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Future Trends in Morbidity and Mortality in Europe

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Contents

1 Introduction 1
2 Future Trends in Morbidity in Europe 3
2.1 ... Association between mortality and morbidity 3
2.2 ... Future trends in disability 5
3 Future trends in mortality 10
3.1 ... Limits to life expectancy 12
3.2 ... No limits to life expectancy 14
4 Conclusion 18
References 19

1 Introduction

A lot of research has been performed on past and present trends in morbidity and mortality that are well established. Different concepts and measures have been used to determine trends and underlying structures.

It is generally known that life expectancy has been increasing since decades. First this was due to reduced mortality at young ages. Later the pattern of mortality has changed. At present time, reduced mortality at high ages has an important impact on the increase of life expectancy. The question arises how the additional years will be spent: healthy or disabled. Concerning disability in the last two to three decades downward trends have been observed in several developed countries. However, there are differences in the trends of disability by the level of severity.

Main causes of the decrease in disability and the increase in life expectancy are the strong medical progress that we experienced since the beginning of the 20th century as well as changed health behaviors. Therefore, scientists are asking what the development will bring in the future. Will the severity of disability decline as well as the number of people who suffering? Will be possible to further postpone the onset of disabilities to higher ages? Will the pattern of mortality change further under the impact of medical, biological, and technological progress in the future? Is it possible that life expectancy will increase in the same amount as it did in the 20th century?

These are necessary questions. The answers to these questions have to be carefully given because they have a strong impact on Social security and political decisions.

However, nobody is able to give exact answers concerning the future. Therefore, scientists have to answer questions on the basis of observed trends and theoretical concepts.

In the following report projections on the future trends in disability for different countries are introduced. Information on future trends is given by either projected numbers of the disabled populations or by estimated life expectancy in health or disability. Since scarce literature exists on projections of future trends in disability in Europe the work is not only restricted to trends in Europe but also includes information for other developed countries.

The second part of the report concentrates on future trends in mortality. Since it is possible to determine future mortality from different perspectives different opinions

how mortality will further decline and life expectancy will increase exist. There are scientists who claim that there is a fixed limit to life expectancy. On the other side scientist insist that there is no limit in sight and life expectancy will increase at the same pace as before. These different sides are introduced in the second part.

2 Future Trends in Morbidity in Europe

Trends in morbidity are linked to trends in mortality and to the progress of medicine and biotechnology that can prevent from disabling diseases or postpone the onset of these into the last time of life.

In the first report on trends in morbidity the focus was set on past and present trends in disability (Muth et al. 2006). There, trends in functional limitation, mild, moderate, and severe disability, in sensory limitation, and in total disability have been reported for industrialized countries.

Functional limitation tends to show deteriorated trends for the 1980s and 1990s for both sexes. The results on mild disability and IADL disability did not show clear trends. While there are several studies observing an improved situation in the USA, France, Japan, and Denmark, other studies observed worsening trends for France, The Netherlands, and Sweden.

Considering moderate disability too few studies exist to talk about common trends. Recent studies on ADL disability, which reflects severe limitation, suggest no clear trend for the USA, but a worsening for The Netherlands and Finland. Severe disability can be also measured as a combination of ADL and IADL. Results suggest that there is a declining trend of severe disability. The results for total disability are clear. They indicate declining disability.

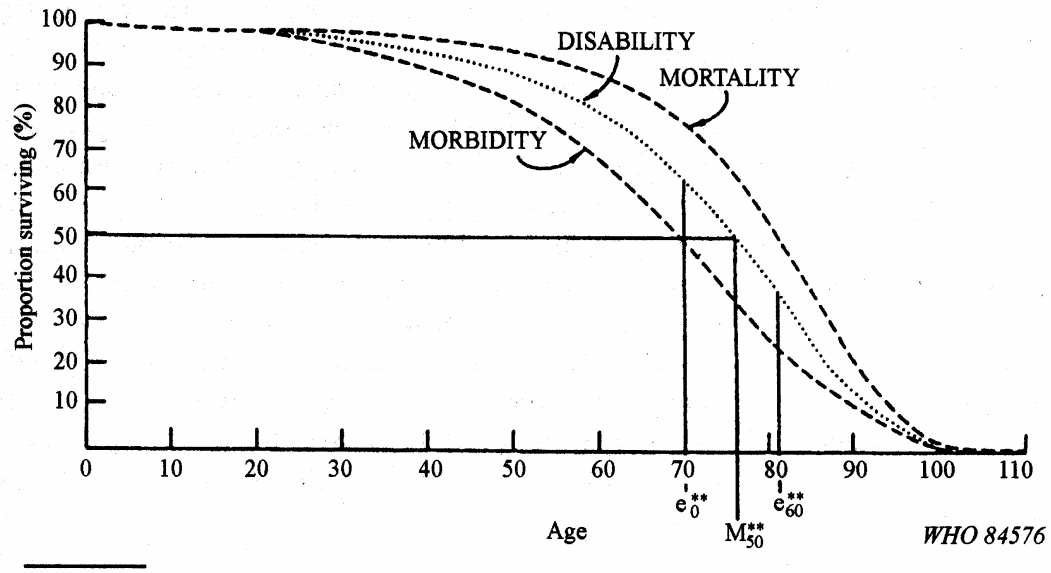
In a total overview, studies suggest that severe and total disability have been declining since the 1980s. However, for less severe disability no clear trends were observed for industrialized countries.

