on Aging* 11, 3–32.
- Rogers, R.G. and Hackenberg, R. (1987) 'Extending epidemiologic transition theory: a new stage', *Social Biology* 34, 234–243.
- Scott, S. and Duncan, C.J. (2000) 'Interacting effects of nutrition and social class differentials on fertility and infant mortality in a pre-industrial population', *Population Studies* 54, 71–87.
- Smith, L.R. (1994) 'Reflections on the next stage of the epidemiological transition', in Mathers, C., McCallum, J. and Robine, J-M. (eds) *Advances in Health Expectancies*. Canberra: Australian Institute of Health and Welfare.
- United Nations (1986) *Disability: Situation, Strategies and Policies*. New York: United Nations (ST/ESA/176).
- Vallin, J. (1993) 'Life expectancy: past, present and future possibilities', in Robine, J-M., Mathers, C.D., Bone, M.R. and Romieu, I. (eds) *Calculation of Health Expectancies: Harmonization, Consensus Achieved and Future Perspectives*. Montrouge: John Libbey Eurotext.
- Verbrugge, L.M. and Patrick, D.L. (1995) 'Seven chronic conditions: their impact on US adults' activity levels and use of medical services', *American Journal of Public Health* 85, 173–182.
- Verbrugge, L.M., Lepkowski, J.M. and Imanaka, Y. (1989) 'Comorbidity and its impact on disability', *Milbank Quarterly* 67, 450–484.
- Verbrugge, L.M., Lepkowski, J.M. and Konkol, L.L. (1991) 'Levels of disability among US adults with arthritis', *Journal of Gerontology* 46, S71–S83.
- World Health Organization (1980) *International Classification of Impairments, Disabilities, and Handicaps*. Geneva: World Health Organization.
- Yount, K.M. (1999) 'Persistent inequalities: women's status and the differential treatment of sick boys and girls. A case study of Minia, Egypt', PhD dissertation. Baltimore: Johns Hopkins University.
- Zelinsky, W. (1971) 'The hypothesis of the mobility transition', *Geography Review* 61, 219–249.

## 4

## Trends in Health Expectancies

JEAN-MARIE ROBINE, ISABELLE ROMIEU and JEAN-PIERRE MICHEL\*  
INSERM, Montpellier, France and \*Institutions Universitaires de Gériatrie, Geneva, Switzerland

The analysis and interpretation of chronological series of disability-free life expectancy (DFLE) was one of the initial aims of the Network on Health Expectancy and the Disability Process (REVES). The argument was as follows:

Several countries have now put together chronological series of DFLE using a common procedure: USA (1966–1976), England and Wales (1976, 1981, 1985), Quebec, Canada (1978, 1987). How should observed deviations in DFLE be interpreted? Should the new observed value of DFLE be compared to the preceding one or to an expected value, such as an expected value of DFLE in which mortality alone evolves while disability stagnates? (Introduction to the Network, February 1989)

In the mid-1970s the rapid increase in life expectancy (LE) at birth was assumed to have ended in low mortality countries. The sustained and continuous increase in LE observed over the 1980s was totally unexpected. The drop in the mortality of the oldest old was particularly surprising and led many to wonder whether people only escaped death from heart disease to live in poor health (Fuchs, 1984). This question has fuelled an important debate about the relationship between changes in mortality and morbidity. Historically the increase in LE meant an improvement in the health status of the population. This was no longer necessarily the case, because chronic diseases had replaced, or were progressively replacing, acute diseases such as infectious diseases. The risk of becoming ill was not solely linked to the risk of dying but also to the risk of becoming disabled (Riley, 1990). Thus, with a constant recovery rate, if the risk of dying diminished more than the risk of becoming ill, the risk of being ill increased.

In the absence of pertinent data on changes in morbidity, the relationships between changes in these risks were debated, gradually focusing on three main theories, the expansion of morbidity, dynamic equilibrium and the

compression of morbidity (Manton, 1982; Robine, 1986; Crimmins, 1990) (see Chapter 2). In the 1980s various observations summarized by Lois Verbrugge in a paper 'Longer life but worsening health' (Verbrugge, 1984)<sup>1</sup> contributed strongly to a pessimistic view about the changes in population health status with declining mortality. The debate has continued until now, continually renewed with the availability of new data on trends in health expectancy and health status (see below).

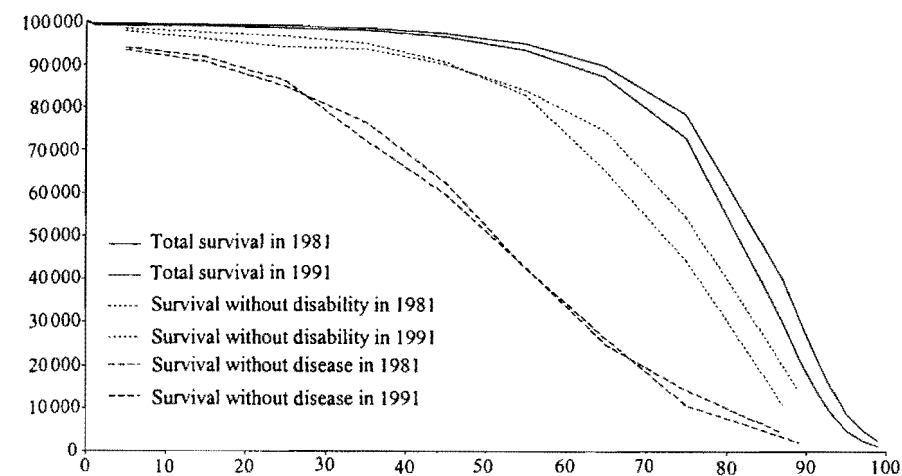
## THE DISABLEMENT PROCESS

The concept of 'health state expectancy' (HSE), a composite measure of morbidity and mortality (DFLE or active life expectancy (ALE)), has been developed in order to monitor the quality of the years of life gained, particularly for older people (Sanders, 1964; Sullivan, 1971). According to Sanders, 'In such an analysis we would not only determine for each age the probability of survival, but also the subsidiary probabilities of those surviving on the basis of their functional effectiveness. This would range from individuals who were completely dependent on others, even for carrying on their daily living activities, to those fully equipped to carry on with no apparent handicap all the functions characteristic of their age and sex' (Sanders, 1964).

Chronic diseases have numerous and varying consequences, ranging from the absence of any discomfort to death, making them the object of an international classification (WHO, 1980, 2001). Adding the risks of disability to the risks of disease permitted a considerable improvement in models of health. The concept of disability allowed rigorous definition of the theories summarized above.

The various theories on changes in the health status of populations could be described in terms of relative changes in LE and various HSE like DFLE (Robine, 1986, 1992). The HSE might be good indicators for estimating change in the health of population while the mortality rate has been falling and the demographic transition has been continuing. For example, the pandemic theory assumes a decrease in the proportion of healthy years in LE (Robine *et al.*, 1991). Precise definitions of the various theories, assumptions and scenarios in terms of relative changes in LE and various HSE were the topics of several studies since the beginning of the REVES network (Robine, 1986, 1991; Robine and Mathers, 1993, Robine *et al.*, 1996a; Nusselder *et al.*, 1996; Nusselder, 1998) (see Chapter 2 dealing with the compression of morbidity). Yet, the application of the general model of health transition (Chapter 2, Figure 2.1) to the 1981 and 1991 French data showed that the increase in LE was accompanied by a parallel increase in

<sup>1</sup> There was obviously a link to the book 'Doing Better but Feeling Worse: Health in the United States' edited by John H. Knowles, in 1975.



**Figure 4.1.** Survival without disease and survival without disability (WHO model, 1984) France, 1981 and 1991, females.

Source: Robine, J.M., Mormiche, P. and Cambois, E. (1996) Evolution des courbes de survie totale, sans maladie chronique et sans incapacité en France de 1981 à 1991: application d'un modèle de l'OMS. *Annales de Démographie Historique* 99–115. Reproduced with permission

DFLE, while LE without chronic diseases has remained constant (Robine *et al.*, 1996b) (Figure 4.1). This apparent contradiction in the changes in morbidity and disability provides an example of the theory of dynamic equilibrium proposed by Manton in 1982. With the decline in mortality, the prevalence of chronic diseases increased but these diseases were, on average, less severe and less often resulted in disability (Manton, 1982).

In contrast to mortality, notions such as health or morbidity are difficult to define. Health is 'a composite of current state and prognosis (i.e. the probability of moving to other states) that occurs throughout an individual's life' (Fanshel and Bush, 1970). In this way health is not only, 'the ability to function now, but the outlook for future functional ability' (Fanshel, 1972). This life-course definition of health is the justification for the use of health state expectancies as fundamental health indicators for populations, because they measure the lifetime spent in different health states.

## CHRONOLOGICAL SERIES

Only provision of time series of both LE and HSE will make it possible to answer the questions raised earlier in this chapter and decide which theoretical approach is supported. This explains why REVES devoted several sessions of

its meetings to the presentation and analysis of empirical chronological series on disability or time series on HSE. Since the creation of REVES, several series have been presented:

- Various HSE from Australia, Canada, China, England and Wales, Finland, France, Japan, the Netherlands, Sweden, Taiwan and the United States.<sup>2</sup>
- Mental health series in the Netherlands and in the United States<sup>3</sup> and
- HSE trends by socioeconomic status (SES) in Sweden, Finland, United States and France<sup>4</sup> (see Chapter 5: Social Inequalities).

In addition, several theoretical or methodological papers dealing with the interpretation of chronological series were presented,<sup>5</sup> in particular on changes in disability during the epidemiological transition, in term of incidence, prevalence, severity level, and recovery (see Chapter 3).

#### TIMES SERIES ON DISABILITY DATA

After the creation of REVES, publications and analysis of time series on disability, without DFLE calculation, continued especially in the United States, focusing on various aspects of functional status. Many authors employed the same data, particularly data from the American National Health Interview Survey (NHIS). Some authors continued to note that an increase in disability is not evident in the old (Verbrugge, 1989). Some authors underlined that changes in the disability prevalence at the older ages were linked to the drop of the mortality rate at these ages (Crimmins, 1990; Riley, 1990).

#### Pandemic or Disability Decline in North America

In 1991, Crimmins and Ingegneri pointed out that for those aged 45 to 75, activity restriction increased from 1969 to 1975, levelled off from 1975 to 1982 and decreased from 1982 to 1988 (the last year of NHIS observation at that time). Beyond 75 years of age, there was not a clear trend from 1969 to 1988.

