Bridging the micro-macro gap in population forecasting

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Report on analysis of age profiles of key morbidity and mortality events

Part 1: Trends in morbidity and mortality

Work Package 4

Morbidity and Mortality

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Introduction

Societies in industrialized countries are affected by the developments demographic change poses on them. Low fertility rates and trends in longevity and mortality are challenging our present social systems. In order to provide high quality and sustainable health care services and pension systems in the future, an instrument is required to monitor and forecasts future scenarios adequately. The EU-financed project "MicMac" – Bridging the Micro-Marco Gap in Population Forecasting" is a multistage population approach that combines cohort data with individual biographic data. With this new approach – combining the traditional cohort-component model and the projection of life courses of individual cohort members – it is possible to provide more comprehensive information about future developments.

Within this project we conducted a systematic literature review focusing on the effects of age, sex, education, marital status, smoking and obesity on various indicators of disability and mortality (Doblhammer et al. 2006). This literature review serves as input for the illustrative projections using the MicMac micro-simulation approach. In order to provide background information for these illustrative projections and scenarios, the following manuscript gives an overview over recent trends in morbidity and mortality in European countries.

In times of constantly increasing human life expectancy, medicine improved enormously leading to remarkable changes in morbidity and mortality rates in industrialized countries. The purpose of this review is to give an overview over these developments in European countries, also taking into account developments in other low mortality countries such as the USA or Japan. It is supposed to depict differences between the sexes as well as differences between marital states and socioeconomic groups.

To do this, a literature search was performed using the databases PsycInfo and Medline. We used search terms such as trends, age or old age, disability, total or all cause mortality, longevity, socioeconomic disparity or determinants. We considered studies and reviews

published since the late 1990s, where the emphasis was put on trends over the last two decades.

This review is divided into three parts: The first part examines trends in morbidity, distinguishing between different kinds of disability. The second part gives an overview over mortality trends for the different countries and for very old ages. In the third part, mortality trends are examined, considering sex differences, differences in marital status as well as mortality differences due to education.

Trends in disability

Health is an important factor to characterize populations. Mostly, it is measured by quality of life, self-reported health, but also by self-reported limitations, and years spent with disability or without disability. In the following part of the review an overview over trends in disability is given.

Disability can be measured in different ways. It can also be distinguished between different levels of disability. This overview is restricted to trends in prevalence rates. We explore trends in functional limitations including mobility and physical functioning, in mild disability and disability in instrumental activities of daily living (IADL), in moderate disability, severe disability, disability in activities of daily living (ADL), sensory and cognitive limitations, and total disability (combined measures). Disability in IADL is often used as definition of mild disability and disability in ADL as definition of severe disability.

Functional limitation (mobility, physical functioning)

Functional limitations are based on the concepts of physical performance (Nagi 1976) and mobility (Rosow-Breslau 1966) (see Doblhammer et al. 2006).

There is a large body of studies that examines health and disability trends since the 1960s, a lot of them done on trends in the United States. In the USA, health was examined from the beginning of the 1960s. For the U.S. population aged 45–75 the prevalence of activity restriction increased between 1969 and 1975, levelled off until 1982 and decreased from 1982–1988. For people aged 70+ and 75+ no clear trend was found (Crimmins and Ingegneri 1991, Waidmann et al. 1995). Two further surveys (SOP and SOA-NHIS)[1] showed slight improvements for the population aged 65 and over between 1962 and 1984.

For the 1980s and 1990s several studies reported statistically significant declines in functional limitations for the middle aged and older aged U.S. population (Robine and Michel 2004, Freedman and Martin 1998, 1999, 2000). With data from the SIPP[2], impairments in physical functioning were found to be declining significantly in the non-institutionalized population aged 50 and over (controlled for compositional change of the

[1] SOP – Survey of Older Population; SOA-NHIS – Supplement on Aging – American National Health Interview Survey

[2] SIPP – Survey of Income and Program Participation

non-institutionalized population) for the time between 1984 and 1995. The average annual decline was between -1.45% and -1.62% (Freedman and Martin 1998, 1999; Freedman et al. 2002). This might suggest an improvement in physical vigour (Robine et al. 2002). Also results from the SOA showed declining functional limitation between 1984 and 1995 for the older population aged 70+ with an average annual change between -0.2% and -1.39% (Freedman and Martin 2000).

Also in Europe the prevalence of functional limitation declined in the late 1980s and in the 1990s. In Spain disability (walking limitation) declined clearly from 1986–1999 for the elders aged 65+ from 28.4% to 15.3% for men and from 37.5% to 25% for women (Sagardui-Villamor et al. 2005).

The Swedish elderly population aged 77+ experienced a slight increase in mild mobility limitation. There was also an increase in severe mobility limitation. It was significantly higher in 2002 than in 1992 (Parker et al. 2005). In France, from 1988 to 1998, there was a statistically significant decline in mobility disability for the elderly community-dwellers aged 65+ (Pérès and Barberger-Gateau 2001, Pérès et al. 2004). In contrast to Spain and France, no clear trends were apparent for the Netherlands. Between 1990 and 1998 a slight decline of mobility limitation was found for the ages 45–74 in the non-institutionalized population (Picavet and Hoeymans 2002), however no change was found between 1992–1998 for those aged 55–84 (Portrait and Alessie 2002).

Outside of Europe estimates of prevalence of functional limitation were made for Japan 1993–2002. For people who were living in the community and were older than 66 years functional limitation declined slightly from 39.5% to 38.5%.

In contrast to the results of declining disability reported above, there were significant increases in New Zealand, Quebec, and Thailand (Michel and Robine 2004). Table 1 gives an overview over the trends in functional limitations by time period, countries, ages, and sexes.

Table 1: Changes in functional limitation in the USA, Spain, France, The Netherlands, Sweden, Great Britain, Australia, New Zealand, Quebec, and Thailand for the time period 1969–2002.

Functional limitation	Author	Country	Period	Age	Sex
Improvement	Crimmins and Ingegneri (1991)	USA	1982-1988	45-75	both sexes
	Freedman and Martin (1998, 1999)	USA	1984-1993	50+	both sexes
	Freedman and Martin (2000)	USA	1984-1995	70+	both sexes
	Sagardui-Villamor et al. (2005)	Spain	1986-1999	65+	both sexes
	Pérés and Barberger-Gateau (2001), Pérès et al. (2004)	France	1988-1998	65+	both sexes
	Schoeni et la. (2006)	Japan	1993-2002	66+	both sexes
Stagnation/ no trend	Crimmins and Ingegneri (1991)	USA	1975-1982	45-75	both sexes
	Crimmins and Ingegneri (1991)	USA	1969-1988	75+	both sexes
	Waidmann et al. (1995)	USA	1986-1991	45-64	male
	Waidmann et al. (1995)	USA	1982-1991	70+	female
	Waidmann et al. (1995)	USA	1975-1981	45+	male
	Portrait and Alessie (2002)	The Netherlands	1992-1998	55-84	both sexes
Deterioration	Crimmins and Ingegneri (1991)	USA	1969-1975	45-75	both sexes
	Waidmann et al. (1995)	USA	1969-1975	45-69	male
	Picavet and Hoeymans (2002)	The Netherlands	1990-1998	45-74	both sexes
	Parker et al. (2005)	Sweden	1992-2002	77+	both sexes
	Michel and Robine (2004)	Great Britain, Australia, New Zealand, Quebec, Thailand	1980s-1990s		

Mild disability and difficulties in instrumental activities of daily living (IADL)

Instrumental activities of daily living assess, according to Lawton and Brody (1969), everyday functional competences like using the telephone, shopping, food preparation, housekeeping, laundry, mode of transportation, responsibility of own medication and the ability to handle finances. These activities are in most cases considered to be mild limitations in daily life. However, mild disability can be measured with all other disability concepts. People being mildly disabled are considered those who are only slightly limited in a few activities according to the particular definition.

For the United States several studies reported significant decline in IADL disability for the elderly during the 1980s and 1990s (Robine et al. 2002; Michel and Robine 2004). IADL disability declined on average with -0.4% and -1.66% per year respectively for the

periods 1982–1993 and 1982–1996 (NHIS, non-institutionalized population 70+). The same appeared with results from NLTCS[3] data (population aged 65+) with an average decline per year of -1.79% (1982–1994) and -2.74% (1982–1999) (Freedman et al. 2002). These results indicate that there was a stronger decline of IADL disability in the mid and end of the 1990s in the United States than in the 1980s (also see Spillman 2004). Arbeev and colleagues (2004) included the institutionalized population (age 65+) for the period 1982–1999. The prevalence of IADL disability declined for males aged 65–69 from 3.23% to 1.5% (-1.26% per year), for males aged 70+ from 5.71% to 3.46% (-1.24% per year), for females aged 65–69 from 3.41% to 2.38% (-1.22% per year), and for females aged 70+ from 6.44% to 3.95% (-1.24% per year). With the data of the SOA between 1984 and 1995 a slight decline in prevalence of IADL disability was found for women. For men results were contradictory. For them increases as well as decreases were observed (Crimmins and Saito 2000; Liao et al. 2001; Freedman et al. 2002).

Table 2. Changes in mild limitation/IADL limitation in the USA, Japan, France, The Netherlands, and Sweden for the time period 1982–2002.

Mild limitation/IADL	Author	Country	Period	Age	Sex
Improvement	Schoeni et al. (2001)	USA	1982-1993	70+	both sexes
	Manton et al. (1997a)	USA	1982-1994	65+	both sexes
	Manton and Gu (2001)	USA	1982-1999	65+	both sexes
	Arbeev et al. (2004)	USA	1982-1999	65+	both sexes
	Liao et al. (2001)	USA	1984-1985	65+	both sexes
	Crimmins and Saito (2000)	USA	1984-1995	70+	female
	Pérès et al. (2004)	France	1988-1998	75-84	female
	Schoeni et al. (2006)	Japan	1993-2002	66+	both sexes
	Bronnum-Hansen (2005)	Denmark	1987-2000	65 (LE with disability)	both sexes
Stagnation/ no trend	Crimmins and Saito (2000)	USA	1984-1995	70+	male
Deterioration	Pérès et al. (2004)	France	1988-1998	75-84	male
	Perenboom et al. (2004)	The Netherlands	1989-2000	65 (LE with disability)	both sexes
	Parker et al. (2005)	Sweden	1992-2002	77+	both sexes

[3] NLTCS – National Long Term Care Study

Parker et al. (2005) defined mild disability as mild IADL disability or mild ADL disability. In Sweden, from 1992 to 2002 mild IADL and mild ADL disability increased in the elderly community-dwelling and institutionalized Swedish population aged 77+ (Parker et al. 2005). In France, prevalence of disability increased for men and decreased significantly for women between 1988 and 1998. In terms of odds ratios there was no change in the risk of being IADL disabled for men. However, for women the risk of being IADL disabled declined statistically significantly by 39% over 10 years (Pérès et al. 2004).

In Japan the prevalence of any IADL disability declined significantly between 1993 and 2002 for people aged 66+ from 22% to 19 % (-1.34% per year). The risk of having any IADL disability was in 2002 by 26.6% significantly lower than 1993, adjusted for age, sex, SES, and marital status (Schoeni et al. 2006).

For the Netherlands, in the Health Interview Survey (NetHIS), mild disability is defined as mild vision and hearing limitation, and mild limitations in mobility and ADL. Perenboom et al. (2004) calculated disability-free life expectancy (DFLE) for the non-institutionalized population aged 65 for the period 1989–2000. For men life expectancy (LE) in mild disability increased significantly from 3.7 to 6.2 years, while DFLE[4] decreased from 5.5 years (38.3% of LE) to 4.6 years (30.3% of LE). This means a clear deterioration of health for men. In contrast, for 65 year old women there was a clear increase in LE with mild disability from 3.6 years (22.1% of LE) to 5 years (22.5%) but no change in DFLE. The situation in Denmark between 1987 and 2000 was more favourable for the 65 years old population; LE without long-term disability increased whereas LE with disability decreased (for men significantly). Table 2 gives an overview over the trends in mild disability by time period, countries, ages, and sexes.

Moderate and severe disability/ADL difficulties

Activities of daily living (ADL) are according to Katz et al. (1963) a set of basic human functions – activities which people perform habitually and universally. The index of ADL measures the functions bathing, dressing, toileting, continence and feeding. Moderate disability is measured according to the concept of ADL as being limited in 2 to 3 items mentioned above.

[4] DFLE – disability free life expectancy

Being severely disabled means having difficulties performing mostly all ADL items. Severe disability can also be measured by IADL *and* ADL disability.

There exist only two studies that looked at moderate disability. For The Netherlands, moderate DFLE and LE with moderate disability (including vision and hearing limitation, moderate limitation in mobility and ADL) was calculated (Perenboom et al. 2004). Between 1989 and 2000 LE with moderate disability increased slightly for non-institutionalized 65 year old men. DFLE decreased absolutely and relatively. For women LE with moderate disability declined and DFLE did not change. For Finland, moderate ADL disability was studied for the population aged 75+ in 1979, 1989, and 1999. Moderate ADL disability is defined as having 1–4 ADL limitations. The prevalence was 21.6% in 1979, 26.5% in 1989 and 19.5% in 1999. This means that there was an increase from the end of the 1970s to the end of the 1980s but a decrease of disability to the end of the 1990s for the old Finnish population (Winblad et al. 2001).