2.1 Association between mortality and morbidity

Regarding the medical progress and the increased life expectancy scientists ask whether declined mortality leads to additional years of health or additional years of disability. Concerning this, there are three different well known opinions on the association between mortality and morbidity. They are known as (1) the *compression of morbidity hypotheses*, introduced in 1980 by Fries, (2) *the expansion of morbidity hypotheses*, introduced by Gruenberg (1977), Olshansky (1991) and others, and (3) the *dynamic equilibrium hypotheses*, introduced by Manton (1982).(Doblhammer and Kytir 2001)

The hypotheses can be understood easier with the help of the curves depicted in Figure 1. There the survival curves of mortality (observed for females in the United States), morbidity and disability (both hypothetical) are shown.

Due to the fact that in general morbidity occurs first the area under the morbidity curve is the smallest (see Figure 1). Disability occurs after morbidity and has a slightly bigger area under the curve. The mortality curve is the one that is situated at the right side of both morbidity and disability curve. The hypotheses explained below consider the size of the area between the morbidity or disability curve and the mortality curve which can increase or decrease in dependence of the pace with which the curves are moving or remain as they are.



e_0^{**} and e_{60}^{**} are the number of years of autonomous life expected at birth and at age 60, respectively.
M_{50}^{**} is the age to which 50% of females could expect to survive without loss of autonomy.

Figure 1: Observed mortality and hypothetical morbidity and disability survival curves for females in the United States. From World Health Organization (1984).
Source: Nusselder (2002)

The hypotheses of compression of morbidity is based on the assumption raised by Fries (1980) that there is a fixed limit to life expectancy at age 85. He states that the onset of diseases and disability can be postponed to higher age by social and scientific progress which as well includes medical intervention and change of lifestyle. With the existence of a fixed limit of life expectancy this would lead to a compression of morbidity and disability into the last years. Referring to Figure 1 due to an increasing age of onset of diseases and disability the curves of morbidity and disability are

shifting right against the fixed mortality curve (Nusselder 2002). Therefore, the life time with morbidity or disability is compressed into the last years of life.

The hypothesis of expansion of morbidity is the opposite of the compression hypothesis. It states that the progress in medical technology has led to an increased survival of people with disabling conditions. The onset of fatal diseases can be postponed, however, there were no advances to postpone or prevent the onset of nonfatal diseases. Therefore, although there is mortality decline from fatal diseases which increased the life expectancy, the life time with disabling nonfatal diseases is prolonged. In terms of survival curves: the mortality survival curve shifts to the right, but the morbidity and disability curves remain at their place or possibly shift right, but at a slower pace (Gruenberg 1977; Olshansky et al. 1991).

The third hypotheses of a dynamic equilibrium between morbidity and mortality was introduced by Manton et al. (1982). It is assumed that the increase in life expectancy is accompanied by a parallel increase of the proportion of life expectancy in health and life expectancy in disability. Medical progress and intervention results (1) in the elimination of fatal diseases but does not affect the progress of non fatal diseases and results (2) in reduced severity of diseases and therefore, in their longer duration (Manton 1982).

2.2 Future trends in disability

Although this report is required to give information on future trends in morbidity in Europe it is hardly possible to find studies that focus on disability trends in Europe. In general, only few articles exist that have projected disability into the future or give hints on the future progress. Most projections and forecasts on disability were performed for the United States. Therefore, the focus of this report will not only be on European countries, but also on the USA.