<sup>2</sup> Australia (Mathers, 1991a, 1994; Mathers and Jain, 1999), Canada (Brunelle, 1991; Wilkins and Adams, 1992; Wilkins *et al.*, 1994; Wilkins and Chen, 1995; Martel and Bélanger, 2000), China (Qiao, 1997), England and Wales (Bone, 1991; Jagger and Clarke, 1991; Bebbington and Wittenberg, 1999; Kelly and Baker, 2000), Finland (Sihvonen *et al.*, 1996), France (Robine, 1994; Cambois and Robine, 1999), Japan (Koizumi, 1994), the Netherlands (Boshuizen, 1991; Perenboom *et al.*, 1993; Deeg *et al.*, 1994, 1996; Perenboom *et al.*, 2000), Sweden (Pettersson, 1995), Taiwan (Tu and Chen, 1992, 1994, 1995; Chen *et al.*, 1996; Tu *et al.*, 1997) and the United States (Colvez, 1992; Corder *et al.*, 1992; Crimmins *et al.*, 1992a, 1992b; Osborn, 1992; Crimmins and Saito, 1997a; McClellan and Yan, 2000).

<sup>3</sup> Perenboom and van de Water, 1997; Sauvaget *et al.*, 1997.

<sup>4</sup> Pettersson, 1995; Sihvonen *et al.*, 1996; Crimmins and Saito, 1993, 2001; Cambois and Robine, 1999; Cambois *et al.*, 2001.

<sup>5</sup> Robine, 1991; van de Water, 1991; Brunelle, 1993; Crystal *et al.*, 1993; Myers and Lamb, 1993; Riley, 1993; Robine and Mathers, 1993; Smith, 1994; Riley and Alter, 1995; Myers and Elman, 1996; Nusselder *et al.*, 1996; Alter and Riley, 1997; Lamb, 1999.

Using comparable data from two other surveys, the 1962 and 1975 Survey of Older Population and the 1984 Supplement on Aging (SOA-NHIS), the same authors showed a slight improvement in health for 65+ people during a 25-year period (Crimmins and Ingegneri, 1991). In 1992 Preston, by analysing the gains in the level of education from one cohort to another, brought out new elements which could explain the improvement in health in older populations in the United States (Preston, 1992).

Manton *et al.*, using data from the National Long Term Care Study (NLTC, 1982, 1984 and 1989), showed that in the 65+ population, the prevalence of IADL (instrumental activities of daily living) disability decreased from 1982 to 1989 whereas the prevalence of ADL disability and the prevalence of institutional placement remained stable (Manton *et al.*, 1993a, 1993b). Freedman and Soldo, by combining the NLTC data (1982–1989) with the NHIS data and the Longitudinal Study of Aging (LSOA, 1984–1990), published a first report on changes in disability in the old in the United States confirming Manton's results (Freedman and Soldo, 1994). Later Manton *et al.* extended their conclusions to 1994 (Manton *et al.*, 1995, 1997, 1998) and finally to 1999. According to Manton, the main findings are an acceleration of the decline in chronic disability prevalence from 1994 to 1999 compared with 1989 to 1994, the large relative and absolute drop in institutional use and a greater decline for black Americans after 1989 (Manton and Gu, 2001). In addition, the prevalence of severe dementia for the US age 65 and older population appears to decline significantly from 1982 to 1999 when severe dementia is measured by the inability to undergo a cognitive battery such as the Short Portable Mental Status Questionnaire (SPMSQ) or the Mini-Mental State Examination (MMSE) and to answer a questionnaire without the help of a proxy (Corder and Manton, 2001).

In 1995, using once again the NHIS data, Waidmann *et al.* reconsidered the existence of a turning point in the 1980s at least in the United States (see above Crimmins and Ingegneri, 1991). Like their predecessors, they re-examined all the available data and did not find a clear trend for the oldest old (70 years and over) from 1969 to 1981. This did not prevent them from taking for granted that the health of the young adult and the elderly deteriorated during the 1970s and then improved during the 1980s. Then, Waidmann *et al.*, comparing their results to the 'failure of success' hypothesis (i.e., the pandemic or expansion of morbidity), noted that the improvement in survival was highest among the oldest (over the age of 70), while the apparent deterioration in health was more centred on the youngest from 45 to 69 years of age (Waidmann *et al.*, 1995). On the other hand, Crimmins *et al.* pointed out that the variations observed with the 1984–1990 LSOA or the 1982–1993 NHIS looked more like fluctuations than clear trends (Crimmins, 1996; Crimmins *et al.*, 1997b).<sup>6</sup> However, in the

<sup>6</sup> See also Crimmins and Ingegneri 1993; Crimmins, 1997; Crimmins and Saito, 1997b.

age range from 30 to 69 years disability increased for the later born cohorts (Reynolds *et al*, 1998) and the ability to work improved significantly for those in their 60s (Crimmins *et al*, 1999).

But, while there was a growing body of evidence for a decline in disability rates among the elderly, estimates of the extent of the fall of these disability rates were imprecise. A few studies showed smaller declines or no sustained increase in disability. Others, which in the past had shown either increasing disability or no change over time, now showed statistically significant declines in elderly disability rates (Waidman and Manton, 1998). Documenting her argument with data from the Union Army pensions, indicating a long-term decline in chronic diseases for older men in the United States (50 to 74 years) between 1900–1910 and more recent periods, Costa showed that the shift from manual to white-collar jobs was the main determinant of this transition (Costa, 2000). In the Framingham Heart Study covering the second part of the 20th century, at the same age between 55 and 70 years, there was substantially less disability in the offspring cohort than in the original cohort. The secular decline in disability was strongly evident among individuals with chronic diseases. In addition, fewer offspring perceived their health as fair or poor and fewer had chronic diseases (Allaire *et al*, 1999). For the last years of the 20th century, using the 1992–1996 Medicare Current Beneficiary Surveys (MCBS), Waidmann and Liu found at age 65 years and over a consistent decline in the rate of IADL disability.<sup>7</sup> Trends toward a more educated elderly cohort, already indicated by Preston (see above), could only partially explain the disability decline (Waidmann and Liu, 2000; Crimmins *et al*, 1999).

Analysis carried out by Freedman and Martin, using data from the Survey of Income and Program Participation (SIPP), shown that between 1984 and 1993 four functional abilities – vision of printed characters, lifting and carrying a sack of roughly 10lb, climbing stairs and walking a quarter of a mile (about three city blocks) – increased significantly (Freedman and Martin, 1998). Setting aside the question of vision, which depends partly on the wearing of glasses, these results clearly suggested an improvement in physical vigour. Among the four considered explanatory variables, education was the most important in accounting for this trend. This analysis suggested that future changes in education would continue to contribute to improvements in functioning (Freedman and Martin, 1999). In addition, using the 1993 Asset and Health Dynamics of the Oldest Old study (AHEAD) and the Health and Retirement Survey (HRS), Freedman *et al* showed that the percentage of the non-institutionalized population aged 70 years and older with severe cognitive impairment declined from 6.1% in 1993 to 3.6% in 1998. According to the authors, this cognitive functioning improvement

<sup>7</sup> The decline in ADL disability was largely concentrated in the last year, in 1996.

might account for much of the observed improvement in IADL function (Freedman *et al*, 2001).

Again analysing the NHIS data from 1982 to 1996 for persons aged 70 and over, Schoeni *et al* have recently shown that most of the decline in disability took place between 1982 and 1986 with little change after 1986. Most of the decline involves routine activity needs, not personal care needs. The only group to experience improvements were elderly persons with more than a high school degree (Schoeni *et al*, 2001). Thus the most recent results from the NHIS (Schoeni *et al*, 2001), the NLTCs (Manton *et al*, 1997; Manton and Gu, 2001) and the MCBS (Waidmann and Liu, 2000) brought contradictory conclusions for the United States, raising again concerns about the disability trend among old people.

For Canada as a whole, despite similar methodology, large increases in disability were observed in the results of the Health and Activity Limitations Survey (HALS) between 1986 and 1991. However, the differences were not significant beyond the age of 55 (LaRoche and Morin, 1994). On the other hand, researchers concluded from a Manitoba study that there was a deterioration in the functional health in the elderly population, but the ADL questions were markedly changed between the two surveys (Roos *et al*, 1993). In Quebec, where the 1998 Health and Activity Limitations Survey is comparable to the 1986 and 1991 surveys, an increase in disability prevalence has been observed for all age groups, resulting from a large increase in mild disability combined with a decrease in moderate and severe disability (Saucier and Lafontaine, 2001).

### Disability Changes in Europe and Japan

Outside of North America, during the same period of time, different studies have shown an improvement in functional health for the elderly in terms of ADL in Sweden (Svanborg, 1988) and in the United Kingdom (Jagger *et al*, 1991; Spiers *et al*, 1996). In this last country, the decrease in the inability to carry out ADL was particularly clear over the period from 1976 to 1994 (Grundy, 1997). In France, an improvement in the health of the elderly living at home was observed between 1980 and 1991, as well as the near stability in health of those residing in institutions. Despite an increase in the survival of older people in France, the health of the elderly population, wherever their place of residence, improved between 1980 and 1991 (Robine *et al*, 1998). These results were similar to those already found in the Paris area for the 1965–1980 period (Mizrahi and Mizrahi, 1989, 1993, 1994).

In Finland, contradictory results were published. On the one hand, an increase in the proportion of people reporting long-standing illness from 1964 to 1996, especially among the elderly, was reported. On the other hand, a

decrease in the proportion of people with ADL disabilities was noted from 1986 to 1994.<sup>8</sup> A third Finnish study attested a decrease in the proportion of people reporting poor or rather poor health in the age group 55 to 64 years from 1979 to 1998 (Aromaa *et al.*, 1999). In Switzerland, in the French cantons, from 1979 to 1994 there was a clear increase in ADL performances and in mobility. Hearing abilities improved over the age of 80 and perceived health improved for all the older population (Lalive d'Épinay *et al.*, 2000).

According to Grundy *et al.* the prevalence of disability reported in the 1996/7 UK disability survey was much higher than in the earlier 1985 survey of disabled adults in private households. The authors underlined that this last result was not in accordance with trends from the United States (Grundy *et al.*, 1999). It was more in line with the Labour Force Survey in Great Britain which showed an important increase, year after year, in the disability rate at working age for the period 1984–1996 (Cousins *et al.*, 1998). However, the detailed data revealed a decrease in the prevalence of the most severe levels of disability and an increase in the prevalence of the least severe levels, especially above the age of 75 years. The decrease in the prevalence of the most severe levels of disability was in line with the decrease in the inability to carry out ADL for the period 1976–1994, noted above (Grundy, 1997).