Concerning severe disability, in the USA, in the years 1982–1999 severe ADL disability declined for the population aged 65+ including the institutionalized except for women aged 70+ (NLTCS data) (Arbeev et al. 2004). Their prevalence of ADL disability increased from 16.38% to 17.99%. The overall decline of disability was also confirmed for the non-institutionalized 70+ population from 1982–2002 (NHIS[5] data). Disability declined on average -0.62% per year (Schoeni et al. 2005). In contrast, Freedman and colleagues did not find a clear trend in ADL disability in their review between 1982 and 1999 (Freedman et al. 2002). However, for this period in the USA, the changes in any ADL or any IADL disability – as one measure – were more emphasized than the changes in ADL disability – as a second measure of severe disability. Any ADL or any IADL disability declined by -2.15% per year. For the period 1997–2004 it declined by -1.36% per year in the 65+ population (Freedman et al. 2006). For earlier periods any disability was analyzed with NLTCS data in the 65+ population living in communities and in institutions. Its prevalence declined during the period 1982–1994 (Waidmann and Manton 2000). The same was observed with data from the NHIS and LSOA[6] for the non-institutionalized population aged 70+ between 1982–1993 (Waidmann and Manton 2000). Further declines in ADL and

[5] NHIS – National Health Interview Survey

[6] Longitudinal Study of Aging

IADL disability from 1991–1995 were found with data from the MCBS[7]. In contrast, Michel and Robine (2004) concluded that there was stagnation in severe disability in the older U.S. population. They stressed that most decline in disability was affected by decline in IADL disability but not in ADL (Michel and Robine 2004).

Analyses of the NHIS data for the periods 1982–1993 and 1982–1996 showed average declines of any disability of -0.92% and -1% per year (Freedman et al. 2002). Data of the NLTCS for the period 1982–1994 and to 1999 confirmed this trend with an average annual percent decline of -1.11 and -1.55 (Manton et al. 1997a; Manton and Gu 2001; Freedman et al. 2002). The same applies for results from the MCBS data with an average decline of 1.53% per year (Waidmann and Liu 2000; Freedman et al. 2002). These results suggest that there was an acceleration of decline in the beginning of the 1990s, which was confirmed with NLTC data for the period 1984–1999 (Spillman 2004).

Freedman et al. (2004) reviewed four national data sets to resolve inconsistencies in old age disability for the USA. ADL disability was measured in different ways as having difficulty, getting help or using equipment. The review reported consistent declines of 1–2.4% between 1984 and 2001 in disability as having difficulties with and using help in ADL. However, no consistent trends in disability, measured as getting help or using equipment for activities of daily living were found.

Severe IADL disability decreased in Sweden for the community-dwelling and institutionalized elderly population between 1992 and 2002. In contrast, severe ADL disability increased slightly. In Finland, severe ADL disability, defined as 5–6 ADL limitations, showed for the population aged 75+ a steady increase from 1979 to 1999 (Winblad et al. 2001). For The Netherlands, contradictory results from two studies using the same data (NetHIS) are known. Perenboom et al. (2004) found for the male 65+ non-institutionalized population clear decreases of years of LE with severe disability for the period 1989–2000, but no change for females. In contrast, Picavet and Hoeymans (2002) examined the non-institutionalized 16+ population for 1990–1998, and found no change of severe disability for all ages, but a slight significant increase of prevalence for ages 64–75 (+0.3 percentage points per year). In France the indication is clear. Between 1988 and 1998 the prevalence of disability declined clearly, as well as the risk of being ADL disabled (23% lower, controlled for sociodemographic factors) (Pérès et al. (2004).

[7] MCBS – Medicare Current Beneficiary Survey

Table 3. Changes in moderate and severe disability in the USA, France, Sweden, The Netherlands and Japan for the time period 1982–2004

Moderate limitation	Author	Country	Period	Age	Sex
Improvement	Winblad et al. (2001)	Finland	1979-1999	75+	both sexes
Deterioration	Perenboom et al. (2004)	The Netherlands	1989-2000	65 (LE with moderate disability)	female
ADL disability					
Improvement	Arbeev et al. (2004)	USA	1982-1999	65+	both sexes
	Schoeni et al. (2005)	USA	1982-2002	70+	both sexes
Stagnation/ no trend	Freedman et al. (2002)	USA	review of several studies: no clear trend		
Deterioration	Arbeev et al. (2004)	USA	1982-1999	70+	female
	Perenboom et al. (2004)	The Netherlands	1989-2000	65 (LE with disability)	both sexes
	Winblad et al. (2001)	Finland	1979-1999	75+	both sexes
any ADL and/or any IADLdisability					
Improvement	Freedman et al. (2006)	USA	1997-2004	65+	both sexes
	Freedman et al. (2004)	USA	1984-2001	old age	both sexes
	Waidmann and Manton (2000)	USA	1982-1994	65+	both sexes
	Waidmann and Manton (2000)	USA	1982-1993	70+	both sexes
	Schoeni et al. (2001)	USA	1982-1996	70+	both sexes
	Manton et al. (1997a)	USA	1982-1994	65+	both sexes
	Manton and Gu (2001)	USA	1982-1999	65+	both sexes
	Waidmann and Liu (2000)	USA	1992-1996	65+	both sexes
	Perenboom et al. (2004)	The Netherlands	1989-2000	65 (LE with severe disability)	male
	Pérès et al. (2004)	France	1988-1998	75-84	both sexes
	Parker et al. (2005)	Sweden	1992-2002	77+	both sexes
	Schoeni et al. (2006)	Japan	1993-2002	66+	both sexes
Stagnation/ no trend	Perenboom et al. (2004)	The Netherlands	1989-2000	65 (LE with severe disability)	female
Deterioration	Picavet and Hoeymans (2002)	The Netherlands	1989-2000	64-75	both sexes

In Japan prevalence of any ADL disability declined between 1993 and 2002 with -1.35% per year for the elderly 66+. Also the risk of having ADL disability was in 2002 by 26.4% significantly lower than in 1993. The average annual decline of prevalence of any ADL or IADL disability is -1.36% per year and the risk of being disabled in any ADL or IADL is by 29.1% lower in 2002 (Schoeni et al. 2006). Table 3 gives an overview over the trends in moderate and severe disability by time periods, countries, ages, and sexes.

Sensory limitations/cognitive limitation

Sensory limitations are considered to be limitations in vision and hearing.

In the United States significant declines in cognitive limitation were observed for the period 1986–1993 for people aged 65+ and also for 1993–1998 for people aged 70+. Prevalence of hearing difficulties did not change between 1984 and 1995. Visual impairments did not change between 1984 and 1995 with the data of SOA-NHIS for a population aged 70+ but decreased statistically significantly for non-institutionalized people aged 50+ in the SIPP[8] (Freedman et al. 2002). In contrast, Desai et al. (2001) did not find any changes between 1984 and 1995 for visual and hearing impairments.

Table 4. **Changes in sensory and cognitive limitation in the USA, Spain, The Netherlands, and Sweden for the time period 1984–2002.**

Sensory limitation	Author	Country	Period	Age	Sex
Improvement	Liao (2000) - *cognitive impairment*	USA	1986-1993	65+	both sexes
	Freedman et al. (2001, 2002) - *cognitive impairment*	USA	1993-1998	70+	both sexes
	Freedman and Martin (1998, 1999) - *visual impairment*	USA	1984-1995	70+	both sexes
	Sagardui-Villamor et al. (2005) - *visual and hearing impairments*	Spain	1986-1999	65+	both sexes
Stagnation/ no trend	Freedman and Martin (1998, 1999) - *visual impairment*	USA	1984-1995	50+	both sexes
	Desai et al. (2001) - *visual and hearing impairment*	USA	1984-1995	70+	both sexes
	Picavet and Hoeymans (2002) - *visual and hearing impairment*	The Netherlands	1990-1998	16+	both sexes
Deterioration	Parker et al. (2005) - *hearing impairment*	Sweden	1992-2002	77+	both sexes

[8] SIPP – Survey of Income and Program Participation

For the Spanish population aged 65+ including the institutionalized, a clear decline (5–46%) of impairments in seeing and hearing for both sexes was reported by Sagardui-Villamor et al. (2005) for the period 1986–1999. Cognitive limitation declined for high educated men and women and increased for less educated people (especially strong for women). For Sweden in contrast, for the oldest old at ages 77+, a highly significant increase in hearing limitations between 1992 and 2002 was found by Parker et al. (2005).

In the Netherlands no changes in vision and hearing impairments were observed between 1990 and 1998. Table 4 gives an overview over the trends in moderate and severe disability by time period, countries, ages, and sexes.

Total disability/combined measures

Arbeev et al. (2004) reported total disability to be decreasing in the USA for both sexes and all ages (65+) between 1982 and 1999 from 10.2% to 5.8% at age 65–69 for males, from 25% to 18% for 70+ old males, from 11.4% to 8.4% for females aged 65–69, and from 33.7% to 29.1% for 70+ old females. The prevalence of institutionalization also decreased. For earlier periods Waidmann and Manton (2000) reported declines in the nursing home use rate or institutionalization rate for 1977–1995 and 1982–1994 calculated with data from the NNHS[9] and NLTCS. Due to different definitions of institutionalization the decline was stronger with NNHS data.

For Canada LE free of severe disability was calculated by Wilkins and colleagues (1994) for 1986 and 1991. A significant decline for both sexes was found. In contrast, LE free of any disability declined not significantly (Wilkins et al. 1994). Robine et al. (2002) found several studies for this period proving deteriorated health with increasing disability prevalence in Canada.

In their review of trends in disability Waidmann and Manton (2000) reported results of increasing DFLE for the elderly aged 65 in France between 1981 and 1991 and also disability declines at age 95+ for the period 1982 to 1994. For Belgians aged 65 DFLE increased between 1980 and 1990 (van Oyen and Roelands 1994, Waidmann and Manton 2000). In Britain an improvement of DFLE for 1981 and 1985 was observed for both sexes in contrast to 1976 (Bebbington 1988, Waidmann and Manton 2000). Further an absolute and relative increase of DFLE of people aged 65 was found in Italy in the early 1980s for

[9] NNHS – National Nursing Home Survey

both sexes, in The Netherlands in the 1980s and in Switzerland 1981–1988 for females. DFLE deteriorated for Swiss males and in Japan in the late 1960s for both sexes (OECD,

Table 5. Changes in total disability in the USA, Canada, France, Belgium, The Netherlands, Switzerland, Great Britain, Spain, Italy, and Japan for the time period 1966–1999.

Total disability	Author	Country	Period	Age	Sex
Improvement	Arbeev et al. 82004)	USA	1982-1999	65+	both sexes
	Robine (1994)	France	1981-1991	65 (LE free of disability)	both sexes
	Manton et al. (1997b)	France	1982-1994	95+	both sexes
	van Oyen and Roelands (1994)	Belgium	1980-1989	65 (LE free of disability)	both sexes
	Bebbington (1988)	Britain	1976-1985	65 (LE free of disability)	both sexes
	OECD, REVES sources	Italy	1980-1983	65 (LE free of disability)	both sexes
	OECD, REVES sources	The Netherlands	1981-1990	65 (LE free of disability)	both sexes
	OECD, REVES sources	Switzerland	1981-1988	65 (LE free of disability)	female
	Sagardui-Villamor et al. (2005)	Spain	1986-1999	65+	both sexes
	Picavet and Hoeymans (2002)	The Netherlands	1990-1998	45-64, 75+	both sexes
Stagnation/ no trend	Mathers (1994)	Australia	1981-1992	65 (LE free of disability)	both sexes
Deterioration	Wilkins et al. (1994)	Canada	1986-1991	65 (LE free of disability)	both sexes
	Robine et al. (2002)	Canada	1986-1991	review of studies	both sexes
	OECD, REVES sources	Switzerland	1981-1988	65 (LE free of disability)	males
	OECD, REVES sources	Japan	1966-1970	65 (LE free of disability)	both sexes

REVES sources, Waidmann and Manton 2000). In Australia 1988–1992 there was no consistent change in DFLE (Mathers 1994, Waidmann and Manton 2000).

In Spain total disability declined clearly for all ages in 1999 compared to 1986. There was an average decline between -2.7% and -4.1% per year for the age groups 65–69, 70–74, 75–79, 80–84 for both sexes and between -2.5% and -2.8% per year for women and men aged 85+ (Sagardui-Villamor et al. 2005). In The Netherlands, between 1990 and 1998 total disability for non-institutionalized decreased by -0.3 percentage points for ages 45–64 and even stronger by -0.7 percentage points for age 75+. Total disability declined for community-dwelling people but did not change for institutionalized (Picavet and Hoeymans 2002). Table 5 gives an overview over the trends in total disability by time periods, countries, ages, and sexes.

Summary

The review of the trends in disability showed that there was a common improvement in health of the older populations for most countries in terms of disability over the 1980s and 1990s.

Functional limitation/mobility disability declined clearly and in most cases significantly in the USA, Spain, France and The Netherlands. As said before, significant increases in functional limitations in the last two decades of the 20th century appeared in Australia, Great Britain, Quebec, and Thailand (Michel and Robine 2004). Mild disability did not decline for all countries. It improved in the USA, Denmark, Japan, and for French females. It deteriorated in The Netherlands and for French males. Moderate disability improved in Finland. However, it increased in The Netherlands for the elderly non-institutionalized men but improved for women. In the USA, results for severe disability defined as ADL disability showed a downward trend but increased in The Netherlands and Finland. Severe disability, defined as any ADL or any IADL disability, also declined clearly in the USA, France, Sweden, and in Japan in the 1980s and 1990s. In contrast, in Canada as well as in The Netherlands no clear trends in severe disability were observed for both sexes.

Sensory limitations and cognitive limitations declined for the USA and Spain in the 1980s and 1990s.

Disability, examined as prevalence of any disability or LE with any disability, declined over the last two decades in the USA, in European countries like France, Belgium, The Netherlands, Great Britain, Italy, Spain, and Switzerland as well as in Australia.

Studying trends in disability showed that research is not evenly distributed over the different concepts and measures of disability. It is possible to examine mild, moderate, and severe disability. This is measured partially with different concepts of disability or within these concepts. The most known and applied concepts are activities of daily living and instrumental activities of daily living.