For Germany it was projected that the level of disability and the disabled population will increase significantly until 2050. Considering the period 1999-2020 the growth rate of the disabled population will be 2%. The rate will fall to 1.6% in the period 2020-2050. As a result the disabled population will increase to 4.73 million people in 2050 which is 145% of the disabled population in 1999. It was predicted that in the future there will be a shift of the disabled population to older ages. The share of 80 year old persons will increase from 49% in 1999 to 62% in 2020. After 2020 the shift in the age structure will be even more serious.

In the German care system three levels of disability are distinguished. The lowest level reflects people with considerable disability; the medium level those with serious disability; the highest level those with most serious disability. It was projected that the highest increase of disability will appear at the medium level for serious disabled persons. However, the share of most seriously disabled persons will stagnate (Schulz et al. 2001). To conclude: the number of disabled persons and also the level of disability will increase. In an earlier study an increase of 55% of the share of disabled persons in Germany was predicted for the period 1993-2040 (Schneekloth 1996).

Within a European project about "Future Elderly LIving Conditions In Europe" (FELICIE, funded by the European Commission, under the 5th Framework) the care need among the population aged 75+ by family status for nine European countries (Belgium, the Czech Republic, Finland, France, Germany, Italy, the Netherlands, Portugal and the United Kingdom) is projected until 2030 (Doblhammer and Ziegler 2006). Two scenarios are projected: in the Constant Disability Share (CDS) Scenario the gain in life expectancy results in a proportional growth of years spent disabled. The Healthy Life Gain (HLG) Scenario assumes that all added years in life expectancy are healthy years. The years spent in disability will therefore stay constant.

In both scenarios, for both males and females, and for all countries a marked increase in the number of severely disabled persons until 2030 is projected. The increase in the number of disabled persons is much larger for men than for women. In the CDS scenario the increase of males in need of care is between about 100% (United Kingdom, Belgium) and 150% (Czech Republic, Netherlands), indicating that in all countries (except Portugal where the increase is only about 50%; and Finland where it is high with about 180%) the number of males in need of care will at least double if prevalences in disability remain constant. For females the increase will be between 40% in Germany and 80% in the Netherlands.

The real increase will be somewhere between the CDS and HLG scenario. Marriage and higher education are confirmed to have a positive influence on health. They assume that a growing proportion of these groups in the population combined with medical progress will lead to an increase of elderly in need of care that is less than parallel to the increase of the total elderly population.

In a review of life expectancy and disability-free as well as severe-disability-free life expectancy for eight countries (USA, UK, Finland, Australia, France, New

Zealand, Germany, Canada) Robine et al. (2002) note that parallel to the increase of life expectancy the severe-disability-free life expectancy was also increasing over a period between 1970 and 1995. However, the disability-free life expectancy was almost stagnating. Considering this, it was concluded that the gain in life expectancy might be years with less severe disability (Robine et al. 2002). Regarding the expectation of an increasing level of education of the future elderly populations past trends give evidence to expect that future gains in life expectancy will be gains in disability-free life expectancy. This is explained by the fact that higher educational level might be accompanied with better health behaviors and therefore leading to less disability. Hence, it is expected that there will be a compression of disability in the near future.

In 2000 projections of disability were performed for the OECD countries (Australia, Canada, France, Germany, Japan, The Netherlands, Sweden, the UK, and the USA). There a dynamic approach and static approach was used. The dynamic approach projects past trends in institutionalization and disability into the future. In the static approach the institutionalization and disability rates are kept constant. The base year for all countries is in general 1995 and trends are projected to 2000, 2010 and 2020 (Jacobzone et al. 2000).

The projections with the static approach reflect the pure demographic effects. The projection shows strong increases in institutionalization for those countries who are expecting a strong increase of the very old population. It is especially high in the groups of people aged 80+. Strongest increases are expected for Japan and Canada. The population of disabled older persons in households is – with the static approach – for all countries projected to increase as well as the population of all disabled older persons in households and institutions. Japan, Canada, and Australia will experience the highest growth rates until 2020. The growth rates are projected to be lowest in the United Kingdom and Sweden. The total prevalence of disabled persons is projected to decrease until 2020 in Australia, the Netherlands, Sweden, and slightly in Canada and the United Kingdom. The results of the dynamic approach predict for all OECD countries a decreasing prevalence of disabled persons until 2020 (except for the Netherlands, no results are available), with the strongest decrease in Sweden and Canada. For all countries the decreasing prevalence of disabled persons is explained by the fact of health gains and the strong increase of the population aged 65+.