In Japan, the data from the 1992, 1995 and 1998 Comprehensive Survey of Living Conditions of the People on Health and Welfare suggest a trend to worsening health when looking at the ability/inability of people aged 65 and over (the most severe disability level) to perform at least one ADL even if the need for help with ADL in general declined (Saito, 2001).

### A Paradoxical Situation

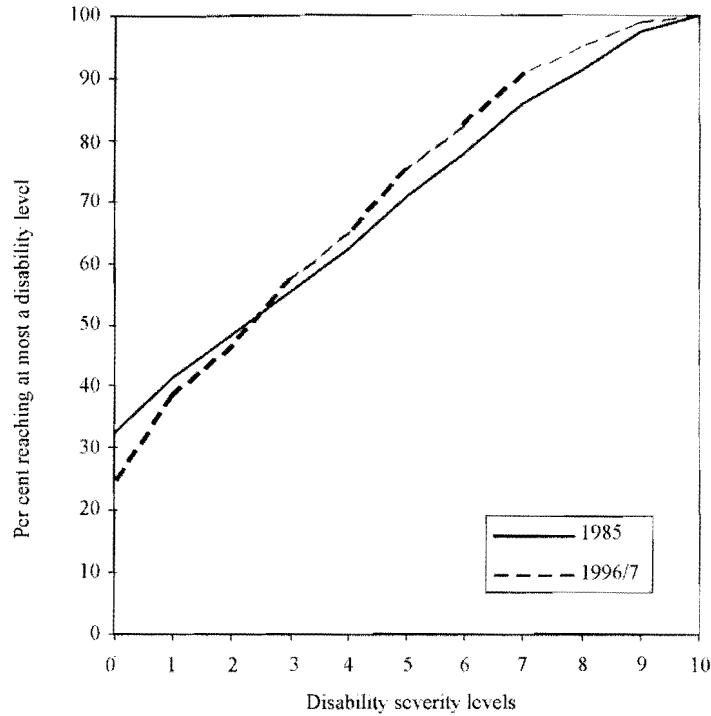
Finally, the situation in the United States and in Europe was quite paradoxical. On the one hand, most of the studies on disability found a general rise in disability. On the other hand, close examination of all these studies, particularly those studying the United States, showed the following: (1) the differences recorded in children (learning difficulties, etc.) were strongly linked to the development of different educational programmes; (2) the inability to work in adults was strongly linked to the development of social programmes (development and promotion of disability pensions) and to the condition of the labour market; (3) ADL disabilities did not increase in the elderly, and these measures were the least susceptible to changes in the social environment; (4) and finally, whatever the age studied, the most severe forms of disability were not increasing (Robine, 2000). To summarize the whole body of data collected since the end of the 1960s, it appeared that not a single study in the United

<sup>8</sup> However, two cohort studies have shown the opposite, at a local level, for an earlier period (Anttila, 1991; Winblad, 1993).

States clearly identified deterioration in functional health in the elderly. During the 1980s, other countries began to collect data. Most series indicated an improvement in functional health, namely for ADL in England and Wales (1976–1994), Finland (1986–1994), Switzerland (1979–1994) or for discomfort in daily life in France (1980–1991). In the 1990s, American studies using new data (1984 and 1993 SIPP; 1992 and 1996 MCBS; 1993 AHEAD and 1998 HRS) suggested that global functional health (including cognitive functioning) and/or IADL disability of the elderly had improved significantly over the last few years. But other series showed contradictory results: the American NHIS data indicated no precise disability trend, while two UK disability surveys showed a global increase in disability. What could be the explanations for such differences? This was all a bit chaotic.

Extreme caution must be exercised before drawing general conclusions. But globally the results suggested that the functional status of the elderly population has improved over the last thirty years. The drop in mortality at older ages has continued to increase the proportion of over-65 survivors. This change should have or could have led to an increase in disability rates at the top of the scale, but this was not the case. However, the different components of morbidity – e.g. disease, functional status and perceived health – did not necessarily evolve in unison (Crimmins, 1996; Spiers *et al.*, 1996). The concept of 'functional health' itself consisted in functional limitations, difficulties in performing tasks, activity restriction, and dependence. The improvement over time in ADL and IADL performances was not necessarily linked with the improvement in physical and sensory abilities such as mobility, agility, vision or hearing (Manton *et al.*, 1993b; Freedman and Martin, 1998) or in cognitive abilities (Freedman *et al.*, 2001).

Two hypotheses can be raised. Firstly, the fall in mortality was accompanied by a redistribution of the levels of disability with, on the one hand, a decrease in the prevalence of the most severe levels and, on the other hand, an increase in the prevalence of the least severe levels. Changes in the total prevalence of disability would depend on these opposing changes. This hypothesis, initially raised in France (Tartarin and Bouget, 1994), can be empirically verified in England and Wales (Figure 4.2). It is also observed in Quebec between 1986 and 1998 (Saucier and Lafontaine, 2001). This redistribution would explain the result of Waidmaan and Liu showing an increase over time in the proportion of physical limitations but not of disability (Waidmann and Liu, 2000). Secondly, the disability attributed to disease or old age would be in fact the consequence of the low educational and training level of the earliest cohorts. Better educated and better trained, most recent cohorts had better cognitive performances and therefore better performances for activities requiring mental skills. Cognitive abilities and IADL measures would be affected by changes in level of education. These hypotheses provide further justification for distinguishing between various concepts of health, chronic morbidity, perceived health, and

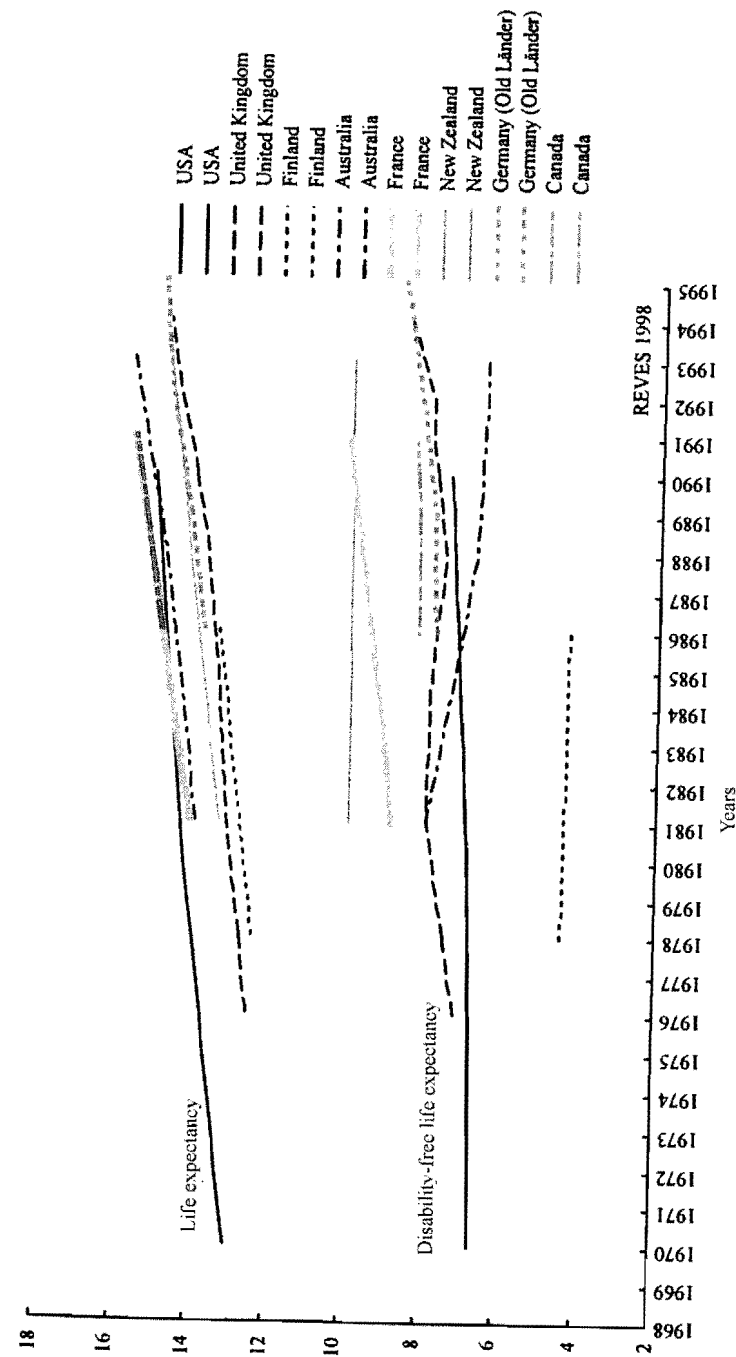


**Figure 4.2.** Cumulated distribution of disability severity levels, Great Britain, 1985 and 1996/7, both sexes at age 80 and over.  
 Source: Grundy, E., Ahlburg, D., Ali, M., *et al* (1999) *Disability in Great Britain*. HMSO, Department of Social Security (Research Report 94). Reproduced with permission

functional health. It is this multifaceted point of view which allows the calculation of health state expectancy.