Although we generally find an improvement in severe disability, as well as functional limitations/mobility disability, results should be taken with caution. Most studies do not adjust their results for panel attrition, which especially might affect frail people. Those with poor health may be more susceptible to loss to follow-up resulting in an ever more healthy survey population over time.

Trends in total mortality

Life expectancy in industrialized countries has been substantially increasing for about 160 years (Oeppen and Vaupel 2002). High life expectancy is especially remarkable for Northern, Western, Southern and partially Central European countries, the USA, Australia, New Zealand, and Japan. These countries are known as low-mortality countries today. Eastern European countries also experienced declining mortality, but at a later point of time. However they are catching up now.

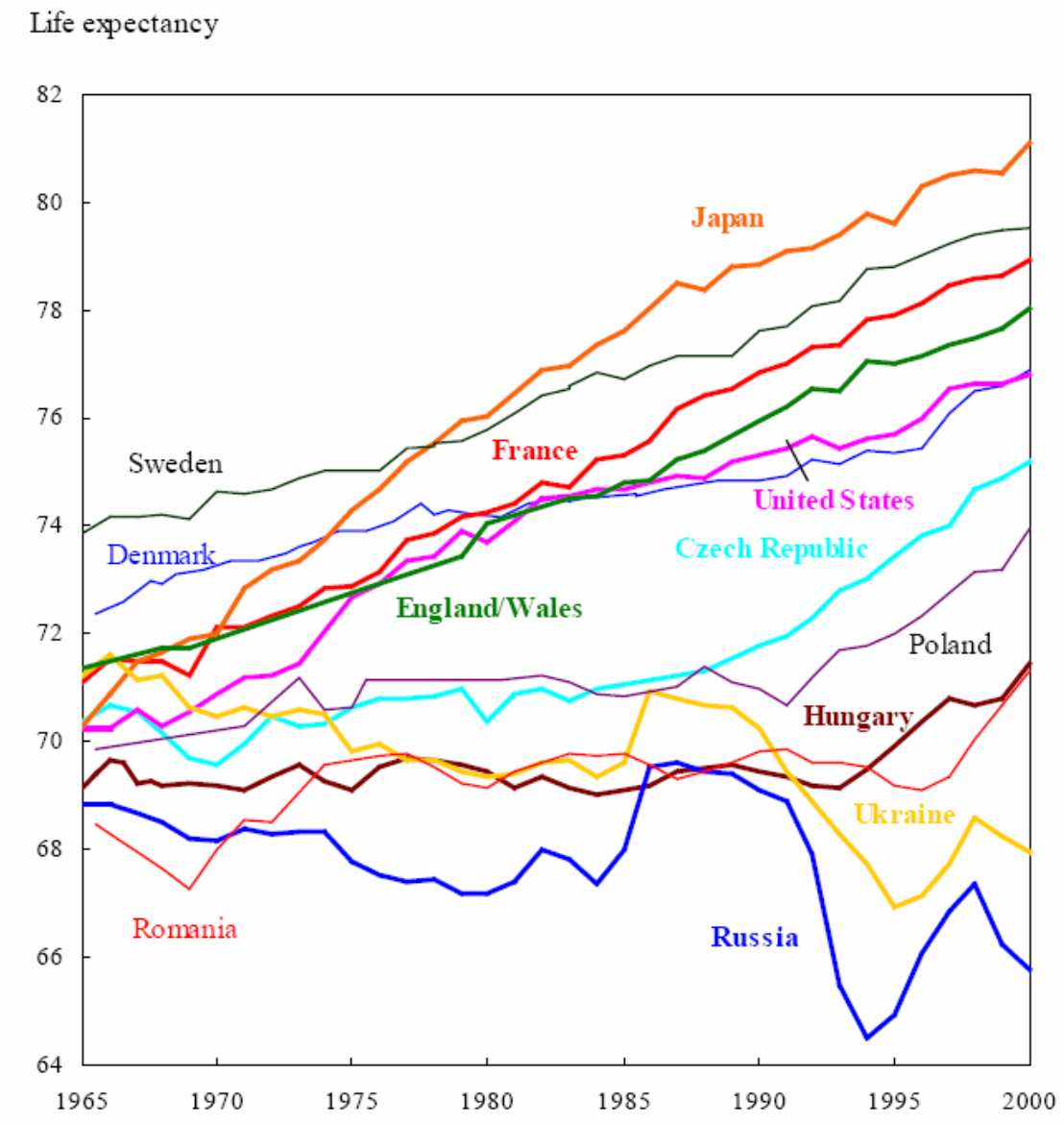
In the first half of the last century gains in life expectancy were mainly due to the reduction of infant and child mortality and of infectious diseases as main causes of death. Therefore, main gains were reached at younger ages. Infant and child mortality declined to a very low level until the 1950s. Since then changes of mortality at young ages had low impact on the increase of life expectancy. Comparing the European countries the lowest infant mortality can be found in the Northern countries right before the Western, Western Central, and Southern countries. Central and Eastern European countries still have to catch up to the mortality level of the other countries. However, their mortality is at a low level already (Vallin and Meslé 2001).

Increases in life expectancy in the second part of the 20th century were influenced by overall mortality reduction among the elderly at retirement age (Janssen and Kunst 2005). Today main causes of death are causes related to old age that are chronic degenerative diseases (Kinsella 1992). Thus, there was a shift in the trend from dying at younger ages to dying at older ages (Janssen and Kunst 2005).

Mortality decline did not start at the same time and from the same level in the European countries. As well, the pace of decline over time was different between countries (Janssen and Kunst 2005). Relative differences among countries are still apparent but they have narrowed over time. Remaining differences in recent times are mostly the result of relatively low life expectancy at birth in Eastern Europe. The pace of mortality decline in these countries was not the same as in other European countries. This is because Eastern European countries did not experience steady mortality declines since 1900 (Kinsella 1992).

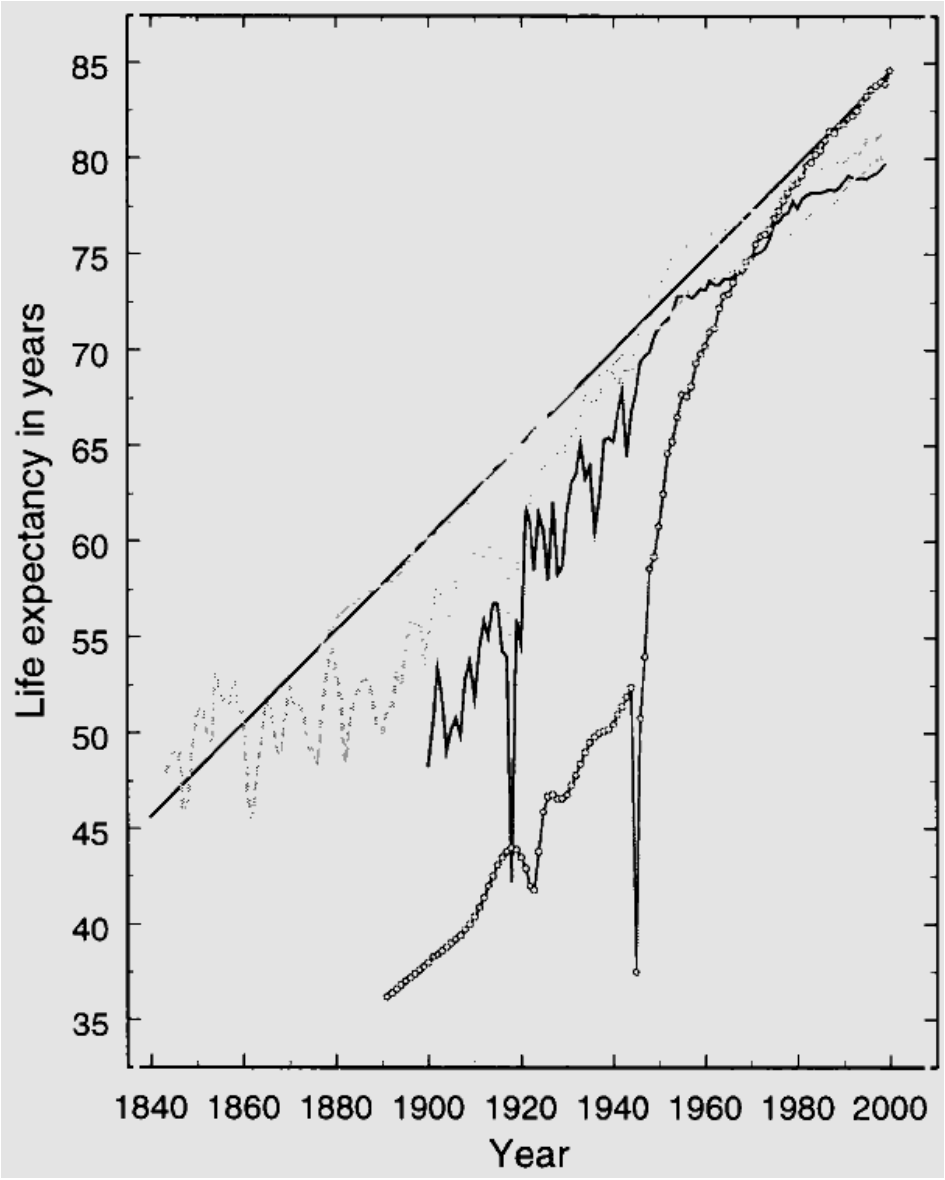
There were also differences in mortality improvements for males and females. Females experienced steady declines of mortality since the 1950s. In contrast, male mortality showed a later acceleration of mortality decline in the 1970s, like in Australia, The Netherlands, Norway, and the United States (Kinsella 1992).

Figure 1 shows the development of increased life expectancy at birth for several European countries and for Japan from 1965 to 2000. The trends for these countries will be explained later.



Source: France: Vallin and Meslé, 2001; Russia: Meslé *et al.* 1998; Ukraine: Meslé and Vallin, in press; other countries: various statistical and demographic yearbooks.

Figure 1. Trends in life expectancy at birth in Europe, the United States, and Japan for the time period 1965–2000.



Trends in female life expectancy in Japan (–·–), New Zealand (· · ·), Norway (· ·)
and the United States (—) compared with the fitted trend in record life expectancy

Source: Oeppen and Vaupel (2002)

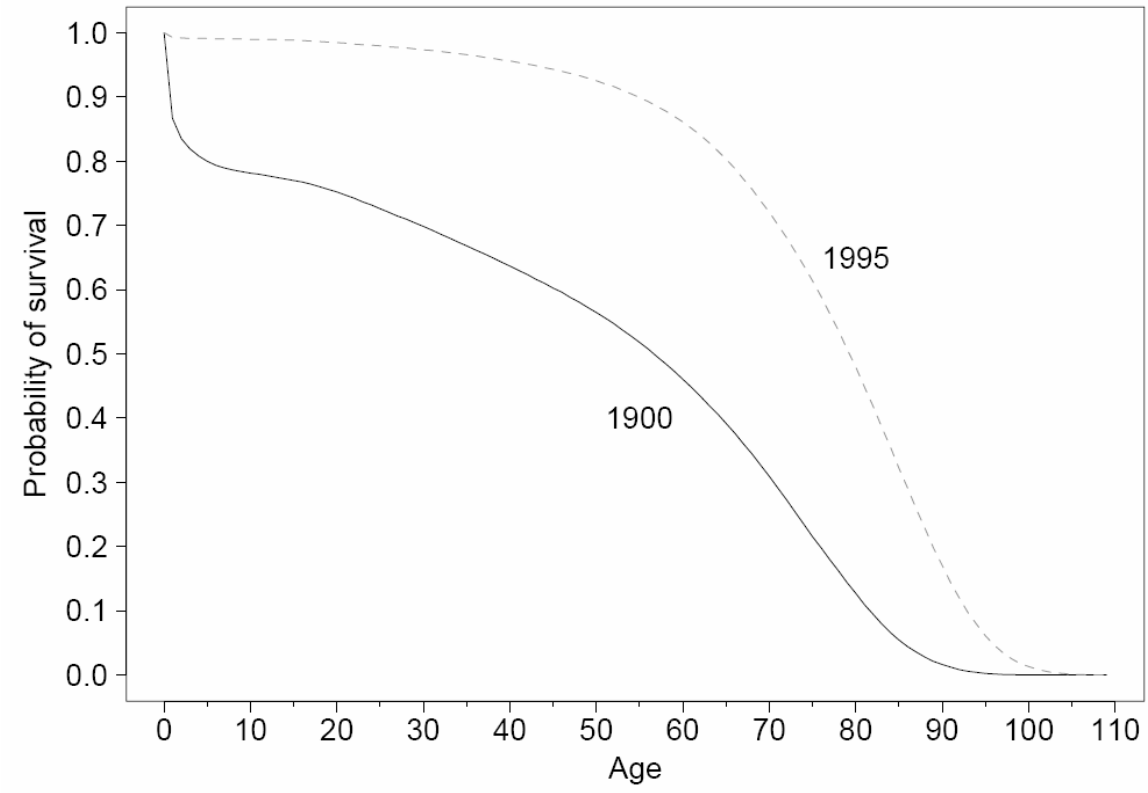
Figure 2. Trends in female life expectancy in Japan, New Zealand, Norway, and the United States since 1840.

Figure 2 illustrates the enormous increase of life expectancy at birth over a period of more than 100 years. It shows that New Zealand and Norway started at a relative high level before 1900 in contrast to Japan, which had a very low life expectancy at birth, and the

United States. For all countries life expectancy increased steadily. The improvement was enormously rapid for Japan.