Waidmann and Liu (2000) projected the older disabled population for the period 1995-2040 for the United States on the basis of disability prevalence trends between 1992 and 1996 drawn from data of the Medicare Current Beneficiary Survey (MCBS). They used three approaches. In the first one it was assumed that the observed prevalence rates remain constant into the future. Results show that the population of the elderly will increase enormously. This applies for all levels of disability (ADL, IADL, physical disability, and institutionalization). In the second approach it was assumed that the changes in disability prevalence will continue indefinitely. Their results show a downward trend in IADL and ADL disability and it was concluded that these trends could offset the negative effect of the large increase of the elderly population on the Medicare expenditures. In the third approach the assumption is that the prevalence rates in the subgroups will remain constant, however, with a compositional shift in the population. Results are similar to those of the first approach (Waidmann and Liu 2000). Results show that the predicted future trends in disability are dependent on the assumptions. However, the authors conclude that the trend toward a more educated elderly population might have an impact on disability declines and on the size of the disabled older population.

In a recent study Manton et al. (2006) projected life expectancy and healthy life expectancy for the United States on the basis of three data sources (data of Civil War Union Army veterans, National Long Term Care Survey – NLTCS - , National Center for Health Statistics – NCHS). Projections were performed for the period 2015-2080. Two scenarios were used: (1) assumption of a continuation of the observed disability decline of 1.7% per year between 1982 and 1999 until 2022, for the period 2022 to 2080 an annual disability decline of 0.8% is assumed; (2) disability decline of 0.8% per year beginning in 1999. With these two scenarios, increasing life expectancies as well as increasing active life expectancies and decreasing disabled years have been calculated for the ages 65 and 85. This might be evidence for a compression of disability in the future. The projected decline of disability in the United States is based on the expectation that there will be further improvements in therapy, educational level, general public health and nutrition. Additionally it is expected that the further decline after 2025 will be due to new biomedical and technological innovations.

Generally, projections of future trends in disability in developed countries show positive results. It is mostly expected that disability and the life time with disability will decrease further.

3 Future trends in mortality

For predicting the future of mortality it is necessary to know the past and the present trends of mortality. In a recent report mortality trends as well as mortality differences between European countries and for several risk factors have been reported. For further details see Muth et al. (2006).

Infant and child mortality has been decreasing sharply due to the reduction of infectious diseases especially in the first part of the 20th century. This was achieved through advances in income, salubrity, nutrition, education, sanitation, and medicine (Riley 2001). Until the mid of this century infant mortality fell to 2-3% of births, compared to 20-30% in former times (Wilmoth 2000). The remarkable increase of life expectancy was due to this strong mortality reduction. Next to infant and child mortality also maternal mortality was reduced enormously and had an impact on the increased life expectancy (Olshansky and Carnes 1994). Since the mid of the 19th century life expectancy has increased in developed countries from 45.7 years in 1850 to 80.7 years in 2000 (Bongaarts and Feeney 2002). The examination of mortality records from 1850 to 2000 for five high income countries together in one database (Denmark, England and Wales, Netherlands, Norway, and Sweden) revealed that the reduced mortality at younger ages had an impact of 17.5 years on this increase (Bongaarts and Feeney 2002).

Since 1950, the reduction of mortality has changed its character, however, it has not slowed down (Wilmoth 2000). There was a shift of mortality reduction from younger to older ages due to the reduction of chronic degenerative diseases (Wilmoth 2000; Vallin and Meslé 2001), which can be called “aging of mortality decline” (Wilmoth 1997). Especially since the 1970s an acceleration of the decline of death rates at older ages has occurred (Kannisto et al. 1994; Vaupel 1997). A consequence of the reduction of old age mortality is the increased survival to older age. This drags behind an increase of the population of very old people reaching age 80, 90, and even 100 and higher. In several countries the developments of populations of centenarians (people who reach their 100th birthday) have been observed. For example in Switzerland the number of persons aged 100 and more increased from 10 in 1860 to 796 in the census year 2000. This is an multiplication by 80 in 140 years (Robine and Paccaud 2005).