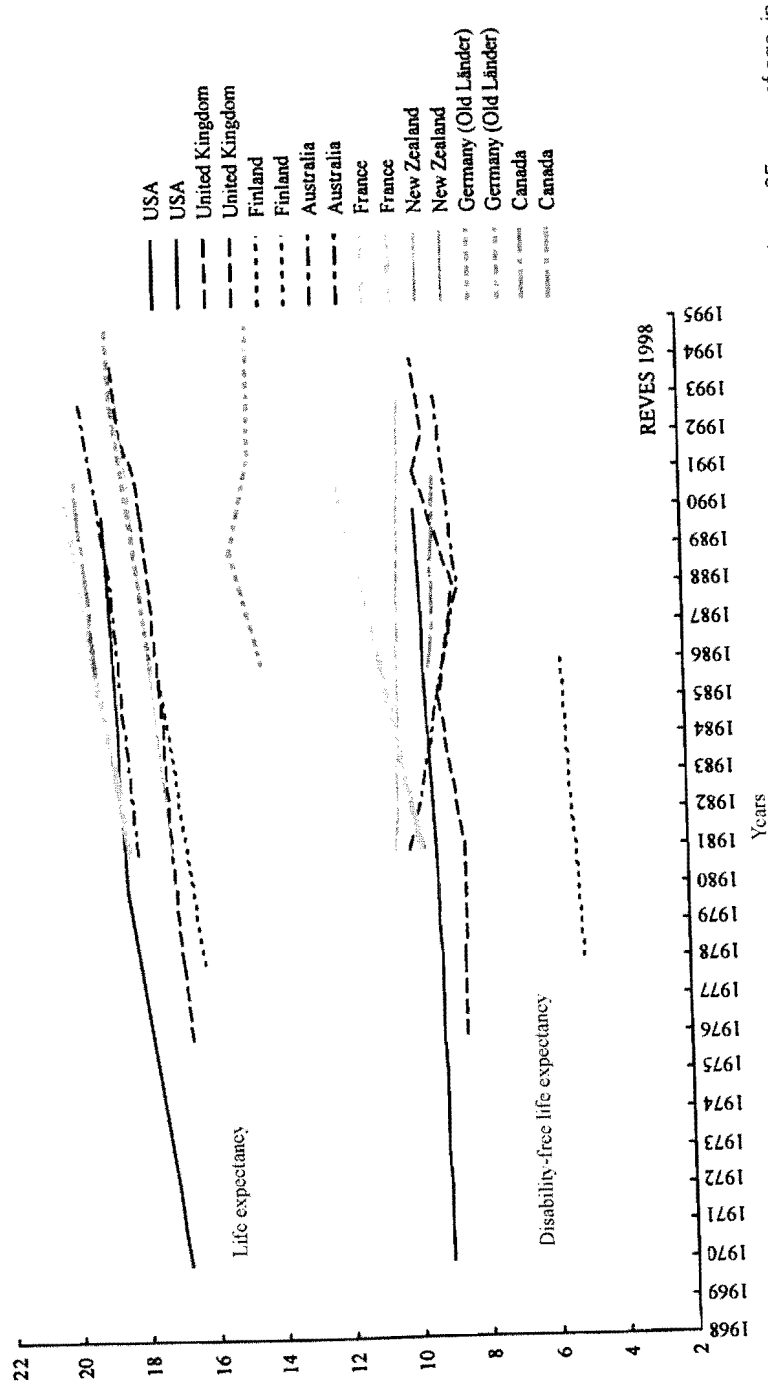
**CHRONOLOGICAL SERIES ON HEALTH EXPECTANCIES**

In 1991, a first synthesis of time series on HSE for three countries – Australia, England and Wales and the US – concluded that overall the studies supported the theory of the ‘pandemic of disabilities’ (Robine *et al*, 1991). However, this work based on various DFLE calculations showed that the series of LE without severe disability supported the ‘theory of equilibrium’. Following this first synthesis, most authors differentiated severe and non-severe disability in the analysis and the presentation of new series. The most recent synthesis integrated calculations from almost 50 countries including 15 time series performed in low mortality countries: Western Europe, Nordic countries, North America, Australia, Japan and New Zealand (Robine and Romieu,



**Figure 4.3.** Changes in life expectancy and disability-free life expectancy – all levels of disability combined – at 65 years of age, in different countries, men.  
 Sources: Crimmins *et al*, 1989, 1997a; Bebbington and Darton, 1996; Sihvonen, 1994; Mathers, 1991b, 1996; Robine and Mormiche, 1994; Davis and Graham, 1997; Brückner, 1997; Wilkins *et al*, 1994





**Figure 4.4.** Changes in life expectancy and in disability-free life expectancy – all levels of disability combined – at 65 years of age, in different countries, women.  
 Sources: Crimmins *et al.*, 1989, 1997a, Bebbington and Darton, 1996; Sihvonen, 1994; Mathers, 1991b, 1996; Robine and Mormiche, 1994; Davis and Graham, 1997; Brückner, 1997; Wilkins *et al.*, 1994

1998; Robine *et al.* 1999). The data gathered cover a 25-year period, from 1970 to 1995, and could be used to compare changes in LE and DFLE (all levels of disability combined), with changes in severe DLFE.

Figures 4.3 and 4.4 show that although the increase in LE at age 65 appeared universal and regular in the low mortality countries, the same is not true for the DFLE – all disability levels combined – which appeared to have stagnated. The gains in LE might be years with disability.

Figure 4.3 presents series ranging from 1970 to 1995 of total LE and DFLE – all disability levels combined – at age 65 in men in eight different countries: Australia, Canada, Finland, France, Germany, New Zealand, the United States and the United Kingdom. The analysis of the earliest series demonstrated that DFLE – all levels combined – was stagnating. However, the relationship over time differed across countries. For instance, the Canadian and Finnish series still suggested that DFLE was levelling off, whereas the American, British, German, and French series showed that DFLE was increasing (the increase was particularly strong in France). In contrast, the Australian series showed a decrease in DFLE. Hence, no general conclusion can be firmly drawn even if the general feeling, when looking at Figure 4.4, was that while LE was increasing for the various countries, DFLE – all severity levels combined – was apparently stagnating.

Figures 4.5 and 4.6 show that severe DFLE evolved in parallel with LE in all the countries in which data were available, namely, Australia, Canada, France, Japan, the United States and the United Kingdom. This means that if the years gained in LE were years of life with disability, they were not with severe disability. A more careful look at the figures and a thorough knowledge of the data used allows one to distinguish between

- ‘very’ severe DFLE (institutionalization and/or bed confinement), which had been evolving at the same rate as LE since 1970 (American, French and Japanese series), and
- severe DFLE (or ALE), which had been evolving at the same rate as LE since the end of the 1980s for females (Australian and UK series, see Figure 4.6).

All these figures give the impression that (1) ‘very’ severe DFLE has been increasing along with LE since data has been available, (2) severe DFLE has been clearly increasing only for the last 10 years, and (3) DFLE – all levels of disability combined – has basically stagnated over the same period of time, even if most of the data show a tendency toward a slight increase at the end of this period.

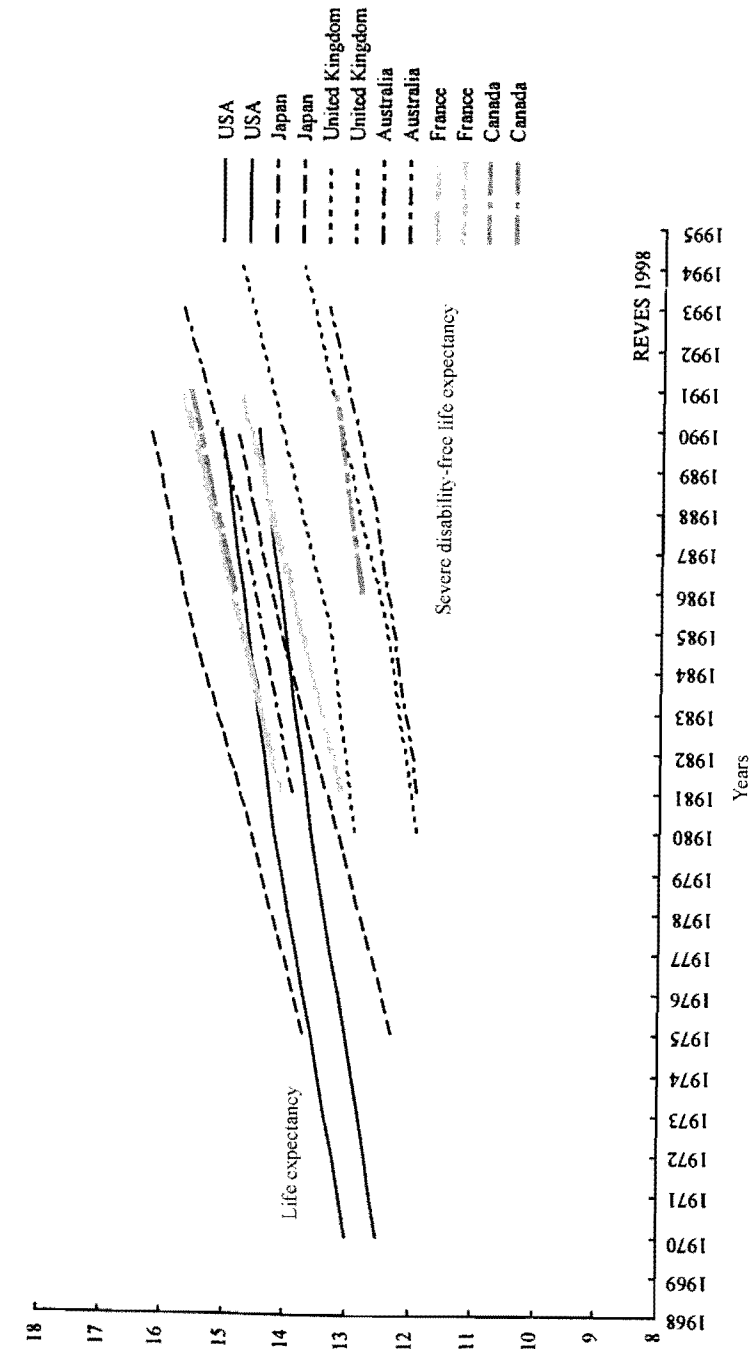
Therefore, it clearly appears that DFLE has evolved very differently depending on the severity level of disability: a decrease for the most severe levels of disability (institutionalization and/or bed confinement), and an increase for the less severe levels of disability (no ADL dependency). Changes

in DFLE – all levels of disability combined – are nothing else than the result of these opposite changes.