The decrease of mortality and the increase of survival at all ages led to a shift in the survival curves to the right side. This can be seen in Figure 3. It shows the differences of the survival curves 1900 and 1995 of U.S. American women.

To illustrate the mortality development of low-mortality countries some numbers shall be given. Oeppen and Vaupel (2002) point out that life expectancy has risen for 160 years by 3 months per year. Life expectancy of Swedish women was with about 45 years the highest in 1840. Until today it has increased to 80 years and over. In Europe, French women had the highest life expectancy with 82 years in the mid-1990s. Today the highest life expectancy at birth is held by Japan. Japanese women are holding the record of 83.1 years of life expectancy at birth (Vallin and Meslé 2001).



Source: Wilmoth (2000)

Figure 3. Survival curve of U.S. American females in 1900 and 1995.

In Germany female life expectancy at birth increased from 38.5 years in 1871/81 to 81.6 years in 2002/04. For males it increased from 35.6 years in 1871/81 to 75.9 years in 2002/04 (DESTATIS 2006, www.destatis.de/download/d/bevoe/sterbet03.xls; 28.10.2006). Life expectancy increased by more than 50% for both sexes since the late 1870s. At the moment life expectancy in Japan is the highest.

Male total mortality declined by about 40% over the last 3 decades of the 20th century for ages 45–74. It declined most in Finland whereas it increased in Hungary and Poland until the 1990s. Female mortality decreased at the time period 1970–2000 for the same age group at a higher pace. It declined most in Spain. In Hungary and Poland it decreased only

Table 6. Absolute contribution (in years) of age groups to the change in life expectancy in Sweden, Denmark, France, Italy, and Russia for the time periods 1950–65, 1965–80, 1980–95.

age group	Absolute contributions, in years										
	men						women				
	Sweden	Denmark	France	Italy	Russia	age group	Sweden	Denmark	France	Italy	Russia
1950-65											
0-1	0.65	1.22	2.39	2.37	5.80	0-1	0.52	1.01	2.03	2.34	5.65
1-14	0.33	0.27	0.59	1.50	3.93	1-14	0.26	0.22	0.62	1.59	4.19
15-29	0.27	0.26	0.25	0.51	0.78	15-29	0.30	0.29	0.53	0.75	1.12
30-59	0.46	0.14	0.88	1.05	1.80	30-59	0.96	0.74	1.29	1.14	1.38
60-74	0.10	-0.43	0.32	-0.36	0.33	60-74	1.01	0.74	1.12	0.83	0.73
75+	0.15	-0.03	0.35	0.11	0.21	75+	0.60	0.33	0.83	0.48	0.33
Total	1.97	1.42	4.79	5.17	12.85	Total	3.64	3.33	6.41	7.14	13.41
1965-80											
0-1	0.55	0.83	0.94	1.73	0.28	0-1	0.44	0.63	0.82	1.56	0.30
1-14	0.21	0.20	0.14	0.42	0.05	1-14	0.14	0.17	0.13	0.41	0.09
15-29	0.08	-0.15	-0.08	0.19	-0.39	15-29	0.08	0.00	0.05	0.17	0.08
30-59	-0.07	-0.19	0.51	0.45	-2.22	30-59	0.40	-0.05	0.67	0.85	-0.47
60-74	0.18	0.07	0.77	0.66	-0.51	60-74	0.82	0.66	1.01	1.20	-0.20
75+	0.16	0.17	0.28	0.14	-0.39	75+	0.98	1.15	0.81	0.73	-0.47
Total	1.11	0.93	2.57	3.59	-3.18	Total	2.80	2.57	3.49	4.92	-0.68
1980-95											
0-1	0.25	0.29	0.40	0.75	0.31	0-1	0.21	0.21	0.32	0.64	0.27
1-14	0.11	0.14	0.19	0.15	0.13	1-14	0.10	0.08	0.15	0.10	0.12
15-29	0.28	0.20	0.29	0.03	-0.55	15-29	0.10	0.10	0.13	0.04	-0.21
30-59	1.05	0.42	0.86	0.95	-2.48	30-59	0.43	0.32	0.52	0.45	-0.93
60-74	1.11	0.38	1.12	1.05	-0.62	60-74	0.64	-0.29	0.88	0.73	-0.46
75+	0.62	0.18	0.86	0.80	0.00	75+	1.03	0.26	1.54	1.25	-0.10
Total	3.42	1.62	3.72	3.64	-3.21	Total	2.51	0.67	3.54	3.21	-1.32

Source: Vallin and Meslé (2001), p.82-84

from the beginning of the 1990s, after that it was stagnant (Kesteloot 2006). The main reasons of all-cause mortality decline were especially declines in mortality from cardiovascular diseases. This was due to improved medical treatment and changed lifestyles and behaviours including healthier nutrition (Kesteloot 2006).

Mortality decline showed different patterns for age over the whole life course. These different patterns had different impacts on the increase of life expectancy over time. Before the 1950s the impact on the increase of life expectancy at birth was highest for the young ages; since the 1950s the highest impact shifted to higher ages. In recent time it shifted from working ages to ages after retirement and even to higher ages. Table 6 shows the impact of age on increases in life expectancy for a selection of countries. It can be seen that age groups above age 60 have an increased impact on the increase of life expectancy at birth. Trends in life expectancy in these countries will be discussed in detail in the next part. Myers (1996) studied the contribution of age groups on life expectancy at birth from 1950 to 1990 in Australia, Canada, France, Hungary, Japan, and Sweden. He found similar patterns to those shown in Table 6.

Trends in total mortality in the Northern European countries

The increase of life expectancy at birth from the 1950s to the mid-1990s was less rapid in the group of the Northern European countries Norway, Sweden, Finland, and Denmark than in countries of highest life expectancy at birth of Western or Southern Europe. The Northern countries had a good position in the 1950s. But the deceleration of mortality decline started earlier and ended later than in the other groups of Europe. It started in the mid-1950s and stopped in the late 1970s. Finland, by far, had the lowest life expectancy at birth in Northern Europe. But it was able to catch up until the 1990s. Northern European countries showed declined mortality at all ages, as other European countries also did. Only Denmark took a special position.

Denmark

Change of mortality in Denmark was remarkable over the last century. Life expectancy at birth increased for men from 51.6 years in 1900 to 68.9 years in 1950 and to 72.6 years in 1990. For women the increase was from 54.8 years to 71.5 years and 78.8 years, respectively. The decline of mortality was rapid in Denmark, however, life expectancy did not increase in the same way as it did in other Northern and Western European countries. The

increase of life expectancy has stagnated since the late 1950s for men and since the 1970s for females. That is why especially female life expectancy at birth is low, compared to the other Northern countries, and has not increased at the same pace (Vallin and Meslé 2001). There was a certain resistance to mortality decline for females at ages 50–60 already after 1965 (Kesteloot 2006). Since the end of the 1970s mortality decline at ages 45–74 and 75–84 stagnated, too. This was also found to be true for mortality rates at ages 80+ (Janssen et al. 2004). However, Kesteloot (2006) found that male mortality for the ages 45–74 and 75–84 showed accelerated decline since 1995.

Janssen et al. (2005) examined whether the recent Danish mortality trends were determined by cohort effects. Mortality decline at age 60+ occurred for male birth cohorts 1890–1915 and for female cohorts born after 1920 (Jacobsen 2002; Janssen and Kunst 2005). With these results they confirm findings from an earlier study in which they explained that the stagnation of female mortality was due to increased mortality since 1960 at ages 35–74, which started between 1960 and 1965 among the ages 40–59. They showed that higher mortality particularly occurred among women born between the world wars. These cohorts were the first showing an increased tobacco consumption. Therefore, tobacco related causes of death had an impact on the increased mortality at higher ages and to the stagnation of life expectancy at birth among women (Janssen et al. 2005; Kesteloot 2001).

For death rates at ages 80–99 no stagnation in decline was found. Kannisto (1994) illustrates that death rates at ages 80–99 declined between 1955/59 and 1985/89 by 13.6% for males and by 32.7% for females. There was a sustained decline of mortality at these ages, for males since 1984 and for females since 1962 (Kannisto 1994).

Trends in mortality in the Western European countries

The Netherlands

Referring to Vallin and Meslé (2001), the Western European countries are the United Kingdom, Ireland, France, Belgium, and The Netherlands. This group of countries started at a lower level of life expectancy at birth in the 1950s than the Northern countries. They experienced a sharp increase in the 1950s, stagnation in the 1960s and declining mortality since the 1970s (Vallin and Meslé 2001). In contrast, the development of Dutch mortality was more similar to the Northern countries with higher life expectancy than in the other

Western countries since the 1950s. The Netherlands are also different because the country experienced different patterns of mortality change at advanced ages compared to the Western countries. Life expectancy at age 60 increased consistently for men and women until 1990/94. In contrast, life expectancy at age 85 only increased until 1980/84 for men and decreased after that. For women it increased until the late 1980s and stagnated then. Nusselder and Mackenbach (2000) found that this decrease and stagnation was due to the different contribution of age groups. In the 1970s mortality reduction was apparent at all age groups up from age 60 and led to increases of life expectancy at age 60 as well as at age 85. In the 1980s only mortality at ages 60–79 continued to decline. Mortality changes up from the age of 85 for men and age 90+ for women had negative effects on life expectancy at age 85. Causes of these negative contributions were less mortality reductions from cerebrovascular diseases and other cardiovascular diseases and mortality increases from chronic obstructive pulmonary diseases, mental disorders and diabetes mellitus. However, there were some causes of death that still showed declines in mortality, but did not have large effects on life expectancy and therefore reached no further increase of life expectancy at age 85.

Janssen et al. (2005) studied the birth cohorts 1865–1935 and found that the mortality decline at 60+ stagnated for males for the birth cohorts 1890–1915 and for females born after 1920.

At very old age 80–99 there was sustained decline of mortality since 1965 for women and since 1977 for men (Kannisto 1994). However, Janssen et al. 2003 found that mortality rates at ages 80–84 and 85–89 only fell until 1980 and stagnated since then. At ages 90–94 and 95+ they also fell until 1980 but increased thereafter. Causes of death that contributed to the stagnation of mortality decline in the Netherlands were smoking related diseases and diseases related to old age (Janssen et al. 2003).

France

France is remarkable in the group of Western European countries because it showed a stronger decline in mortality and therefore, a stronger increase in life expectancy at the end of the 1990s. Kannisto (1994) characterized French mortality as declining very regular, rapid and sustained over the post-war period.

In contrast to other countries, French women experienced only a little slowdown in the 1960s and a rapid mortality decline after 1970. Between 1994 and 1996 they had the high-

est life expectancy at birth in Europe with 82 years. Only in Japan life expectancy was higher (83.1 years) (Vallin and Meslé 2001).

Remarkable of French mortality is that the decline did not slow down after the mid-1980s (Vallin and Meslé 2006) and that in contrast to European low-mortality countries mortality from diseases related to old age did not increase (Janssen et al. 2004). The mortality decline at ages 65–70 were steeper than for example in the United States and The Netherlands. This pattern is similar to Japan, where it was even steeper than in France (Vallin and Meslé 2006).

In France, gains in life expectancy between 1968 and 1984 came from mortality declines at ages 65–80. For the period 1984–2000 there were still declines of mortality for the ages 65–100, where reductions were strongest for the ages 70–90. The reduction of mortality at advanced ages was mainly due to improvements in mortality from cardiovascular and cerebrovascular diseases (Meslé and Vallin 1999, Vallin and Meslé 2006).

Trends in mortality in the Southern European countries

A special characteristic of the Southern European countries is that they had lower life expectancy in the 1950s than the Northern, Western, and Central Western European countries. Especially for men life expectancy was very low. However, these countries had a very strong increase of life expectancy at birth and have caught up with the other European countries in the 1990s.

Italy

In Italy, as in other industrialized countries, females experienced mortality declines at a higher pace than males. Before the beginning of the 20th century, life expectancy at birth was at a similar level for both sexes. The slow mortality decline of males led to an increased sex gap in mortality in the end of the 20th century. Since the 1970s mortality decline accelerated for males. Life expectancy at birth was 62.4 years for males and 66 years for females in 1965 (Table 7). Compared to the Northern and Western European countries this was rather low. However, it increased to 74.3 years for males and 80.3 years for females in 1995 and to 76.8 years for males and to 82.5 years for females until 2004 (VID/IIASA 2006).

Until 1980 male mortality was mainly reduced at ages below 50. Since then male mortality reductions at ages beyond 50 primarily contributed to the increase of life expectancy

at birth. In contrast, female mortality showed steeper and more consistent declines at all ages up to age 80 over the whole time period. Compared to the two country groups mentioned before, in Italy, also the decline of infant mortality had a large impact on the increase of life expectancy (Vallin and Meslé 2001).

In the future, mortality changes at very old ages will play an important role. This will be especially due to mortality declines from cardiovascular and from respiratory tract diseases which will be reached by medical prevention and treatment of diseases (Caselli et al. 2003). Caselli et al. (2003) report that especially for women, mortality is increasingly concentrating on old ages. In 1995, 85% of the deaths were after age 70. Of them 64% were after age 80.

Large regional differences between the North and the South existed before and after the 1970s. Between the 1970s and the 1990s male mortality at age 60+ was higher in the North than in the South of Italy. The gap, however, decreased slightly due to large decreases of mortality over time. In contrast, for females, the pattern was different. For them mortality at age 60+ was lower in the North than in the South. As well as for men, females experienced large mortality declines in the North. That is why for females the gap between the North and the South increased from the 1970s to the 1990s. The strong decline of mortality at older ages in the North of Italy was caused by strong declines of mortality from cardiovascular diseases.

Trends in mortality in the Central and Eastern European countries

Mortality changes in Central and Eastern Europe were not as constant and favourable as in the other European countries. Especially in Eastern Europe, in countries of the former USSR, mortality was high. In all countries, trends were more favourable for females than for males.