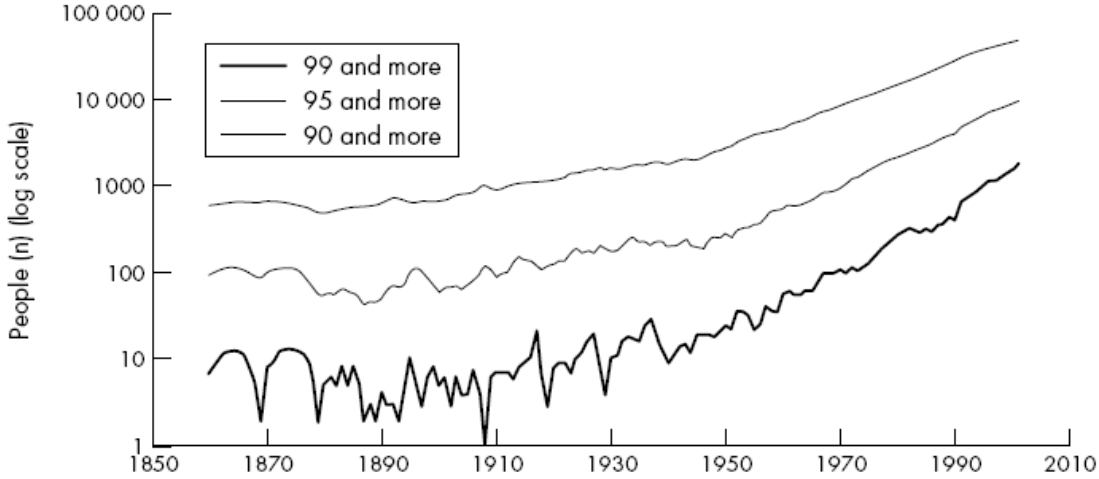


Figure 2: Development of the 90+, 95+ and 99+ year old population of Switzerland, 1850-2010.

Source: Robine and Paccaud (2005)

Figure 2 depicts the development of the number of people age 90 and more, 95 and more, and 99 and more for Switzerland.

Robine and Vaupel (2002) state that the number of new cases of supercentenarians included in the International Database on Longevity (IDL) (including Belgium, Denmark, England and Wales, Finland, France, Japan, The Netherlands, Norway, and Sweden) have increased exponentially from the mid-1970s. A very special case is the development of the number of people aged 105 in Japan. It appeared that this number increased from 11 cases in 1963 to 582 in 2001, which means a multiplication by 53 in only 37 years (Robine and Saito 2003). Even here the increase is exponential.

With the increase of the number of centenarians also the maximum age at death has been increasing remarkably. Both, the increase of the number of centenarians and the increase of the maximum age at death, are due to the increase of births one century ago and the substantial decline of infant and child mortality. The most important factor that had an influence on these increases has been the decline in mortality after age 80 (Vaupel and Jeune 1995). For Sweden, Wilmoth et al. (2000) found that after 1969, the decline of mortality after age 70 contributed with 95% to the rise of the maximum age at death. Today, the ever known and validated highest age at death is 122. The French women Mme Jeanne Calment reached this age in 1997. If she is considered as outlier the highest age would be 117 years in the case of the Canadian woman Marie Louise Meilleur, who died in 1998 (Robine and Vaupel 2002). The

oldest man whose age was verified was Christian Mortensen who died at age 115 in 1998 (Wilmoth 2000).

In Germany, life expectancy for women rose from 38.45 in 1871/81 to 81.78 years in 2003/05 (Statistisches Bundesamt 2006). The highest life expectancy today is held by Japanese women with 84,6 years in 2000 (Robine and Saito 2003). In Europe French women have the highest life expectancy with about 82 years for the same year (Vallin and Meslé 2001).

To which age the life expectancy will increase further is uncertain. However, this is a question demographers are interested in. There are different opinions how the future of mortality and of the increase of life expectancy will look like. There are pessimistic and optimistic views. The pessimistic views do assume that there is a limit to life expectancy at about 85 years. The optimistic views assume that there is no limit.

3.1 Limits to life expectancy

In 1980 Fries (1980) stated that the length of life is fixed at a natural limit of 85 years of life expectancy. He has based this limit on the extrapolation of life expectancies of the US population at different ages which intersect at about age 85. This will occur in 2045. Further, the statement that there is a fixed limit, is based on biologic discoveries, i.e. the organisms has an organ reserve to restore internal homeostasis in case of an external disturbance. With increasing age the organ reserve and the ability to restore homeostasis declines. The final result is natural death. Wilmoth (1997) concluded that the maximum life expectancy corresponds to Fries' "ideally 'rectangular' survival curve" and thus to a limited mortality distribution (Wilmoth 1997, p.53).