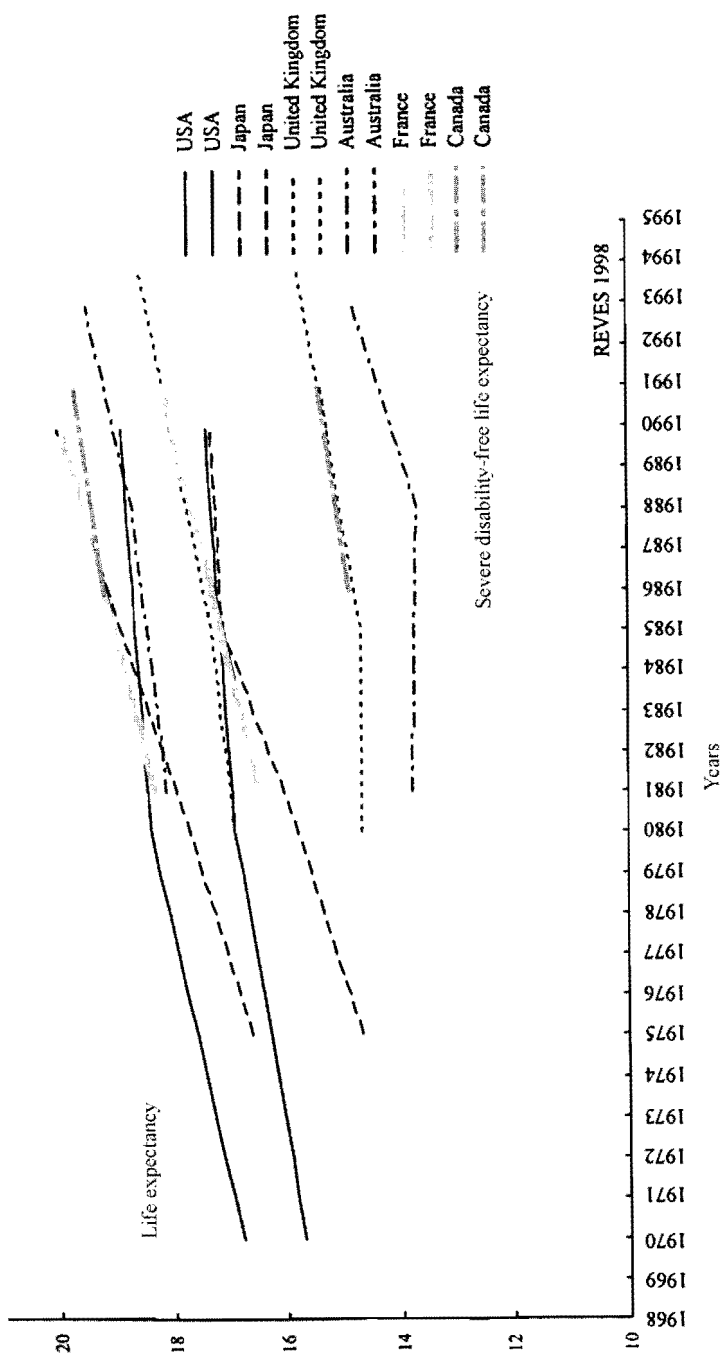
In Great Britain, for instance, between 1981 and 1995, LE at 65 years of age increased continuously from 13.0 to 14.7 years for males and from 16.9 to 18.3 years for females. But LE free of long-standing illness increased only slightly from 7.6 to 8.3 years for males and from 8.5 to 9.5 years for females (Kelly and Baker, 2000). This suggests that applying the general model of health transition (WHO, 1984) to the available data in England and Wales (Bone *et al.*, 1995; Grundy, 1997; Grundy *et al.*, 1999; Kelly and Baker, 2000) would bring similar conclusions to those of its previous application to French data (Robine *et al.*, 1996b). An increase in LE in England and Wales between 1981 and 1995 was accompanied by a parallel increase in severe DFLE (or ALE). During the same period of time, LE free of limiting long-standing illness remained constant or increased slightly and DFLE – all levels combined – stagnated.

DFLE calculations and analysis suggest that a vital key to the interpretation of time series is the level of severity of disability. The more severe the levels, the more similar the changes. The less severe the levels, the more the change varies from one country to another. The analysis of time series of DFLE by severity level in comparison to trends in total LE and LE without disabling chronic disease or LE without long-standing illness supports the 'theory of dynamic equilibrium', which partly explains the increase in LE by a slowing down in the rate of progression of chronic diseases (Manton, 1982). In the low mortality countries, the decline in mortality among the oldest old during the 1980s and the 1990s is accompanied by an increase in the prevalence of chronic diseases, and maybe by an increase in the total prevalence of disability, but these diseases are on the average less severe and lead less often to severe levels of disability. The results indicate that at worst the increase in LE is accompanied by a pandemic of light and moderate, but not of severe disabilities.

One of the most recent studies, distinguishing functional limitations (seeing, hearing, walking difficulties) which can be seen as a pre-disability level from activity restrictions, provides another example illustrating a possible redistribution of disability severity levels. In Quebec, between 1986 and 1998, LE increased by two years whereas life expectancy without functional limitation (seeing, hearing) decreased by one year. But during the same period, LE without activity restriction (all levels combined) stagnated whereas LE without moderate and severe activity restriction increased in parallel with LE (Pampalon *et al.*, 2001). Another recent study using microcensus data for the years 1978, 1983, 1991 and 1998 suggests that both LE in good perceived health and the ratio of healthy years to LE increased between 1978 and 1998 in Austria, leading to the conclusion that elderly people in the 21st century may not only live longer but also live longer in good health (Doblhammer and Kytir, 2001).



**Figure 4.5.** Changes in life expectancy and in severe disability-free life expectancy at 65 years of age, in different countries, men. Sources: Crimmins *et al.*, 1989, 1997a; Crimmins and Saito, 1993; Inoue *et al.*, 1997; Bebbington and Darton, 1996; Mathers, 1991b, 1996; Robine and Mormiche, 1994; Wilkins *et al.*, 1994



**Figure 4.6.** Changes in life expectancy and severe disability-free life expectancy at 65 years of age, in different countries, women. Sources: Crimmins *et al*, 1989, 1997a; Crimmins and Saito, 1993; Inoue *et al*, 1997; Bebbington and Darton, 1996; Mathers, 1991b, 1996; Robine and Mormiche, 1994; Wilkins *et al*, 1994

**CAUSES AND MECHANISMS**

To go further in the analysis several authors studied specific changes in the statistical relationships linking chronic morbidity to disability. Using the data from the French National Health Surveys, the presence of chronic disabling diseases led significantly less often to disability in 1991 than in 1981, suggesting that the reported morbidity was less severe in 1991 (Robine *et al*, 1998). American studies confirmed the French study with the data of the Supplement on Aging (SOA) to the 1984 and 1994 NHIS (Crimmins and Saito, 2000; Freedman and Martin, 2000). Although chronic conditions increased, the percentage of older Americans with upper body limitations (reaching up over one’s head; reaching out; and using one’s finger to grasp or handle) declined from 5.1% to 4.3% between 1984 and 1994. Those with lower body limitations (walking for a quarter mile; walking up 10 steps without resting; standing for about two hours; stooping, crouching or kneeling; and lifting or carrying a 25lb object) declined from 34.2% in 1984 to 28.5% in 1995 (Freedman and Martin, 2000). When the gender differentials were examined there were no functioning and disability changes for old men with disease and an improvement in Nagi functions (Nagi, 1976) and IADLs for women with disease. On the other hand, there was no improvement in ADL disability for either sex (Crimmins and Saito, 2000). The Framingham Heart Study essentially confirmed these results (Allaire *et al*, 1999).

**CONCLUSION**

The time series on health expectancies have contributed significantly to our current knowledge on changes in the health of populations experiencing declining mortality in the oldest old. The hypothesis of a rectangularization of the survival curves at extreme ages is largely questioned today. The shape of the survival curve, the mortality trajectories at the extreme ages and the limits of human life span need to be reassessed (Nusselder and Mackenbach, 1995; Mesrine, 1997; Barbi *et al*, 1999; Olshansky and Carnes, 1995, 2000).

Health expectancy and HSE time series enabled comparisons of changes in the three fundamental dimensions of a population’s health, namely mortality, chronic morbidity and disability. In particular, the series offered a unified framework to support international comparisons and synthesis analyses whereas accumulation of empirical studies of prevalence of disability series led essentially to contradictory results. But behind these general conclusions, heterogeneity has been noted between comparable countries and needs to be understood. For example, not all the developed countries have the same fall in mortality among the oldest old (Nusselder and Mackenbach, 2000). The decrease in ADL disability, noted in several European countries, is not verified

in North America although such a decrease could be expected given the hypothesis of redistribution of disability by severity levels. France has experienced a large decrease in its disability rates – all disability levels combined – whereas a stagnation or even an increase has been observed in England and Wales.

However, limitations in the times series are real and need to be avoided in the future. Presently, most series are too short. Current protocols from the surveys used to constitute the statistical series have to be preserved as long as possible to allow the continuation of the series. Disability severity levels are still poorly defined and standardized, complicating analyses as well as communication with policy makers. Standardization of disability as well as general health measures should become a priority.

Health state expectancies series could be improved, but they are still relevant and provide meaningful series for policy making. They do not aim to replace life expectancies but, on the contrary, they enable the assessment of whether the increase in life expectancy is accompanied by a compression or expansion of morbidity or disability. Recent studies show that people with lower risks (defined on the basis of smoking, body mass index, and exercise patterns) not only live longer, but experience fewer years of disability before death (Vita *et al*, 1998; Ferrucci *et al*, 1999; Nusselder *et al*, 1999, 2000). None of these studies suggests that there is a trade-off between quantity and quality of life, but rather, at least for two of them, that there is a possible compression of disability, with quantity and quality of life going hand in hand. Thus, if future increases in life expectancy are due to better behaviours, they could also be accompanied with larger increases in disability-free life expectancy leading to a compression of disability. In fact, in the United States some forecasts of disability in elderly populations are very optimistic (Manton *et al*, 1997; Manton and Gu, 2001). Improvement in the level of education of successive cohorts impacts directly on the cognitive performance of older people and therefore indirectly on the decrease in IADL restrictions. A recent study in the United States showed through calculation of DFLE from 1970 to 1990 that compression of morbidity has begun among those of higher educational status, whereas those of lower status are still experiencing expansion of morbidity, and underlined again the possible role of education (Crimmins and Saito, 2001). In France, when comparing DFLE and LE for males, compression of disability between 1980 and 1991 is verified for all occupational groups (Cambois *et al*, 2001). Moreover, several recent studies have shown an improvement in perceived health of older people (Aromaa *et al*, 1999; Lalive d'Épinay *et al*, 2000), with life expectancy increasing together with life expectancy in good perceived health in Austria from 1978 to 1998 (Doblhammer and Kytir, 2001).

We conjecture that a positive synergy between improving levels of education, improving nutritional status, better working conditions and better health behaviours (including better management of early impairments) should

improve the functional abilities and performance of essential activities for daily life of future cohorts. We hypothesize there will be a redistribution of the levels of severity of disability. To prove our hypothesis we need to continue the HSE time series as well as distinguishing between and standardizing disability severity levels.