Life expectancy in Central Europe started in the 1950s at a substantially lower level than in Western and Northern European countries, but at a slightly higher level than in the Southern countries. Over the time, female life expectancy at birth increased steadily but at a slow pace. Male life expectancy, in contrast, increased strongly only until the early 1960s but stagnated until the time around 1990, which is marked by political changes. The changes in life expectancy at birth were characterized by increased mortality at working ages due to increased mortality from circulatory diseases, cancer, and digestive diseases. However, this development contributed more to male mortality and to a less extent to fe-

male mortality. The positive trend in the 1990s was affected by decreased mortality from circulatory diseases (Meslé 2004).

In Eastern Europe mortality was even less favourable than in Central Europe. Life expectancy increased sharply between 1950 and 1965 from a very low level. However, progress did not sustain. Life expectancy stagnated for women since then. For men it stagnated or slightly decreased until the early 1970s and decreased since then. Between 1985 and 1995 life expectancy showed strong fluctuations, especially for men. Until the mid-1990s they lost partially 5 years of life expectancy (Meslé 1997). However, it seems that there was a sustained positive trend since the mid-1990s (Vallin and Meslé 2001). Western, Northern and Southern European countries experienced general mortality declines over the whole life course since the 1950s, whereas countries of Eastern Europe partially experienced increases at adult ages (e.g. Hungary) and at old ages (e.g. Russia, Ukraine). This was mainly due to increased mortality from cardiovascular diseases and from violence and alcohol related deaths, which both played an important role. This mortality pattern can be found at a higher extent for males than for females (Meslé 1997, Shkolnikov et al. 2004).

In Table 7, a brief overview is given over the increase of life expectancy at birth for a selection of countries reflecting the geographical regions of Europe from 1950–1995.

Table 7. **Life expectancy at birth in Europe for the time period 1950–1995.**

Country	men				women			
	1950	1965	1980	1995	1950	1965	1980	1995
Denamrk	68.8	70.2	71.2	72.7	71.4	74.7	75.3	77.9
Sweden	69.8	71.7	72.8	76.3	72.5	76.1	78.9	81.4
Germany	64.7	67.8	69.6	73.3	68.4	73.5	76.1	79.7
France	62.9	67.7	70.2	73.9	68.5	74.9	78.4	82
Netherlands	69.2	71.1	72.4	74.6	72	76.1	79	80.3
Greece	63.4	68.7	72.2	75	66.7	72	76.4	80.1
Italy	62.4	67.4	70.8	74.3	66	72.9	77.7	80.7
Hungary	59.5	67	65.7	65.4	63.7	71.8	73	74.5
Poland	55.7	66.9	66.9	67.8	61.5	72.8	75.4	76.3
Russia	51.9	64.4	61.5	58.5	60.5	73.4	73.1	71.8

Source: Vallin and Meslé (2001), p.48-49

Trends in mortality in the United States

In the United States mortality rates declined in the period 1900–1999 by 58% for men and by 69% for women, whereas mortality rates declined most between 1940 and 1952 due to changed lifestyle habits during the Second World War. However, female mortality decline slowed remarkably down since 1975.

Trends in mortality at very old ages

Mortality was not only declining at working ages and ages after retirement. It was also declining at very high ages. Declining mortality at very high ages on the one side had an impact on the increase of life expectancy. However, this impact was low. On the other side, declining mortality at high ages saves lives. This resulted in increasing numbers of people reaching higher ages above 80. Furthermore, this led to increasing numbers of centenarians (100+) and supercentenarians (110+).

It was observed that mortality did not increase exponentially at the oldest ages. It rather decelerates (Lynch and Brown 2001). The process of declining mortality at very high ages over time as well as not exponentially increasing mortality rates with age, reflect a slow down in the pace of ageing (Vaupel 1997, Lynch and Brown 2001).

Trends in mortality at age 80+

Mortality declined at all ages and even after age 80 since the 1950s (Oeppen and Vaupel 2002). Especially striking is the accelerated survival improvement at very old ages 80–99, which started in the 1970s as Vaupel showed for aggregated data from Austria, Belgium, England and Wales, France, West Germany, Japan, Scotland, Sweden, and Switzerland (Kannisto-Thatcher oldest-old database). As a consequence of the improvement, lives were saved also at older ages and life expectancy increased (Kannisto 1994, Vaupel 1997). A further consequence is the increasing number of people surviving to very old ages.

Since the 1950s mortality rates at age 80+ were declining. The highest impact on this decline of total mortality had the decline of cardiovascular diseases (Kesteloot et al. 2002). In the group of the Northern European countries (Denmark, Finland, Norway, and Sweden) cross national differences in 1950 were higher than in Western European countries (England and Wales, France, and The Netherlands). Norway had the lowest level of mortality at age 80+ for both sexes. The highest mortality was in Finland as already found for trends in life expectancy at birth above. Until 1999 cross national differences nearly disappeared.

However, mortality was slightly higher for the Western than for the Northern countries. Compared to all countries France reached the lowest mortality and The Netherlands had the highest in 1999 for both sexes. In the group of the Northern countries, Danish males and Finnish females had the highest mortality. The decline of mortality in the Western European countries showed a nearly linear and more constant decline than the Northern countries for both sexes. The pace of decline was highest in England and Wales, and in France. However, in the Netherlands there was stagnation in mortality rates since 1980 for both sexes and even a slight increase for males. The decline in the Northern countries was steeper than in Western Europe between 1960 and 1980 but then levelled off and declined at a slower pace. For males in Norway and Denmark there was even stagnation sine 1980 (Janssen et al. 2004).

The stagnation in Denmark, The Netherlands, and Norway might be explained through an increased lifetime exposure to smoking (Janssen et al. 2004). France has a special position because it did not experience increases in old age related mortality, whereas all other countries did. In all countries the most important causes of death are cardiovascular diseases.

Compared to the USA it seems that mortality at very old age is higher in Europe. Vaupel (1997) compared the Upper Midwest and Deep South of the USA at age 65 and over with Europe. He found that mortality before age 65 was higher in the USA than for example in Sweden, France, England, and Japan (Manton and Vaupel 1995, Vaupel 1997). However, death rates at age 90 were substantially higher in Europe than in the USA.

Kesteloot et al. (2002) showed that age-adjusted mortality rates for ages 75–84 were lowest both for the USA and Canada from 1970 until 1982. Since 1982 Japan had the lowest old age mortality.

Trends in mortality of Centenarians and Supercentenarians

Mortality decline in low-mortality countries is spread over all ages. As already mentioned mortality rates were declining even at ages 80–99. The mortality development caused that more people were reaching were very high ages. By the end of the 20th century it was observed that death rates were falling also after age 100 (Oeppen and Vaupel 2002). Therefore, life expectancy was increasing also at very old ages and the number of people reaching their 100th birthday increased too.

Vaupel gave an example for the rapid increase of the number of centenarians for England and Wales: between 1911 and 1920, on average 74 people reached age 100 every year. In 1990 this number was nearly 2000 per year. He stresses that the mortality reduction after age 80 was the most important factor for the enormous growth of the population of the centenarians.

Furthermore, not only the number of centenarians increased enormously since the mid-1950s, but also the number of supercentenarians increased. Supercentenarians are people who reached age 110 and over. Robine and Vaupel (2002) observed, on the basis of the International Database on Longevity (IDL), that the number of supercentenarians has shown an exponential increase since the mid-1970s.

Trends in development of the maximum age at death

In theoretical approaches life expectancy at birth was estimated and forecasted since the early 20th century. However, these estimates were always exceeded by reality shortly after publication (Oeppen and Vaupel 2002).

The substantial mortality reduction after age 80 contributed to the increase of the maximum human lifespan. The today known highest reached age is 122 years. Mme. Jeanne Calment has died in August 1997 and had lived 122 years and 5 months (Vaupel 1997).

In Sweden, for example, maximum age at death was reported to have been 101 in the 1860s and increased to 108 in the 1990s. There was a steady increase in the maximum age at death which accelerated around 1969. This increase was mainly caused by reduction of old age mortality. With 72.12% the mortality reduction above age 70 contributed to the increase of the maximum age at death. The acceleration in increase of the maximum age was caused by accelerated decline of old age mortality in Sweden (Wilmoth et al. 2000). In Switzerland the maximal age at death increased from 102 between 1880 and 1920 to 104 for the period 1920–1960 and currently to 110 (Robine and Paccaud 2005). The country showed an accelerated increase of maximal human age, too.

Referring to the IDL Robine and Vaupel (2002) conclude that the maximum age at death in Western and Northern European countries has increased by 10 years from 112 to 122 years over a period of about 20 years since the 1980s.

Summary

Life expectancy in industrialized was substantially increasing for 160 years by 3 months per year. In Europe life expectancy at birth was increasing to a high level in the Northern, Western, Southern, and Central Western European countries. Central European countries were catching up since the mid-1990s.

Mortality declines since the 1950s were concentrated at ages after retirement. Thus the contribution of mortality decline at older age groups to the increasing life expectancy was increasing but decreasing for young ages.

Mortality declines since the 1950s differed over time between countries and sexes. Females experienced earlier declines of mortality at higher pace than men. The levels and patterns of increased life expectancy can be characterized by geographical regions. Mortality levels are very low in the Northern and Western European countries, today, due to steady mortality declines over time. Main cause of the mortality decline, which was concentrated at higher ages, was reduction of mortality from cardiovascular diseases.

There are countries like Denmark, The Netherlands and France showing different patterns of mortality change according to the geographical regions they belong to. In Denmark and The Netherlands, mortality declines at high ages stagnated since about the 1980s. For The Netherlands causes of the mortality decline were less reduction of mortality from cerebrovascular and other cardiovascular diseases at ages 80+. Moreover, mortality from chronic obstructive pulmonary diseases, mental disorders, and diabetes mellitus increased. For both countries, Denmark and The Netherlands, increased mortality from smoking related diseases due to increased smoking habits were mentioned.

Southern European countries started with high levels of mortality and experienced steep declines over time. They reached mortality levels similar to the Northern and Western European countries in the 1990s. However, mortality changes in Eastern European countries were less favourable. The development of life expectancy at birth in countries of the former Russian Federation was marked by fluctuations showing more stagnant and even more decreases for males and less fluctuation but stagnation and low increases for females since the 1950s. There is still enough space to catch up with the rest of European countries. Central European countries had less unfavourable trends. Life expectancy at birth was stagnating for a long time. Since the mid-1990s it showed a positive trend.

Mortality decline in the second half of the 20th century was marked by declines at working ages, ages after retirement and strikingly, at very high ages 80+. These latter declines

had impact on the number of people surviving to high ages. Terms like octogenarians (people ages 80+), nonagenarians (90+), centenarians (100+) and even supercentenarians (110+) were formed since the numbers of people reaching these high ages increased enormously since the first validated cases were collected in the 1960s. The highest age at death ever observed was 122. The French Mme. Jeanne Calment has died in 1997 at this age.

Trends in mortality differentials by sex

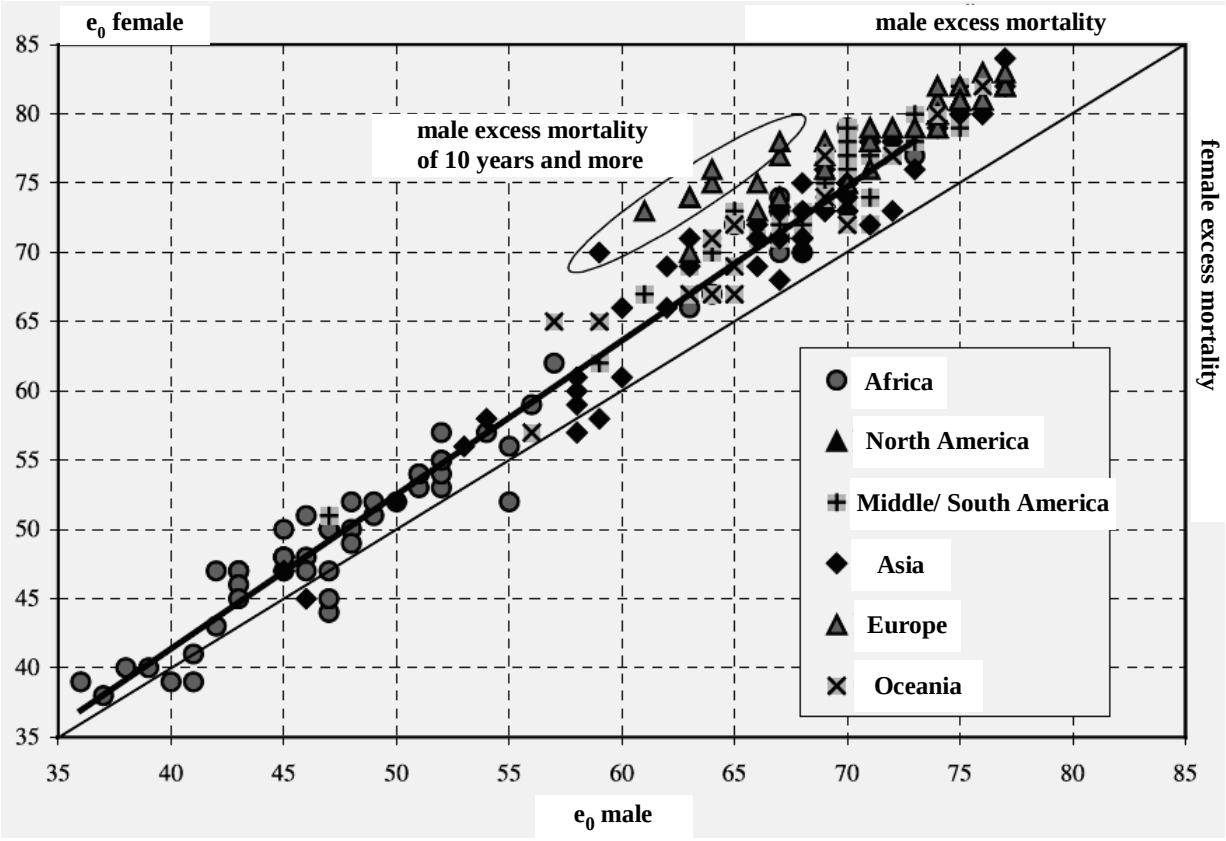
For more than 50 years there have been substantial differences in mortality in males and females and between countries (Vallin and Meslé 2001). Women show clear mortality advantages compared to men. In the following part an overview will be given over the development of all-cause mortality differences between males and females for different countries or groups of countries.