Regarding the methodology Fries has applied to determine the natural limit of life expectancy, Manton et al. (1991) argued that the age of intersection is influenced by the ages for which life expectancy changes are extrapolated and the time period the extrapolation is based on. Depending on age and period of extrapolation Manton et al. (1991) calculated limits between 95.3 and 96.8 years.

There is another view on the future of mortality that does not assume that life expectancy will exceed age 85 in the near future. Olshansky's opinion about the future of life expectancy is not based on biological explanations. It is based on the

possible and plausible reductions of mortality rates at every age that can be reached by medical and technological progress and by intervention to health behavior. It is argued that for an increase of life expectancy to 85 years in the United States females' total mortality death rates at the level of 1995 need to be reduced by 50% at every age, for French women a reduction of 26% and for Japanese women of 20% would be required. To further increase life expectancy to age 100 reductions of 85% would be necessary. However, this is judged to be unrealistic to realize. Olshansky et al. (2001) argue that due to the fact of entropy in the life table small gains in life expectancy need larger reductions in mortality (Olshansky et al. 1990). Therefore, future gains will appear at a slower pace. For significant gains a large progress in developments of biomedical sciences in order to treat diseases and disorders of aging is necessary. However, "life-extending technology that might lead to much higher life expectancies does not yet exist and, should it be developed, must be widely implemented before it would influence statistics on population level" (Olshansky et al. 2005). If trends in mortality observed from 1985 to 1995 will continue it is predicted that life expectancy of 85 can be reached earliest in 2033 in France, 2035 in Japan and 2182 in the United States (Olshansky et al. 2001).

In a recent study Olshansky et al. (2005) bring a new direction into the discussion of the future trend in life expectancy in the USA. This is based on the consideration of the future trends in obesity. The fact that the prevalence of obesity has been rising over the last two decades to 28% of men, 34% of women and nearly 50% of non-Hispanic black women today leads to doubts that the trend of increasing life expectancy might not be negatively effected in the future. Obesity is a risk factor for the development of several diseases, e.g. type 2 diabetes, coronary heart disease, cancer and others (Olshansky et al. 2005). Therefore, the authors expect that life expectancy at birth and at older ages could level off or even decline within the first half of this century. This aspect leads to the conclusion that an approaching of the proposed biological limit of 85 years for the USA is possibly not in sight.

Bonneux et al. (1998) projected the mortality decline between 1950-54 and 1985-89 for Dutch women. Assuming the mortality decline will continue like in this period, Dutch women will reach the life expectancy of 85 years in 2020-24. However, the authors argue that this approach ignores processes in the most recent period which is a leveling off of mortality decline. Assuming the mortality decline between 1985 and

1994 will continue in the future it does not seem that women can reach a life expectancy of more than 85 years because it would take nearly 100 years to reach 85.