## REFERENCES

- Allaire, S.H., LaValley, M.P., Evans, S.R., *et al* (1999) 'Evidence for decline in disability and improved health among persons aged 55 to 70 years: the Framingham Heart Study', *American Journal of Public Health* 89(11), 1678–1683.
- Alter, G. and Riley, J.C. (1997) 'Sickness, recovery, and Redux: Transitions into and out of sickness in the nineteenth-century Britain', in 10th Work-group meeting REVES, Tokyo, REVES paper 294.
- Anttila, S. (1991) 'Functional capacity in two elderly populations aged 75 or over: comparisons at 10 years' interval', *Journal of Clinical Epidemiology* 44, 1181–1186.
- Aromaa, A., Koskinen, S. and Huttunen, J. (1999) *Health in Finland*. Helsinki: National Public Health Institute.
- Barbi, E., Caselli, G. and Vallin, J. (1999) 'Trajectories of extreme survival in heterogeneous populations', in 11th Work-group meeting REVES, London, REVES paper 326.
- Bebbington, A.C. and Darton, R.A. (1996) *Healthy Life Expectancy in England and Wales: Recent Evidence*. London: PSSRU.
- Bebbington, A. and Wittenberg, R. (1999) 'The implications for long term care finance of trends in healthy life expectancy', in 11th Work-group meeting REVES, London, REVES paper 332.
- Bone, M. (1991) 'Changing disability rates over time in Great Britain', in 4th Work-group meeting REVES, Leiden, REVES paper 55.
- Bone, M.R. (1992) 'International efforts to measure health expectancy', *Journal of Epidemiology and Community Health* 46, 555–558.
- Bone, M.R., Bebbington, A.C., Jagger, C., Morgan, K. and Nicolaas, G. (1995) *Health Expectancy and its Uses*. London: HMSO.
- Boshuizen, H. (1991) 'Trends in health expectancy in the Netherlands in the period 1980–1990; some preliminary results', in 4th Work-group meeting REVES, Leiden, REVES paper 58.
- Brückner, G. (1997) 'Health expectancy in Germany: what do we learn from the reunification process?', in 10th Work-group meeting REVES, Tokyo, REVES paper 290 (NUPRI Research paper series no. 72, February 2001).
- Brunelle, Y. (1991) 'The evolution of recognized disability/L'évolution de l'incapacité reconnue', in 4th Work-group meeting REVES, Leiden, REVES paper 56.
- Brunelle, Y. (1993) 'Understanding changes in the health status', in Robine, J-M., Mathers, C.D., Bone, M.R. and Romieu, I. (eds) *Calculation of Health Expectancies; Harmonization, Consensus Achieved and Future Perspectives (Calcul des espérances de vie en santé: harmonisation, acquis et perspectives)*. Paris: John Libbey Eurotext.
- Cambois, E. and Robine, J-M. (1999) 'Differentials in health expectancy for three socio-professional groups in the French male population, 1980–1991', in 11th Work-group meeting REVES, London, REVES paper 357.

- Cambois, E., Robine, J.-M. and Hayward, M.D. (2001) 'Social inequalities in disability-free life expectancy in the French male population, 1980-1991', *Demography* 38(4), 513-524.
- Chen, K., Tu, J., Chang, M. and Yang, C. (1996) 'Morbidity and chronic disability in an elderly population: Taiwan, 1989-1993', in 9th Work-group meeting REVES, Rome, REVES paper 278.
- Colvez, A. (1992) 'Changes in disability-free life expectancy in the USA between 1966 and 1976', in Robine, J.-M., Blanchet, M. and Dowd, J.E. (eds) *Health Expectancy*. London: HMSO.
- Corder, E.H. and Manton, K.G. (2001) 'Change in prevalence of severe dementia among older Americans: 1982 to 1999', XXIV IUSSP General Population Conference. IUSSP, Salvador.
- Corder, L., Manton, K.G. and Stallard, E. (1992) 'Change in the functional level of the United States population in the 1980s', in 5th Work-group meeting REVES, Ottawa, REVES paper 92.
- Costa, D.L. (2000) 'Understanding the twentieth-century decline in chronic conditions among older men', *Demography* 37(1), 53-72.
- Cousins, C., Jenkins, J. and Laux, R. (1998) 'Disability data from the LFS: comparing 1997-98 with the past', *Labour Market Trends* June, 321-335.
- Crimmins, E.M. (1990) 'Are Americans healthier as well as longer-lived?', *Journal of Insurance Medicine* 22(2), 89-92.
- Crimmins, E.M. (1996) 'Mixed trends in population health among older adults', *Journal of Gerontology: Social Sciences* 51B(5), S223-S225.
- Crimmins, E.M. (1997) 'Trends in mortality, morbidity, and disability: what should we expect for the future of our ageing population', in IUSSP/UIESP (eds) *International Population Conference (Congrès International de la Population)*. Beijing, October 11-17, 1997. Liège: IUSSP/UIESP.
- Crimmins, E.M. and Ingegneri, D.G. (1991) 'Trends in health among the American population' Paper prepared for the Pension Research Council Symposium.
- Crimmins, E.M. and Ingegneri, D.G. (1993) 'Trends in health among the American population', in Rappaport, A. and Schieber, S.J. (eds) *Demography and Retirement: the 21st Century*. Westport, CT; London: Praeger.
- Crimmins, E.M. and Saito, Y. (1993) 'Trends in disability-free life expectancy in the United States, 1970-1990: Gender, racial and socioeconomic differences', Paper prepared for the 1993 IUSSP General Convention in Montreal.
- Crimmins, E.M. and Saito, Y. (1997a) 'Trends in disability-free life expectancy in the United States, 1970-1990: gender, racial, and socio-economic differences', in 10th Work-group meeting REVES, Tokyo, REVES paper 292.
- Crimmins, E.M. and Saito, Y. (1997b) 'Getting better and getting worse: transitions in functional status among older Americans', *Journal of Aging and Health* 5, 3-36.
- Crimmins, E.M. and Saito, Y. (2000) 'Changes in the prevalence of diseases among older Americans: 1984-1994', *Demographic Research* 3; article 9.
- Crimmins, E.M. and Saito, Y. (2001) 'Trends in healthy life expectancy in the United States 1970-1990: gender, racial, and educational differences', *Social Science and Medicine* 52, 1629-1641.
- Crimmins, E.M., Saito, Y. and Ingegneri, D. (1989) 'Changes in life expectancy and disability-free life expectancy in the United States', *Population and Development Review* 15, 235-267.
- Crimmins, E.M., Saito, Y. and Ingegneri, D. (1992a) 'Changes in life expectancy and disability-free life expectancy in the United States', in: Robine, J.-M., Blanchet, M. and Dowd, J.E. (eds) *Health Expectancy*. London: HMSO.

- Crimmins, E.M., Hayward, M.D. and Saito, Y. (1992b) 'The relationship between changing mortality rates, changing morbidity rates and the health status of the population', in 5th Work-group meeting REVES, Ottawa, REVES paper 91.
- Crimmins, E.M., Saito, Y. and Ingegneri, D. (1997a) 'Trends in disability-free life expectancy in the United States, 1970-90', *Population and Development Review* 23, 555-572.
- Crimmins, E.M., Saito, Y. and Reynolds, S.L. (1997b) 'Further evidence on recent trends in prevalence and incidence of disability among older Americans from two sources: the LSOA and the NHIS', *Journal of Gerontology: Social Sciences* 52B(2), S59-S271.
- Crimmins, E.M., Reynolds, S.L. and Saito, Y. (1999) 'Trends in health and ability to work among the older working-age population', *Journal of Gerontology: Social Sciences* 54B(1), S31-S40.
- Crystal, S., Sambamoorthi, U. and Merzel, C. (1993) 'Compression versus expansion of morbidity: modeling the impact of antiviral therapy in HIV disease', in Robine, J.-M., Mathers, C.D., Bone, M.R. and Romieu, I. (eds) *Calculation of Health Expectancies; Harmonization, Consensus Achieved and Future Perspectives (Calcul des espérances de vie en santé: harmonisation, acquis et perspectives)*. Paris: John Libbey Eurotext.
- Davis, P. and Graham, P. (1997) 'Personal communication to REVES'.
- Deeg, D.J.H., Kriegsman, D.M.W. and van Zonneveld, R.J. (1994) 'Trends in fatal chronic diseases and disability in the Netherlands 1956-1993 and projections 1993-1998', in Mathers, C.D., McCallum, J. and Robine J.-M. (eds) *Advances in Health Expectancies*. Canberra: Australian Institute of Health and Welfare, AGPS.
- Deeg, D.J.H., Smit, J.H., Kriegsman, D.M.W. and Van Zonneveld, R.J. (1996) 'Transition in health limitations in the Netherlands: comparison across four decades', in 9th Work-group meeting REVES, Rome, REVES paper 270.
- Doblhammer, G. and Kytir, J. (2001) 'Compression or expansion of morbidity? Trends in healthy-life expectancy in the elderly Austrian population between 1978 and 1998', *Social Science and Medicine* 52, 385-391.
- Fanshel, S. (1972) 'A meaningful measure of health for epidemiology', *International Journal of Epidemiology* 1(4), 319-337.
- Fanshel, S. and Bush, J.W. (1970) 'A health-status index and its application to health-services outcomes', *Operations Research* 18, 1021-1066.
- Ferrucci, L., Izmirlian, G., Leveille, S.G., Phillips, C.L., Corti, M.C., Brock, D.B. and Guralnick, J.M. (1999) 'Smoking, physical activity and active life expectancy', *American Journal of Epidemiology* 149(7), 645-653.
- Freedman, V.A. and Martin, L.G. (1998) 'Understanding trends in functional limitations among older Americans', *American Journal of Public Health* 88(10), 1457-1462.
- Freedman, V.A. and Martin, L.G. (1999) 'The role of education in explaining and forecasting trends in functional limitations among older Americans', *Demography* 36(4), 461-473.
- Freedman, V.A. and Martin, L.G. (2000) 'Contribution of chronic conditions to aggregate changes in old-age functioning', *American Journal of Public Health* 90(11), 1755-1760.
- Freedman, V.A. and Soldo, J.S. (1994) *Trends in Disability at Older Ages*. Washington, DC: National Academy Press.
- Freedman, V.A., Aykan, H. and Martin, L.G. (2001) 'Aggregate changes in severe cognitive impairment among older Americans: 1993 and 1998', *Journal of Gerontology: Social Sciences* 56B(5), S100-S111.