The advantage of women is explained in two ways. There are biological and non-biological explanations (Kruger and Nesse 2004, Luy 2002, Gjonça et al. 2005). Biological explanations stress that there are genes and hormones that protect women from different diseases. Different hormones also influence the behaviour of men and women in different ways. The non-biological explanations give behavioural, environmental and socio-cultural reasons for the excess mortality of men. It is known that men adapt more risky behaviours than females (Luy 2002). Because of that, men are more prone to mortality than women due to alcohol and smoking related diseases, and to external causes of death like accidents, injuries and violence (Kruger and Nesse 2004, Gjonça et al. 2005).

There are different ways to examine differences in mortality between the sexes. A common way is to compare life expectancies. This makes it possible to compare countries with each other. However, this measure is a comprehensive one, which does not show changes and trends in mortality at different ages. Another possibility is to calculate mortality sex ratios from age and sex specific death rates. This is more exact since it makes it possible to compare and show trends at exact ages.

Trends in sex differentials in life expectancy at birth

To start with, Figure 4 gives an overview over male excess mortality measured by life expectancy at birth. It shows that in the year 2000, males have higher mortality than females all over the life course. This excess mortality is especially high in Asia and Europe (Luy 2002).



Source: Luy (2002)

Figure 4. Illustration of male excess mortality with life expectancy at birth of all nations of the world in 2000.

Gjonça et al. (2005) examined trends in sex differences in mortality by comparing life expectancies at birth and at age 65 for several developed countries. They looked at changes between 1980 and 2002 in the following countries: Sweden, the United Kingdom, Greece, Germany, Finland, Spain, France, Poland, Hungary, Russian Federation, the USA, and Japan. The study revealed that in 1980 sex differences were lowest in Greece and Japan with 4.6 years and 5.4 years of higher life expectancy at birth for women. They were highest in Poland (8.4 years), Finland (8.5 years), and with distance in the Russian Federation (11.6 years). The median difference of all countries was 6.85 years in 1980. In the year 2002 Sweden (4.4 years) and the United Kingdom (4.7 years) had the lowest differences. The highest differences still were in Poland (8.4) where the difference nearly did not change, in the Russian Federation (13.2 years) and in Hungary (8.4 years) where the difference increased by 1.6 years. The median difference in 2002 was slightly lower than in

Table 8. Sex differences of life expectancy at birth (a) and at age 65 (b) in years and change in years for the time period 1980–2002.

a	1980	2002	change in years
Sweden	6	4.4	-1.6
UK	6	4.7	-1.3
Greece	4	5.2	1.2
US	7.4	5.4	-2.0
Germany	6.5	5.8	-0.7
Finland	8.5	6.6	-1.9
Japan	5.4	6.9	1.5
Spain	6	6.9	0.9
Hungary	7.2	7.4	0.2
France	8.1	7.4	-0.7
Poland	8.4	8.3	-0.1
Russian Federation	11.6	13.2	1.6
median	6.85	6.75	

b	1980	2002	change in years
Greece	1.9	2.4	0.5
US	4.2	3	-1.2
Sweden	3.6	3.1	-0.5
UK	4	3.1	-0.9
Germany	3.4	3.6	0.2
Hungary	3	3.8	0.8
Spain	3	3.9	0.9
Poland	3.5	3.9	0.4
Finland	4.2	3.9	-0.3
Russian Federation	4.9	4.2	-0.7
France	4.2	4.4	0.2
Japan	3.1	4.9	1.8
median	3,55	3,85	

Source: Gjonça et al. (2005)

1980 with 6.75. Table 8 shows the change in years over time for all countries. Sex differences of life expectancy at birth decreased clearly in the USA, Finland, Sweden, the United Kingdom, Germany, and France. In Poland and Hungary it nearly did not change, and increased clearly in Spain, Greece, Japan and the Russian Federation (with an increase of 1.6 years) over the period 1980–2002. To conclude the mortality differences for life expectancy at birth decreased in 6 of 12 countries over the period 1980–2002.

Trovato and Heyen (2003) examined the change of mortality differences between the sexes in Sweden and Japan, two countries with exceptionally low mortality and high life expectancies at birth for both sexes. In Sweden mortality differences already persisted before 1900. Until the 1950s life expectancy at birth was between 2 and 3 years higher for women than for men. This gap started to widen consistently until the beginning of the 1980s were it reached a level of about 6 years difference between the sexes. After that it slightly declined until the end of the 1990s to a difference between male and female life expectancy of 5 years. As Gjonça et al. (2005) found, the difference in Sweden declined further until 2002 with 4.4 years difference. The progress in Japan was different to Sweden. In Japan no convergence of sex-specific mortality has been observed since the first

decade of the 20th century. In the beginning of the century sex differences of life expectancy at birth were minimal. However, differences grew permanently over time. At the end of the 1990s Japanese women had a life expectancy at birth that was about 7 years higher than for men (Trovato and Heyen 2003). Gjonça et al. (2005) found a comparable difference of 6.9 years for 2002.

In a further study of Trovato and Heyen (2006) they examined the trend of sex differences of life expectancy at birth for all G7 countries (Canada, France, Germany, Italy, England and Wales, and the USA). They found that the sex gap of these countries increased until the 1980s and then started to decrease slightly due to a slowing down of the increase of the female life expectancy at birth (for the USA confirmed by Kesteloot 2002). The highest sex gap at life expectancy at birth existed in France since the 1950s until 1999 with a difference of about 7.5 years. The lowest sex gap in 1999 was in England and Wales with a difference of about 4.5 years. These results are consistent with Gjonça et al. (2005). Vallin and Meslé (2001) also observed convergent trends of life expectancy at birth for several other European countries. This trend started between the mid-1970s and early 1980s. Clear downward trends of the sex differences of life expectancy at birth were found in Iceland, Sweden, Denmark, Norway, and Finland. Slightly lower downward trends were apparent in Germany, Austria, Switzerland, and Luxembourg, further in The Netherlands, Ireland, United Kingdom, Belgium, and France. Central European countries and countries of the Russian Federation showed high and still increasing differences in the mid-1990s (Vallin and Meslé 2001).

Trends in sex differentials in life expectancy at age 65

Sex differences of life expectancy at age 65 in 1980 appeared to be lowest in Greece (1.9 years) and in Hungary (3 years). They were highest in Finland (4.2 years), France (4.2 years) and the Russian Federation (4.9 years). In 2002 the lowest differences were found in Greece, the USA, and the United Kingdom. The highest differences were in France (4.4 years) and Japan (4.9 years). As already found for life expectancy at birth, the sex differences of life expectancy at age 65 decreased clearly in the USA, the United Kingdom, Sweden, and Finland and additionally in the Russian Federation. It nearly did not change in Germany and France and increased in Poland, Greece, Hungary, and Spain by 0.4–0.9 years and especially clearly in Japan by 1.8 years.

Trends in sex differentials in death rates

As already mentioned males have higher mortality at all ages. However, mortality differences between the sexes are not equal over the life course. These differences over the life course show a remarkable peak at young adult ages. This is due to external causes that affect more male than female mortality. External causes are connected directly to risky behaviour like smoking, drinking, poor diet in a whole, and accidents and injuries that is adapted more by males than by females (Kruger and Nesse 2004). There is a second peak of male excess mortality around age 60. This is due to internal causes which are age related chronic degenerative diseases especially cardiovascular diseases that affect more males than females.

Kesteloot et al. (2004) and Zhang et al. (1995) examined trends in sex differentials of mortality by calculating sex ratios of age-specific death rates. From these studies the results for the countries Sweden, Finland, the United Kingdom, Germany, France, Spain, Greece, Poland, Hungary, and Russian Federation that were used by Gjonça et al. (2005) will be illustrated in the following.

Kesteloot et al. (2004) looked at changes between 1969/71 and the latest available year of data for these countries, which is between 1996 and 2000 for the age groups 45–74 and 75–84. Results show that in 1969/71 in Greece, Hungary, Japan, Sweden, Spain, Poland, Germany, and England and Wales male mortality at ages 45–74 was 60–90% higher than female mortality. It was 2–2.2 fold in the USA, France and Finland. The sex ratio has risen until 1996/2000 in almost all of these countries except for the United Kingdom and the USA where it decreased by about 30 percentage points (PP). As visible in Table 9 nearly all sex ratios reached a level over 2 in 1996–2000, except for the United Kingdom, the USA, and Sweden where it was lower than 2. The highest increases occurred in Spain and Hungary with 70 PP and 61 PP.

For the age group 75–84 the sex ratios were smaller than at the younger ages and ranged between 1.2 for Greece and 1.6 for England and Wales at the beginning of the period 1969/71. Again it rose over time for all countries except from the United Kingdom and the USA were it slightly decreased. Table 9 shows the changes of the sex ratios in percentage points for several European countries, the USA, and Japan for the period 1969/71–1996/2000. The highest increases in this age group occurred in Spain and Japan with a 39 PP and 51 PP increase, respectively. In 1996/2000 the sex ratio ranged from 1.3 for Greece and 1.9 for Japan (Kesteloot 2004).

Table 9. Mortality sex ratio in Europe, and the USA in 1969/71 and 1996/2000 and change over time in percentage points and percent for ages 45–74 (left) and 75–84 (right)

age 45-74	1969/71	1996/ 2000	change in PP	relative change in %
England and Wales	1.9	1.6	-31.0	-16.0
US	2.0	1.7	-30.0	-15.4
Sweden	1.7	1.8	4.0	2.3
Greece	1.6	2.0	46.0	29.3
Germany	1.9	2.0	17.0	9.1
Japan	1.7	2.3	56.0	32.7
Hungary	1.7	2.3	61.0	36.3
Finland	2.2	2.3	13.0	5.9
Poland	1.9	2.4	52.0	28.1
France	2.2	2.4	26.0	12.1
Spain	1.8	2.5	70.0	40.0

age 75-84	1969/71	1996/ 2000	change in PP	relative change in %
England and Wales	1.6	1.6	-3.0	-1.9
US	1.5	1.5	-3.0	-2.0
Sweden	1.3	1.7	32.0	23.9
Greece	1.2	1.3	13.0	11.0
Germany	1.4	1.6	24.0	17.8
Japan	1.4	1.9	51.0	36.4
Hungary	1.3	1.5	20.0	15.6
Finland	1.3	1.7	36.0	27.3
Poland	1.4	1.5	12.0	8.8
France	1.5	1.8	27.0	17.5
Spain	1.3	1.7	39.0	29.3

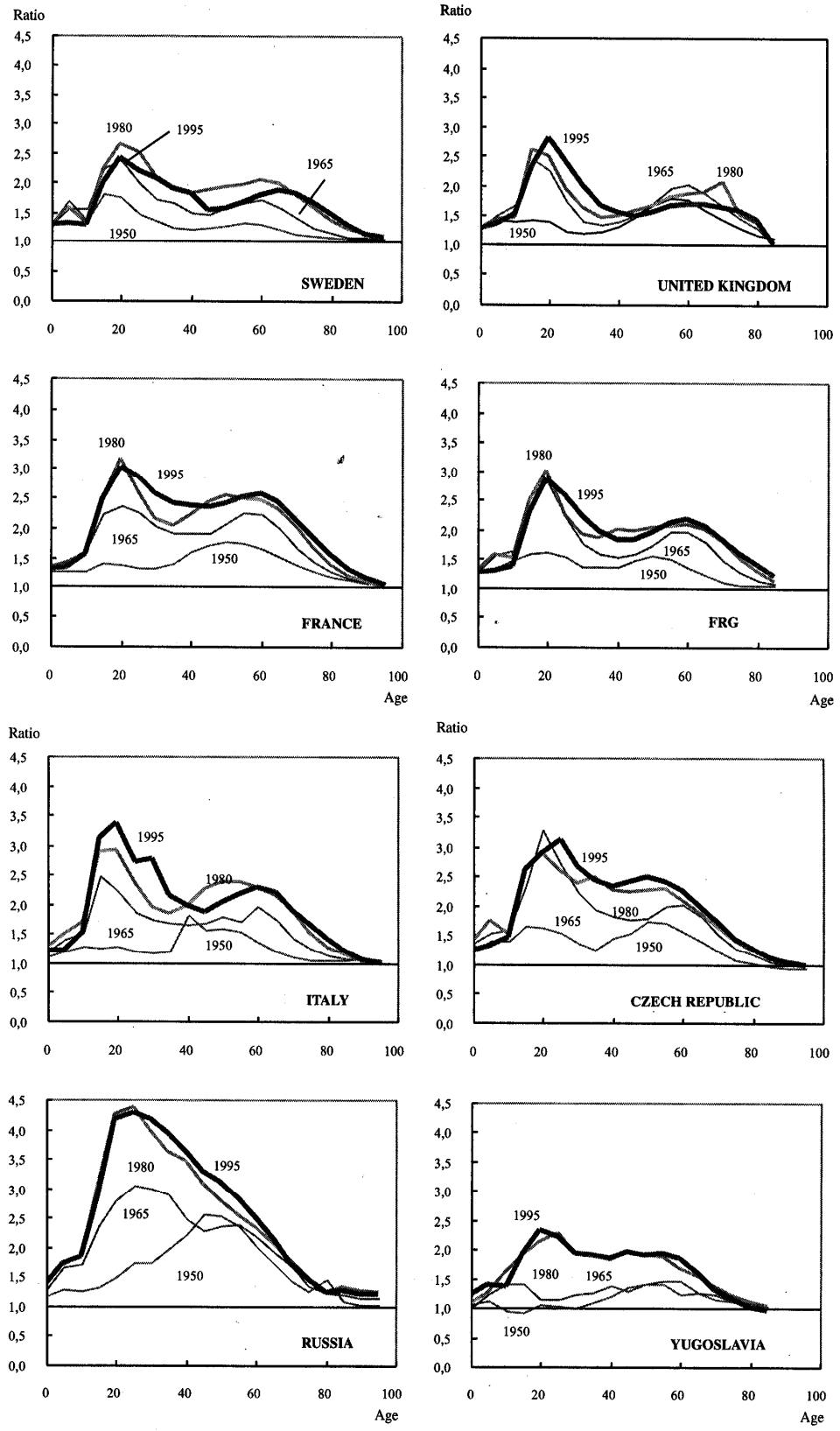
Source: Kesteloot et al. (2004)