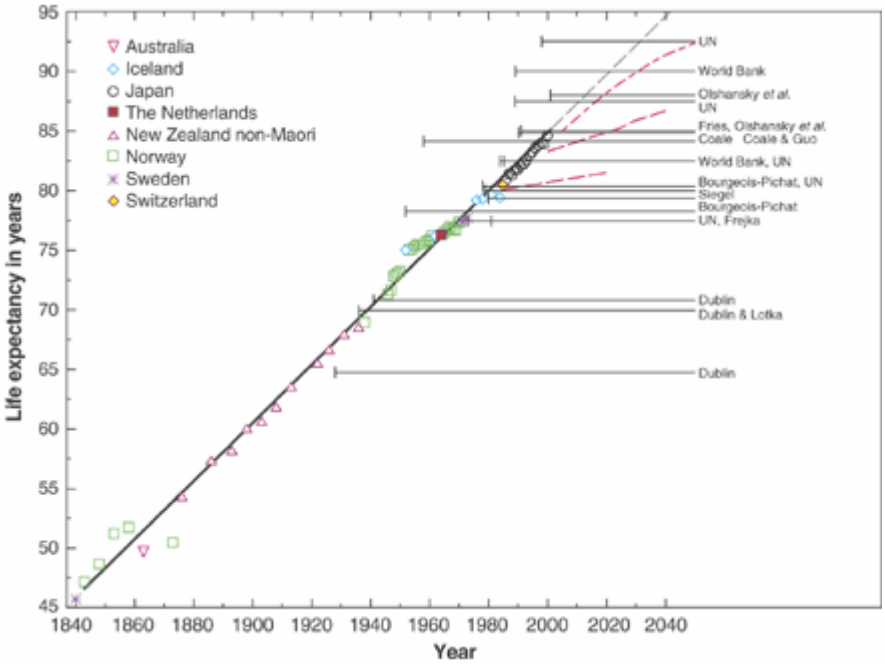
3.2 No limits to life expectancy

A controversial opinion is represented by Vaupel (1997). He argues that there is no limit of mortality at older ages. Due to the widely spread opinion that there is a limit of life expectancy Vaupel notes that forecasts of the growth of elderly populations are too low. With reliable data from Northern European countries (Denmark, Finland, Norway and Sweden) he proves that the large absolute reductions in morality among centenarians and nonagenarians are in sharp contrast to the opinion of an existing mortality limit. He states that if there was an approaching to a biological limit the mortality improvements in low mortality countries would be expected to slow down. However, it was found that there is no correlation between levels of mortality and rates of mortality improvements (Vaupel 1997; Wilmoth 1997).

Table 1: Selection of estimates of maximum life expectancy for females and males or females only (Altered according to Oeppen and Vaupel 2002)

Source	Limit*	Date published	Date exceeded	Exceeded by females in
Dublin	64.8	1928	1921	New Zealand
Dublin and Lotka	69.9	1936	1941	Iceland
Dublin	70.8	1941	1946	Norway
Bourgeois-Pichat	78.2	1952	1974	Iceland
Coale	84.2	1955	2000	Japan
United Nations	77.5	1973	1972	Sweden
Bourgeois-Pichat	80.3	1978	1980	Iceland
United Nations	80	1979	1976	Iceland
Siegel	79.4	1980	1976	Iceland
Frejka	77.5	1981	1972	Sweden
World Bank	82.5	1984	1993	Japan
United Nations	82.5	1985	1993	Japan
United Nations	87.5	1989		
World Bank	90	1989		
Fries	85.0*	1990	1985	Japan
Olshansky *et al*.	85.0*	1990	1996	Japan
Coale and Guo	84.9	1991		
United Nations	92.5	1998		
Olshansky *et al*.	88	2001		

Source: Oeppen and Vaupel 2002



Source: Oeppen and Vaupel 2002

Figure 3: Record female life expectancy from 1840 to the present.
The linear-regression trend is depicted by a bold black line and the extrapolated trend by a dashed gray line. The horizontal black lines show asserted ceilings on life expectancy, with a short vertical line indication the year of publication. The dashed red lines denote projections of female life expectancy in Japan published by the United Nations in 1986, 1999, and 2001 (Oeppen and Vaupel 2002)

Oeppen and Vaupel (2002) observed that the females best practice life expectancy was linearly increasing from about 45 years in Sweden in 1840 to almost 85 years in Japan today. This is an increase of 40 years of life expectancy in 160 years. In months this means a yearly increase of 3 months. As well the male best practice life expectancy increased linearly, however, at a lower level. The authors conclude that the trajectories of life expectancy do not seem to approach a maximum. They suggest that the linear increase should seem “as a regular stream of continuing progress”.

It was observed that between 1928 and 1990 the projected limits of life expectancy in general have been broken after 5 years (see Table 1 and Figure 3). Further, there is no evidence of approaching a maximum since the increase of life expectancy is not slowing down but is increasing (Oeppen and Vaupel 2002). The authors suggest that a life expectancy of 100 years can be reached in the 2060s.

For the United States it is conceivable that if the recorded life expectancy continues to increase females life expectancy could reach 92.5 to 101.5 years in 2070.

The optimistic view of Vaupel and colleagues is explained by the fact that they expect a further progress in prevention, diagnosis, and treatment of diseases that surely lead to dead (Vaupel and Kistowski 2005). It is possible that genetic and

medical research will constantly become more important in influencing human longevity (Kinsella 2005).

With a different approach a life expectancy up to 100 years for the year 2050 for the United States was already predicted in the mid-1990s (Manton et al. 1994). Manton and colleagues (1991) determined a limit to life expectancy by using risk factor levels that reflect "optimal control" (Manton et al. 1991, p.624). Using multiple risk factor data from the Framingham Massachusetts Heart Study and assuming "optimal control" of risk factors Manton et al. (1994) projected that behavioral and lifestyle changes could increase life expectancy in the US population to 95 to 100 years in 2050 to 2060 (Manton et al. 1991; Manton et al. 1994). These findings are consistent with life expectancy limits suggested for populations that are assumed to have "good" health behavior. Also the estimations from the multivariate model of functional disability produced similar results. Concerning this Manton et al. (1991) state optimistically that the increase of life expectancy might be associated with improvements in the health and functioning of the older population. There possibly exists an equilibrium between life expectancy and health status of the older population. The key approach of these calculations is that it was not assumed that e.g. heart disease, stroke, and cancer are eliminated but that "the mean age at death for each is increased due to preventive and disease modifying interventions" (Manton 1996).