- Fuchs, V.R. (1984) 'Through much is taken: reflections on aging, health and medical care', *Milbank Memorial Fund Quarterly/Health and Society* 62, 143–165.
- Grundy, E. (1997) 'The health and health care of older adults in England and Wales, 1841–1994', in Charlton, J. and Murphy, M. (eds) *The Health of Adult Britain 1841–1994*. London: The Stationery Office (vols 1 and 2).
- Grundy, E., Ahlburg, D., Ali, M., et al (1999) *Disability in Great Britain*. London: HMSO, Department of Social Security (Research Report 94).
- Inoue, T., Shigematsu, T. and Nanjo, Z. (1997) 'Health life tables in Japan, 1990: a quality of the longest life expectancy in the world', *Minzoku Eisei* 63(4), 226–240.
- Jagger, C. and Clarke, M. (1991) 'The changing disability profile of the elderly', in 4th Work-group meeting REVES, Leiden, REVES paper 57.
- Jagger, C., Clarke, M. and Clarke, S.J. (1991) 'Getting older – feeling younger: the changing health profile of the elderly', *International Journal of Epidemiology* 20, 234–238.
- Kelly, S. and Baker, A. (2000) 'Healthy life expectancy in Great Britain, 1980–96, and its use as an indicator in UK Government strategies', in 12th Work-group meeting REVES, Los Angeles, REVES paper 406.
- Koizumi, A. (1994) 'Life expectancy and quality of life in Japan', in Mathers, C.D., McCallum, J. and Robine J.-M. (eds) *Advances in Health Expectancies*. Canberra: Australian Institute of Health and Welfare, AGPS.
- Lalivé d'Épinay, C., Bickel, J.F., Maestre, C., et al (2000) *Vieillesse au fil du temps 1979–1994*. Lausanne: Éditions Réalités sociales.
- Lamb, V.L. (1999) 'The effects of population development on elderly health and disablement', in 11th Work-group meeting REVES, London, REVES paper 346.
- LaRoche, S. and Morin, J.P. (1994) *Étude des variations entre les taux d'incapacité de l'ESLA de 1986 et de 1991*. Ottawa, Canada: Statistique Canada, Division des méthodes d'enquêtes sociales.
- Manton, K.G. (1982) 'Changing concepts of morbidity and mortality in the elderly population', *Milbank Memorial Fund Quarterly/Health and Society* 60, 183–244.
- Manton, K.G. and Gu, X. (2001) 'Changes in the prevalence of chronic disability in the United States black and nonblack population above age 65 from 1982 to 1999', *Proceedings of the National Academy of Sciences USA* 98, 6354–6359.
- Manton, K.G., Corder, L.S. and Stallard, E. (1993a) 'Estimates of change in chronic disability and institutional incidence and prevalence rates in the US elderly population from the 1982, 1984, and 1989 National Long Term Care Survey', *Journal of Gerontology: Social Sciences* 48(4), S153–S166.
- Manton, K.G., Corder, L.S. and Stallard, E. (1993b) 'Changes in the use of personal assistance and special equipment from 1982 to 1989: results from the 1982 and 1989 NLTCS', *The Gerontologist* 33(2), 168–176.
- Manton, K.G., Stallard, E. and Corder, L.S. (1995) 'Changes in morbidity and chronic disability in the US elderly population: Evidence from the 1982, 1984 and 1989 National Long Term Care Survey', *Journal of Gerontology: Social Sciences* 50B(4), S194–S204.
- Manton, K.G., Corder, L.S. and Stallard, E. (1997) 'Chronic disability trends in elderly United States populations: 1982–1994', *Proceedings of the National Academy of Sciences USA* 94, 2593–2598.
- Manton, K.G., Stallard, E. and Corder, L.S. (1998) 'Dynamics of dimensions of age-related disability 1982 to 1994 in the US elderly population', *Journal of Gerontology: Biological Sciences* 53A(1), B59–B70.
- Martel, L. and Bélanger, A. (2000) 'Report on the demographic situation in Canada 1998–1999. An analysis of the change in dependence-free life expectancy in Canada

- between 1986 and 1996', in 12th Work-group meeting REVES, Los Angeles, REVES paper 407.
- Mathers, C.D. (1991a) 'Australian trends in disability-free and handicap-free life expectancy 1981–1988', in 4th Work-group meeting REVES, Leiden, REVES paper 52.
- Mathers, C.D. (1991b) *Health Expectancies in Australia, 1981 and 1988*. Canberra, ACT: Australian Institute of Health Publications.
- Mathers, C.D. (1994) 'Health expectancies in Australia 1993: preliminary results', in Mathers, C.D., McCallum, J. and Robine, J.-M. (eds) *Advances in Health Expectancies*. Canberra: Australian Institute of Health and Welfare, AGPS.
- Mathers, C.D. (1996) 'Trends in health expectancies in Australia 1981–1993', *Journal of the Australian Population Association* 13, 1–15.
- Mathers, C.D. and Jains, S. (1999) 'Trends in health expectancies in Australia 1981–1998 and preliminary results from the Australian burden of disease study', in 11th Work-group meeting, London, REVES paper 339.
- McClellan, M. and Yan, L. (2000) 'Understanding disability trends in the US elderly population: The role of disease management and disease prevention', in 12th Work-group meeting REVES, Los Angeles, REVES paper 404.
- Mesrine, A. (1997) 'Form of the mortality curve at the end of life?', in 10th Work-group meeting REVES, Tokyo, REVES paper 300.
- Mizrahi, A. and Mizrahi, A. (1989) *Évolution de l'état de santé. Risque vital et invalidité*. Paris: CREDES, no. 814.
- Mizrahi, A. and Mizrahi, A. (1993) *Évolution des déficiences et des soins aux personnes âgées en institution, France 1977–1988*. Paris: CREDES, no. 966.
- Mizrahi, A. and Mizrahi, A. (1994) *L'évolution paradoxale de l'état de santé des personnes âgées en France: amélioration du pronostic vital, diminution de l'incapacité et augmentation du nombre de maladies. Conférence 'Economics of Aging'*. Paris: CREDES, no. 1027.
- Myers, G.C. and Elman, C. (1996) 'Patterns of health status in early America: Results from the 1880 US Census', in 9th Work-group meeting REVES, Rome, REVES paper 269.
- Myers, G.C. and Lamb, V.L. (1993) 'Theoretical perspectives on healthy life expectancy', in Robine, J.-M., Mathers, C.D., Bone, M.R. and Romieu, I. (eds) *Calculation of Health Expectancies; Harmonization, Consensus Achieved and Future Perspectives (Calcul des espérances de vie en santé: harmonisation, acquis et perspectives)*. Paris: John Libbey Eurotext.
- Nagi, S.Z. (1976) 'An epidemiology of disability among adults in the United States', *Milbank Memorial Fund Quarterly/Health and Society* 54(4), 439–467.
- Nusselder, W. (1998) *Compression or Expansion of Morbidity: a Life-table Approach*. Amsterdam, the Netherlands: Erasmus University Rotterdam.
- Nusselder, W.J. and Mackenbach, J.P. (1995) 'Rectangularization of the survival curve in the Netherlands in the 1980s: an analysis of underlying causes-of-death: preliminary results', in 8th Work-group meeting REVES, Chicago, REVES paper 237.
- Nusselder, W.J. and Mackenbach, J.P. (2000) 'Lack of improvement of life expectancy at advanced ages in the Netherlands', *International Journal of Epidemiology* 29, 140–148.
- Nusselder, W.J., Looman, C.W.N., Stronks, K. and Mackenbach, J.P. (1996) 'Compression of morbidity: an exploration of the conditions', in 9th Work-group meeting REVES, Rome, REVES paper 268.

- Nusselder, W.J., Looman, C.W.N., Marang van de Mheen, P.J. and Mackenbach, J.P. (1999) 'Smoking and the compression of morbidity', in 11th Work-group meeting REVES, London, REVES paper 347.
- Nusselder, W.J., Looman, C.W.N., Marang van de Mheen, P.J., van de Mheen, H. and Mackenbach, J.P. (2000) 'Smoking elimination produces compression of morbidity', *Journal of Epidemiology and Community Health* 54, 566–574.
- Olshansky, S.J. and Carnes, B.A. (1995) 'Living on manufactured time: health implications of exceeding the biological limit to life', in 8th Work-group meeting REVES, Chicago, REVES paper 235.
- Olshansky, S.J. and Carnes, B.A. (2000) 'Anatomical oddities and design flaws of the human body', in 12th Work-group meeting REVES, Los Angeles, REVES paper 382.
- Olshansky, S.J., Rudberg, M.A., Carnes, B.A., Cassel, C.K. and Brody, J.A. (1991) 'Trading off longer life for worsening health: the expansion of morbidity hypothesis', *Journal of Aging and Health* 3, 194–216.
- Osborn, R. (1992) 'Cohort changes in chronic disease and activity limitation', in 5th Work-group meeting REVES, Ottawa, REVES paper 110.
- Pampalon, R., Choinière, R. and Rochon, M. (2001) 'L'espérance de santé au Québec', in *Enquête québécoise sur les limitations d'activité 1998*. Ste-Foy: Les Publications du Québec.
- Perenboom, R.J.M. and van de Water, H.P.A. (1997) 'Mental health expectancy in the Netherlands, 1989–1995', in 10th Work-group meeting REVES, Tokyo, REVES paper 312.
- Perenboom, R.J.M., Boshuizen, H.C. and van de Water, H.P.A. (1993) 'Trends in health expectancies in the Netherlands, 1981–1990', in Robine, J-M., Mathers, C.D., Bone, M.R. and Romieu, I. (eds) *Calculation of Health Expectancies; Harmonization, Consensus Achieved and Future Perspectives (Calcul des espérances de vie en santé: harmonisation, acquis et perspectives)*. Paris: John Libbey Eurotext.
- Perenboom, R.J.M., Van Herten, L.M. and Mulder, Y.M. (2000) 'Trends in DFLE in the Netherlands: Dynamic Equilibrium', in 12th Work-group meeting REVES, Los Angeles, REVES paper 405.
- Pettersson, H. (1995) 'Trends in health expectancy for socio-economic groups in Sweden', in 8th Work-group meeting REVES, Chicago, REVES paper 214.
- Preston, S.H. (1992) 'Cohort succession and the future of the oldest old', in Suzman, R.M., Willis, D.P. and Manton, K.G. (eds) *The Oldest Old*. New York, Oxford: Oxford University Press.
- Qiao, X. (1997) 'Health expectancy of China', in 10th Work-group meeting REVES, Tokyo, REVES paper 305.
- Reynolds, S.L., Crimmins, E.M. and Saito, Y. (1998) 'Cohort differences in disability and disease presence', *The Gerontologist* 38(5), 578–590.
- Riley, J.C. (1990) 'The risk of being sick: morbidity trends in four countries', *Population and Development Review* 16(3), 403–432.
- Riley, J.C. (1993) 'Active life expectancy during the long mortality decline: the transition from brief to protracted sickness', in Robine, J-M., Mathers, C.D., Bone, M.R. and Romieu, I. (eds) *Calculation of Health Expectancies; Harmonization, Consensus Achieved and Future Perspectives (Calcul des espérances de vie en santé: harmonisation, acquis et perspectives)*. Paris: John Libbey Eurotext.
- Riley, J.C. and Alter, G. (1995) 'How long does wellness or sickness predict future health?', in 8th Work-group meeting REVES, Chicago, REVES paper 239.
- Robine, J-M. (1986) *Disability-free life expectancy (DFLE) indicators: General indicators of the health of population*. Québec: Conseil des Affaires Sociales et de la Famille (Scientific Report).