Table 10. Relative change of mortality sex ratio in percent in Europe and the United States for ages 45–54, 55–64, and 65–74 for the time period 1956–1988.

	age 45-54	age 55-64	age 65-74
England and Wales	-3.0	-11.0	6.4
US	0.0	-4.3	8.0
Sweden	23.7	32.2	55.6
Greece	31.4	31.7	21.2
Germany	22.4	21.1	43.2
Japan	40.6	40.8	34.7
Hungary	69.1	52.0	44.0
Finland	15.1	25.0	37.8
Poland	-		
France	25.5	31.2	37.6
Spain	47.5	44.6	43.0

Source: Zhang et al. 1995

Zhang et al. (1995) showed changes of the sex ratios of mortality for the age groups 45–54, 55–64, and 65–74 for the period 1956–1988. Relative changes over this period for the three age groups are shown in Table 10. They show that relative changes in mortality differences for the sexes had the same direction as they were recognized by Kesteloot (2004).



Source: Vallin and Meslé (2001), p. 152

Figure 5. Age specific male excess mortality in 1950, 1965, 1980 and 1995 in eight significant countries.

However, the relative changes for the period 1956–1988 (Zhang et al. 1995) were higher than for the later period 1969–2000 (Kesteloot et al. 2004).

In contrast to the ages up to 84 years discussed above, Kannisto (1994) showed that the sex ratio of mortality at very high age, namely of ages 80–99, had increased over the period 1960/64 to 1985/89. In 1985/89 it ranged between 1.24 for Spain and 1.48 for Netherlands.

Vallin and Meslé (2001) went further and showed changes of the age specific sex ratio over the whole life course for the period 1950–1995 for the high-income countries Sweden, the United Kingdom, France, and the Federal Republic of Germany, further for Italy, Czech Republic, Russia, and Yugoslavia. As is visible in Figure 5 the peak of male excess mortality at young adult ages increased until 1980 to the highest level and decreased slightly until 1995 in Sweden, France, FRG, Czech Republic, and Russia. For the United Kingdom, Italy and Yugoslavia it increased until 1995. The second peak around age 60 was for nearly all countries highest in 1995, except for the United Kingdom, where it was highest in 1965, and for Russia, where there was no second peak at high age. Clearly visible is that the excess mortality of men increases over time and shifts to higher ages, due to reduced mortality at every age.

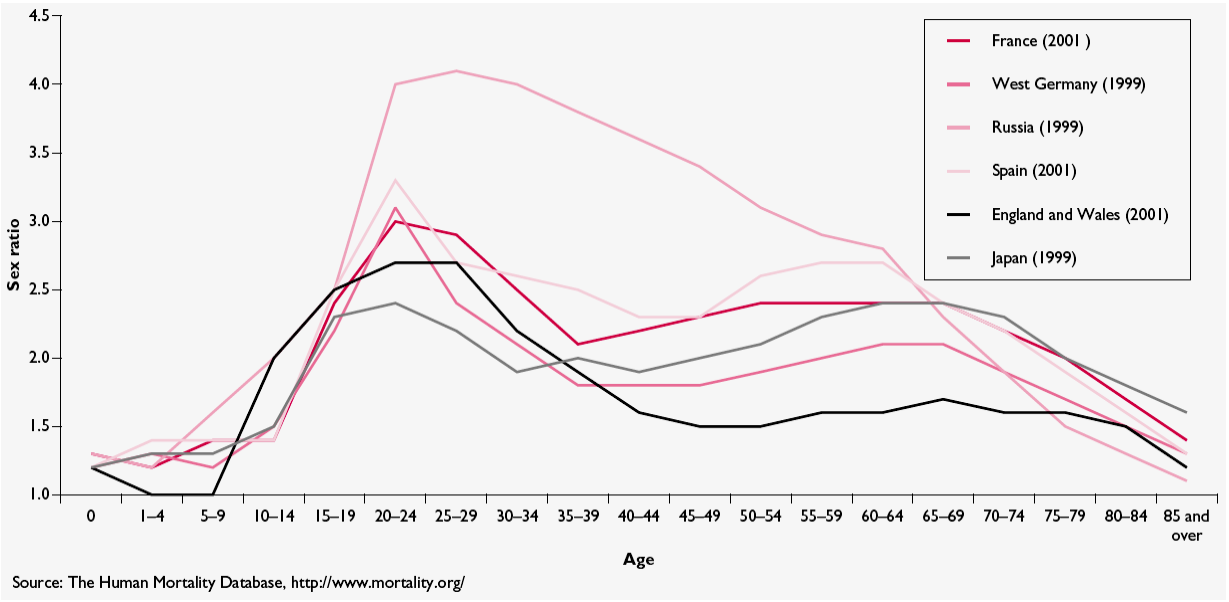
Two further graphs (Figure 6a and 6b) from Gjonça et al. (2005) show the relative male excess mortality over the whole life course for France, West Germany, Russia, Spain, England and Wales, and Japan for the years 1980 and the latest year of available data 1999/2001 in more detail. Up from young adult age on, France had, apart from Russia, the highest sex ratio over all ages in 1980. The lowest excess mortality at all ages was in England and Wales. As already found this fact also applies for life expectancy at birth. Until the end of the 1990s the picture changed. Apart from Russia, Spain had the highest male excess mortality from age 15–19 to age 65–69. At very old ages Japan had the highest excess mortality at the end of the 1990s.

Mortality differences by sex in Denmark and Canada

In the following, changes in sex differentials in mortality will be shown for different age groups with the help of Denmark and Canada. For Denmark the period 1943–92 is considered for illustrating changes in sex differentials in mortality at ages 45–74 (Helweg-Larsen and Juel 2000) and for Canada the period 1921–1997 for ages 20–89, respectively (Andreev 2000).

a

b



Source: Gjonça et al. (2005)

Figure 6. Age specific sex ratio for France, West Germany, Russia, Spain, England and Wales, and Japan in 1980 (a) and 1999/2001 (b).

In Denmark male excess mortality was about 1.1–1.2 in 1943/47 at adult ages. That means the male mortality was 10–20% higher than the female mortality. It rose constantly since then for the three age groups 45–54, 55–64, and 65–74 until 1963/67. For the youngest age group it remained nearly stable from this point of time at 1.5 until 1992. For the middle age group 55–64 it stagnated since 1963/67 and fell since 1978/82 to a level of 1.6.

For the oldest age group the sex ratio of mortality rose until 1978/82 to a level around 1.9 and started to decrease then to 1.7 in 1992. It turned out that the main reason for sex differences in Denmark was differential mortality by sex from cardiovascular diseases.

In Canada in 1921 there were small differences between the sexes. For the ages 20–49 mortality was slightly higher for women than for men, for the ages 50–89 it was the opposite situation. Since female mortality started to decline the sex gap grew until the mid-1970s. Then male mortality also started to decline, female mortality still declined but at a slower pace. This led to a convergence of the death rates and a reduction of the sex gap. This reduction appeared since 1980 at ages 40–69; for the ages 20–29 and 70–79 since 1990. Strikingly, the increase of the sex gap continued for the ages 30–39 and 80–89. As well as for Denmark, the main reason for the sex gap at adult ages in Canada is the higher male mortality from cardiovascular diseases and from cancer.

Forecast of sex differentials

Pampel (2005) forecasted the proportional change in the logged total mortality sex ratio. He calculated the proportional change with and without fixed effects for "nation dummy variables that control for national differences in the timing of cigarette diffusion and other stable factors that influence the logged mortality" ratio (Pampel 2005, p.465). Table 11 shows the predicted proportional change in logged total mortality ratio from 2000 to 2020. Results are shown for basic and fixed effect models for the ages 0–34, 35–69, 70+, as well as for all age groups together in one model.

For ages 0–34 the forecast predicts an increase of mortality differentials on average by 8.8% for all countries in the basic model. Country specific, the increase ranges from a 7.8% increase in Finland to 11.7% in the Netherlands.

In the basic model for the ages 35–69 there will be an increase of sex differences in most of the countries. The increase will range between 0.8% in Switzerland and 19.3% in New Zealand. The sex differences will decrease in Spain, Portugal, Greece, Japan, Italy, Belgium, and Finland. In the fixed effects model the difference will decrease in the countries mentioned above, as well as in Germany, France, Austria, The Netherlands, and Norway. The decrease will range between -0.4% in Portugal and 24% in Belgium. In contrast, an increase of sex differences in mortality is predicted for Switzerland, Australia, New Zealand, Sweden, Denmark, Canada, Ireland, the USA, and the United Kingdom until 2020.

For ages 70+ in the basic model a reduction of sex differences is forecasted in all countries analysed by Pampel (2005) except for Sweden, as is shown in Table 11. The decrease ranges between 6.5% in Portugal and 30.1% in Greece. However, in the fixed effects model there will be a slight increase of the sex gap in Sweden, Canada, the USA, and the United Kingdom. For all remaining countries the difference will decrease.

For all ages together, a common trend is predicted. In the basic model as well as in the fixed effects model for most countries sex differences in mortality will increase. In the fixed effects model the increase will range between 0.5% in Italy and 14% in the United Kingdom. For the countries Spain, Greece, Japan, and Belgium the sex gap is predicted to decline.

Table 11. Predicted proportional change in logged total mortality sex ratio from 2000 to 2020, by Nation and Cigarette Diffusion Measure.

Nation	Cigarette Diffusion Measure	Ages 0-34 Fixed Effects No	Ages 0-34 Fixed Effects Yes	Ages 35-69 Fixed Effects No	Ages 35-69 Fixed Effects Yes	Ages 70+ Fixed Effects No	Ages 70+ Fixed Effects Yes	All Ages Fixed Effects No	All Ages Fixed Effects Yes
Spain	3.3	.088	.078	-.120	-.134	-.207	-.141	-.018	-.045
Portugal	3.4	.088	.083	-.046	-.004	-.065	.036	.026	.053
Greece	3.4	.088	.099	-.261	-.432	-.301	-.621	-.116	-.230
Japan	3.6	.088	.104	-.096	-.136	-.248	-.149	-.022	-.051
Switz.	3.7	.088	.082	.067	.008	-.165	-.053	.093	.038
Italy	3.8	.088	.083	-.050	-.084	-.188	-.070	.025	.005
Germany	3.8	.088	.089	.026	-.021	-.189	-.057	.069	.028
Belgium	3.9	.088	.087	-.132	-.240	-.274	-.260	-.014	-.094
Australia	4.1	.088	.087	.076	.017	-.180	-.020	.112	.057
France	4.2	.088	.081	.052	-.006	-.171	-.054	.079	.026
NZ	4.2	.088	.088	.191	.193	-.082	.084	.187	.152
Austria	4.3	.088	.079	.000	-.032	-.195	-.050	.054	.026
Nether.	4.3	.088	.117	.139	-.021	-.148	-.166	.144	.008
Sweden	4.3	.088	.096	.077	.041	.097	.010	.106	.073
Denmark	4.6	.088	.086	.048	.028	-.150	-.023	.081	.058
Canada	4.6	.088	.088	.166	.106	-.152	.018	.171	.101
Finland	4.8	.088	.074	-.006	-.092	-.127	-.034	.071	.000
Ireland	4.9	.088	.100	.142	.084	-.128	.054	.150	.103
Norway	5.4	.088	.084	.008	-.008	-.154	-.038	.060	.039
US	5.4	.088	.086	.164	.121	-.138	.053	.164	.110
UK	6.1	.088	.100	.236	.161	-.077	.081	.204	.140
r with Diffusion	1.000	.000	.104	.682	.590	.499	.507	.686	.596

[a] Based on assumed falling rate of increase (or decrease at ages 70+)

Source: Pampel (2004)

Summary

The review showed that male excess mortality was remarkable increasing since the 1950s in industrialized countries.

Sex differences in life expectancy are shown to be especially high in Asia and Europe in 2000. However, in the 1980s there was a turning point. For several countries the sex gap did not increase anymore. For a number of low-mortality countries the sex gap of life expectancy decreased since the 1980s to the end of the 1990s in the USA, Finland, Sweden, the United Kingdom, Germany, France, Iceland, Denmark, Norway, Austria, Switzerland, Luxemburg, The Netherlands, Ireland, Belgium. However, it went on increasing in Southern European countries (Spain and Greece), Japan, the Russian Federation, and Central

European countries. For life expectancy at age 65 a similar pattern was observed. The sex gap decreased in the USA, the United Kingdom, Sweden, Finland, and in the Russian Federation. It increased in Southern and Central European countries and in Japan since the 1980s.