Wilmoth (2000) states that there is little empirical evidence for the limits of human life span: In a study on Swedish mortality he and his colleague found that until the 1950s there was a reduction of the variability of age at death reflecting a rectangularization of the life table. Since the 1960s there was no further reduction of the variability, however, the average age at death continued to increase (Wilmoth and Horiuchi 1999). Which means that the distribution of ages at death continues to rise but with no longer compression of morbidity (Wilmoth 2000).

Wilmoth (2000) points out that there is the question how far death rates can fall and whether there is a lower limit to death rates. From the discussion he concludes that it seem implausible that there is a zero death rate at any age. However, it also seems implausible that there is a non-zero lower limit on death rates. Therefore, if there is no lower limit of death rates, than there might be no upper limit to life expectancy, which means that life expectancy can increase further as death rates fall

(Wilmoth 2000). He concludes that there is no evidence of a fixed upper limit of life expectancy.

Tuljapurkar et al. (2000) expect that increasing resources will be spent on mortality reduction and new knowledge will be discovered. According to this it is expected that the "long-run historical pattern of mortality decline" will continue. Using stochastic models to forecast the mortality of the G7 countries Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States the authors show that higher life expectancies for these countries will be achieved than predicted by official forecasts. For Japan the authors forecast a life expectancy above age 85 for the year 2020. Further, Canada, France, and Italy are expected to experience life expectancies above age 85 in 2050 (Table 2).

Table 2

Stochastic forecasts of combined sex life expectancy at birth (e0), compared with official forecasts

		2000		2020		2050	
	Forecast	Central	Range	Central	Range	Central	Range
Canada	S	78.83	1.24	81.64	2.23	85.26	2.78
	O	78.72	0.72	80.31	2.23	81.67	3.55
France	S	79.04	2.71	82.51	4.98	87.01	6.15
	O	78.80	1.30	81.85	3.85	83.50	5.50
Germany	S	77.16	3.07	79.71	4.75	83.12	5.97
	O	77.25	1.50	80.15	4.20	81.50	5.75
Italy	S	78.94	3.28	82.20	5.31	86.26	6.38
	O	78.40	1.35	81.15	4.05	82.50	5.75
Japan	S	81.47	2.07	86.01	3.20	90.91	3.27
	O	80.76	0.00	82.12	0.00	82.95	0.00
UK	S	77.50	2.85	80.10	5.50	83.79	7.47
	O	77.75	1.45	80.75	4.60	82.50	6.00
US	S	76.56	1.73	79.25	3.30	82.91	4.35
	O	76.70	0.35	78.50	2.55	80.45	5.00

Official forecasts have 'high', 'medium', and 'low' variants, except that there is only one official forecast for Japan. For France, Germany, Italy and the UK, mortality forecasts are those published by Eurostat (Data Shop Eurostat, Luxemburg); For Canada, the forecasts follow assumptions of the Canadian Pension Plan. S. stochastic forecast: central (50%), rage 95-5%). O: official forecast: central (medium), range (high-low).

In the discussion whether a fixed limit of life expectancy exists or not Thatcher concludes that "the mortality function cannot fall indefinitely, there must be some high age which is unlikely ever to be exceeded, but it is not predetermined and it is not fixed and definite" (Thatcher 1999).

4 Conclusion

In the report studies on future trends in disability and mortality have been reviewed. There is a common opinion that disability will decline further in developed countries. However, it cannot clearly be said whether there will be a compression or expansion of disability in the future. Although evidence suggests that in general disability can be compressed into the last years of life. Concerning this question it is necessary to distinguish between different groups of risk factors. It is known that trends between socioeconomic groups have been different. Therefore, it can be expected that these differences will not disappear in the near future.

Concerning mortality there is no common opinion on how large further gains in life expectancy will be. However, scientists agree that life expectancy will not stop to increase in next ten to twenty years. This will happen because there is still capacity at older ages for mortality declines.

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