- Robine, J-M. (1991) 'Changes in health conditions over time', in 4th Work-group meeting REVES, Leiden, REVES paper 60.
- Robine, J-M. (1992) 'Disability-free life expectancy', in Robine, J-M., Blanchet, M. and Dowd, J.E. (eds) *Health Expectancy*. London: HMSO.
- Robine, J-M. (1994) 'Disability-free life expectancy trends in France 1981–1991, international comparison', in Mathers, C.D., McCallum, J. and Robine J-M. (eds) *Advances in Health Expectancies*. Canberra: Australian Institute of Health and Welfare, AGPS.
- Robine, J-M. (2000) 'Can we expect to live both a longer and a healthier life?', in Jávör, A., van Eimeren, W. and Duru, G. (eds) *System Science in Health Care*. Budapest: ISSSHC.
- Robine, J-M. and Mathers, C.D. (1993) 'Measuring the compression or expansion of morbidity through changes in health expectancy', in Robine, J-M., Mathers, C.D., Bone, M.R. and Romieu, I. (eds) *Calculation of Health Expectancies; Harmonization, Consensus Achieved and Future Perspectives (Calcul des espérances de vie en santé: harmonisation, acquis et perspectives)*. Paris: John Libbey Eurotext.
- Robine, J-M. and Mormiche, P. (1994) 'Estimation de la valeur de l'espérance de vie sans incapacité en France en 1991', *Solidarité Santé* (1), 17–36.
- Robine, J-M. and Romieu, I. (1998) *Healthy Active Ageing: health expectancies at age 65 in the different parts of the world*. Montpellier: REVES/INSERM, REVES paper 318.
- Robine, J-M., Bucquet, D. and Ritchie, K. (1991) 'L'espérance de vie sans incapacité, un indicateur de l'évolution des conditions de santé au cours du temps; vingt ans de recul', *Cahiers Québécois Démographie* 20, 205–235.
- Robine, J-M., Mathers, C. and Brouard, N. (1996a) 'Trends and differentials in disability-free life expectancy: concepts, methods and findings', in Caselli, G. and Lopez, A. (eds) *Health and Mortality among the Elderly Populations*. Oxford: Clarendon Press.
- Robine, J-M., Mormiche, P. and Cambois, E. (1996b) 'Evolution des courbes de survie totale, sans maladie chronique et sans incapacité en France de 1981 à 1991: application d'un modèle de l'OMS', *Annales de Démographie Historique*, 99–115.
- Robine, J-M., Mormiche, P. and Sermet, C. (1998) 'Examination of the causes and mechanisms of the increase in disability-free life expectancy', *Journal of Aging and Health* 10(2), 171–191.
- Robine, J-M., Romieu, I. and Cambois, E. (1999) 'Health expectancy indicators', *Bulletin of the World Health Organization* 77, 181–185.
- Roos, N.P., Havens, B. and Black, C. (1993) 'Living longer but doing worse: assessing health status in elderly persons at two points in time in Manitoba, Canada', *Social Science and Medicine* 36, 273–282.
- Saito, Y. (2001) 'The changes in the level of disability in Japan: 1992–1998', in XXIV IUSSP General Population Conference. IUSSP, Salvador, August 2001.
- Sanders, B.S. (1964) 'Measuring community health levels', *American Journal of Public Health* 54(7), 1063–1070.
- Saucier, A. and Lafontaine, P. (2001) 'Prévalence et gravité de l'incapacité dans la population québécoise', in *Enquête québécoise sur les limitations d'activité 1998*. Ste-Foy: Les Publications du Québec.
- Sauvaget, C., Tsuji, I., Haan, M.N. and Hisamichi, S. (1997) 'Trends in dementia-free life expectancy among the elderly in the United States of America', in 10th Work-group meeting REVES, Tokyo, REVES paper 311.



- Schoeni, R.F., Freedman, V.A. and Wallace, R.B. (2001) 'Persistent, consistent, widespread, and robust? Another look at recent trends in old-age disability', *Journal of Gerontology: Social Sciences* 56B(4), S206–S218.
- Sihvonen, A.P. (1994) *Suomalaisten toimintakykyiset elinvuodet. Metodinen tarkastelu ja mittaaminen (Health expectancy in Finland. Methodological considerations and measurement)*. Helsinki: STAKES (Report no. 148).
- Sihvonen, A.P., Lahelma, E. and Valkonen, T. (1996) 'Changes in the educational pattern in health expectancy from 1986 to 1994 in Finland', in 9th Work-group meeting REVES, Rome, REVES paper 264.
- Smith, L. (1994) 'Reflections on the next stage of the epidemiological transition', in Mathers, C.D., McCallum, J. and Robine, J-M. (eds) *Advances in Health Expectancies*. Canberra: Australian Institute of Health and Welfare, AGPS.
- Spiers, N., Jagger, C. and Clarke, M. (1996) 'Physical function and perceived health: Cohort differences and interrelationships in older people', *Journal of Gerontology: Social Sciences* 51B(5), S226–S233.
- Sullivan, D.F. (1971) 'A single index of mortality and morbidity', *HSMHA Health Reports* 86, 347–354.
- Svanborg, A. (1988) 'Cohort differences in the Göteborg studies of Swedish 70-year olds', in Brody, J.A. and Maddox, G.L. (eds) *Epidemiology and Aging*. Berlin: Springer.
- Tartarin, R. and Bouget, D. (1994) 'Une allocation dépendance: simulation et projections', *Retraite et Société* No. Spécial.
- Tu, E.J.C. and Chen, K. (1992) 'Changes in active life expectancy in Taiwan: compression or expansion?', in 5th Work-group meeting REVES, Ottawa, REVES paper 104.
- Tu, E.J.C. and Chen, K. (1994) 'Recent changes in active life expectancy in Taiwan', in Mathers, C.D., McCallum, J. and Robine, J-M. (eds) *Advances in Health Expectancies*. Canberra: Australian Institute of Health and Welfare, AGPS.
- Tu, E.J.C. and Chen, K. (1995) 'Recent changes in healthy life expectancy and their implications for medical costs in Taiwan', in 8th Work-group meeting REVES, Chicago, REVES paper 201.
- Tu, E.J.C., Chen, K. and Chang, M.C. (1997) 'Changes in morbidity and chronic disability in an elderly population: Taiwan, 1989–1993', in 10th Work-group meeting REVES, Tokyo, REVES paper 307.
- van de Water, H.P.A. (1991) 'Health expectancy and change over time: Compression or Pandemia', in 4th Work-group meeting REVES, Leiden, REVES paper 54.
- Verbrugge, L.M. (1984) 'Longer life but worsening health? Trends in health and mortality of middle-aged and older persons', *Milbank Memorial Fund Quarterly/Health and Society* 62(3), 475–519.
- Verbrugge, L.M. (1989) 'Recent, present, and future health of American adults', *Annual Reviews in Public Health* 10, 333–361.
- Vita, A.J., Terry, R.B., Hubert, H.B. and Fries, J.F. (1998) 'Aging, health risks, and cumulative disability', *New England Journal of Medicine* 338, 1035–1041.
- Waidmann, T.A. and Liu, K. (2000) 'Disability trends among elderly persons and implications for the future', *Journal of Gerontology: Social Sciences* 55B(5), S298–S307.
- Waidmann, T. and Manton, K.G. (1998) *International Evidence on Disability Trends among the Elderly*. Washington, DC: US Dept of Health and Human Services, Office of Disability, Aging, and Long-Term Care Policy.
- Waidmann, T., Bound, J. and Schoenbaum, M. (1995) 'The illusion of failure: trends in self-reported health of the US elderly', *The Milbank Quarterly* 73(2), 253–287.

- Wilkins, R. and Adams, O.B. (1992) 'Health expectancy trends in Canada, 1951–1986', in Robine, J-M., Blanchet, M. and Dowd, J.E. (eds) *Health Expectancy*. London: HMSO.
- Wilkins, R. and Chen, J. (1995) 'Measures of health expectancy based on physical independence handicap: demographic, regional and social dimensions for Canada in 1986 and 1991', in 8th Work-group meeting REVES, Chicago, REVES paper 209.
- Wilkins, R., Chen, J. and Ng, E. (1994) 'Changes in health expectancy in Canada from 1986 to 1991', in Mathers, C.D., McCallum, J. and Robine, J-M. (eds) *Advances in Health Expectancies*. Canberra: Australian Institute of Health and Welfare, AGPS.
- Winblad, I. (1993) 'Comparison of the prevalence of disability in two birth cohorts at the age of 75 years and older', *Journal of Clinical Epidemiology* 46(3), 303–308.
- World Health Organization (1980) *International Classification of Impairments, Disabilities, and Handicaps: A manual of classification relating to the consequences of disease*. Geneva: WHO.
- World Health Organization (1984) *The Uses of Epidemiology in the Study of the Elderly: Report of a WHO scientific group on the epidemiology of aging*. Geneva: WHO (Technical Report Series 706).
- World Health Organization (2001) *ICIDH-2: International Classification of Functioning, Disability and Health: Full version*. Geneva: WHO.