For age specific death rates at older ages the same patterns existed, as well as for very old ages since the late 1970s.

In the 1980s, the highest excess mortality existed in Russia and in France at life expectancy at birth as well as for death rates over all ages. This applied also for the 1990s.

For all ages together a further increase for all countries mentioned above is predicted. However, for ages 70+ a reduction of the sex ratio is forecasted until 2020.

Trends in mortality differentials by marital status

There are differences in health and mortality between people with the marital states single, married, divorced, and widowed. Married persons show a clear advantage compared to the three non-married states. They are healthier and show for both sexes and at all ages lower mortality.

This advantage of married persons can be explained in two different ways. There are direct and indirect selection processes and causal effects of marriage. Direct selection is the selection of healthier persons into marriage and of less healthy persons into the non-married states. People are indirect selected into marriage through personal characteristics that affect health in a positive way. Persons with poor health habits (e.g. drinking, smoking) or poor psychosocial characteristics (e.g. aggression) are selected into the non-married status. The causal explanation says that married persons are protected from poor health and mortality through psychosocial factors (e.g. integration, social support), material and financial circumstances, and health behaviour (control of unhealthy behaviour) (Valkonen 2001, Martikainen et al. 2005).

Valkonen (2001) reported results from several studies examining excess mortality of non-married persons in comparison to married persons for several countries. With different patterns all these studies found that, in general, excess mortality of single, divorced, and widowed persons increased over time since the 1950s to the 1980s in European countries (Hu and Goldman 1990, Hajdu et al. 1995, Watson 1995, Valkonen 2001).

In a more recent study on mortality trends by marital status Valkonen (2001) examined mortality trends by marital status in twelve European countries (Denmark, Finland, Norway, Sweden, Austria, Belgium, France, the Netherlands, Germany, Hungary, Poland, and Greece) from the early 1980s to the latest year in the 1990s were data was available (earliest from 1979 to latest 1998, these countries have different time ranges). He groups these countries according to their geographical position in Europe into Nordic countries, Western Europe, Southern Europe, and Central Europe. Data were available for two age groups 45–54 and 65–74 for all countries.

In the following an overview will be given overview the change of distribution of marital states in these groups of countries and on the absolute and relative change of mortality differences by marital status.

Northern European countries – changes at ages 45–54 and 65–74

Change in distribution of marital states

For the Northern countries Denmark, Finland, and Sweden the distribution of the marital states in both age groups changed over time. In the age group 45–54 the proportion of single and divorced men and women increased whereas the proportion of widowed and married decreased. For the older age group 65–74 there is a different pattern. For both sexes the proportion of singles decreased while that of the divorced increased. For the widowed there is only a slight change that tends more to a decrease. The proportion of married men decreased over time, while that of married women increased over time.

Between the 1970s and 1990s all marital states in the Northern countries experienced a general decline in mortality. Declines were stronger for the married population than for the non-married population. Only old Danish non-married males and females experienced stagnating or slightly increasing mortality.

Absolute changes in mortality differences between married and non-married persons

Excess mortality of non-married persons shows a clear picture. For both sexes and both age groups married people have a mortality advantage. This means that the mortality of single, divorced and widowed people is always higher than that of married people. For the younger age group there was a general decrease of absolute excess mortality, only Finnish females showed a slight increase. The absolute excess mortality of old people increased in all three countries especially in Denmark. It is measured in deaths per 1000. It ranges at age 45–54 between 3.2 (Sweden) and 7.9 (Finland) for males and between 1.2 (Sweden) and 2.5 (Denmark) for females over time. It ranges at age 65–74 between 12.3 (Denmark) and 21.7 (Finland) for males and between 5.4 (Denmark) and 8.9 (Denmark) for females over time.

Relative changes in mortality differences between married and non-married persons

Generally, excess mortality is always higher for men than for women. The relative excess mortality showed a clear increase in Denmark and is especially high in Finland for both sexes.

Non-married men in the younger age group always showed an excess mortality that was over 100% higher than that of married men. At older age it is lower in a range of 32–78%.

For women the excess mortality in the younger age group ranged between 57% and 91% and in the older age group between 28% and 53%.

Relative changes of mortality differentials by marital status in Finland

The increase of excess mortality of non-married people in Finland has been examined recently (Martikainen et al. 2005). Results show that married men and women at ages 30–64, 65–79, and 80–89 have a clear mortality advantage compared to single, divorced, and widowed persons. Mortality differences between married and non-married people were highest at the youngest age group for both sexes and were higher for men.

In the beginning of the 1970/71 relative excess mortality was highest for divorced men and women at age 30–64 and 65–79 and men at age 80+. For women at the highest age it was highest for the never married and widowed. In contrast, differences were small between single, divorced, and widowed men and women at high age. Mortality differences between the non-married states were highest for both sexes at the youngest age group 30–64.

In the late 1990s the highest relative excess mortality occurred for never married men and women at all ages. Changes over time show for both sexes and all age groups increased excess mortality for all three non-married states. The highest increases were observed for the age group 30–69 and there it was higher for men. At all ages (30–64, 65–79, 80–89) never married men and women had the highest increase of relative excess mortality. For men at age 30–64 the difference compared to married grew by more than 100 percentage points (Martikainen et al. 2005).

Western European countries – changes at ages 45–54 and 65–74

Change in distribution of marital states

The group of countries of Western Europe contains in Valkonen's (2001) analyses Belgium, France, The Netherlands and Germany including East and West until 1990 and the unified Germany thereafter. The trends of distribution of the marital states are the following: in the young age group the proportion of single (except for Germany), widowed and married people decreased and increased for divorced people. At older age the proportion of single and widowed people also decreased but increased for divorced and married people,

which is due to the increase of life expectancy. The proportion of married people in Western Europe was higher than in Northern Europe.

In general, mortality declined for all marital states, at all ages and for both sexes. However, the married had stronger declines than the non-married people.

Absolute changes in mortality differences between married and non-married persons

The change of the absolute excess mortality of non-married people in the young age group 45–54 showed in general a slight decrease with exception from East German males and Belgian women where it increased. It decreased in deaths per 1000 for young males between -0.8 in the Netherlands and -2.7 in France. For females at age 45–54 it decreased between -0.2 in Germany and -0.5 in The Netherlands. The absolute excess mortality of older non-married people decreased for men (except The Netherlands) between -0.5 in Belgium and France and -2.2 in West Germany. It increased for women at age 65–74 between 0.5 in Belgium and 2.9 in the Netherlands.

Relative changes in mortality differences between married and non-married persons

The relative excess mortality at age 45–54 showed a general increase with exception from Dutch men where it slightly decreased. The increases at age 45–54 were higher for males than for females, whereas at age 65–74 they were lower for males than for females. Female excess mortality of non-married persons at age 45–54 increased by 2–39% and at age 65–74 by 12–26%. Male mortality increased by 11–58% and by 5–27%, respectively.

Female non-married persons had higher mortality than married by 36–120% in the 1990s. Male excess mortality was by 48–218% higher for non-married persons.

For all Western European countries there was a tendency of higher excess mortality of single persons.

Southern Europe

Change in distribution of marital states

According to Valkonen's classification (2001) as Southern European country is only considered Greece. The change of distribution of marital status at age 45–54 was the following: the proportion of married decreased for males and increased for females, the proportion of single, divorced, and widowed males increased. For females it only increased for divorced and decreased for single and widowed females. At age 65–74 the proportion of

married males and females, as well as of divorced males increased; it decreased for single and widowed males. For women it increased for the single and the divorced, but decreased for the widowed.

Absolute and relative changes in mortality differences between married and non-married persons

The change of excess mortality of non-married people in Greece is not comparable to the Northern and Western European countries. The absolute and relative excess mortality decreased for women in both age groups. The absolute excess mortality of young and old men increased but the relative excess mortality decreased for the young and did not change for the old men.

Central European countries – changes at ages 45–54 and 65–74

Change in distribution of marital states

Countries of Central Europe are Hungary and Poland. In both countries the proportion of married men and women decreased. In the age group 45–54 the proportion of single males increased and decreased slightly for females over time. The change of proportion in the old age group did not show the same directions as in the younger age group. In Hungary the proportion of married and single men and women decreased whereas it increased for divorced and widowed men and women. The situation in Poland was different. The proportion of married men decreased but increased for women. The share of single males increased but decreased for single women. The proportion of divorced increased for both sexes. That of widowed men increased but decreased for widowed women.

Absolute and relative changes in mortality differences between married and non-married persons

In Hungary the absolute excess mortality of young men and women increased slightly as well as the relative excess mortality. The same applied for old men and women.

In Poland changes were not as uniform as in Hungary. The absolute excess mortality of young people increased for men and decreased for women. The same pattern was true for the relative excess mortality of non-married compared to married people for the same age group. The absolute excess mortality of old Polish men and women declined. The relative excess mortality of men also declined whereas it slightly increased for women.

Finally Valkonen (2001) studied trends in mortality differences for the ages 45–54 and 65–74 for men and women for all countries that were mention above, taken together. He found that there was a general increase in mortality differences by marital status. These increases were higher for men and higher at older ages.

Changes in mortality differences by marital status in Europe, Canada, and Japan

Valkonen et al. (2004) examined trends in marital status differences of mortality over the period 1974–1996 of older people aged 64–74 in ten countries (Belgium, Denmark, England and Wales, Finland, France, Netherlands, Norway, Sweden, Canada, and Japan). They report that over all countries the proportion of widowed men and single women diminished, the proportion of divorced increased clearly over time and the proportion of married men remained nearly constant, while it increased for married women. For all countries together the death rates for all marital states decreased from 1970/71–1996/97 for both sexes. In 1970/71 the excess mortality of non-married men compared to married men was 38–41%. Out of the group of the non-married, widowed men experienced the highest excess mortality. The relative excess mortality of men increased constantly from 40% to 68% in 1996/97. The relative excess mortality of non-married females was smaller than for males. It increased from 26% to 48% over the period 1970/71–1996/97. The absolute excess mortality for non-married men and women increased slightly over time.

A more detailed look at the results by countries shows that the absolute excess mortality for singles increased in all countries, but not in Japan and Belgium. They experienced decreased mortality differences. It has to be mentioned that the proportion of single men in Japan is extremely low. For the excess mortality of divorced men there was not a common pattern for all countries as it increased in four countries and decreased in six countries. For widowed men, again, there was a general pattern of a slightly decreasing absolute excess mortality. Taking all non-married men together the absolute excess mortality increased in all countries except for Belgium, Japan, and France.

Table 12. Change of absolute and relative excess mortality of non-married persons at age 65–74 over the period 1980/81–1996/97 for men and women.

Change	Country
change of absolute excess mortality	
	male
strong increase	Norway, Finland, The Netherlands, Canada, Denmark
moderate increase	Sweden, England and Wales
decrease	Belgium, Japan, France
	female
strong increase	The Netherlands, Denmark
moderate increase	Sweden, Finland, France, England and Wales, Canada, Belgium
decrease	Japan, Norway
change of relative excess mortality	
	male
strong increase	Sweden, The Netherlands, Denmark, England and Wales, Norway, Finland, Canada
moderate increase	France, Belgium, Japan
	female
strong increase	Finland, Canada, The Netherlands, Belgium
moderate increase	Norway, Japan, France, Sweden, England and Wales, Denmark

Source: Valkonen et al. (2004)

For women there was a common trend of increased absolute excess mortality of single and all non-married women, except for Japan and Norway. Also for divorced and widowed women there was a trend of increased excess mortality for nearly all countries (Valkonen et al. 2004). Table 12 gives an overview over the trends Valkonen et al. (2004) found in absolute and relative excess mortality of non-married compared to married people.

Long-term trends in mortality differentials by marital status in The Netherlands

For The Netherlands it was possible to examine changes in mortality differences by marital status since 1850. Van Poppel and Joung (2001) examined changes for the Dutch population age 25+ until 1970.

Relative excess mortality of never married men did not change constantly. In 1850 never married men had 51% higher mortality than married men. It decreased to 42% for the period 1880–89, increased over 50% in 1910–1919 and showed sharp fluctuations afterwards, ending up with a relative excess mortality of 24%. In contrast, the change over time of excess mortality of widowed men was constant. It increased from 1.11 in 1850 to 1.59 in 1969.

The excess mortality of divorced men compared to married men also did not show constant changes. It increased sharply from 1.16 in 1860–69 to 1.75 in 1870–79. There was nearly no change until 1900–09. A sharp increase of excess mortality appeared in 1910–1919 with 1.94, and then it decreased to 1.55 in 1920–29 and increased again until 1949–49. In 1969 mortality of divorced men was 63% higher than for married men. Over the whole period from 1850–1969 divorced men showed the highest excess mortality compared to married men among the non-married.

For single women there was, as well as for men, no trend over the long period from 1850–1969. Until 1899 there was nearly no change of their excess mortality compared to married women. It ranged between 1 and 1.07 since 1850. At 1900–09 there was a clear increase to 1.12. There was again no clear trend and only small changes between 1900 and 1939 ranging between 1.12 and 1.19. For the period 1940–49 there was sharp increase to a level of 35% higher mortality of single women. Until 1969 there was no trend.

Widowed women had slightly lower mortality than married women until 1890. Since then it increased constantly to a level of 70% higher mortality in 1969. Excess mortality of divorced women showed no big changes over time and no trend. Excess mortality ranged between 1.12 and 1.47 for the period 1870–1969. The excess mortality was highest in 1969.

For women excess mortality was the highest for divorced women until 1910–19. Thereafter widowed women experienced the highest excess mortality (Van Poppel and Joung 2001)

Summary

The review of trends of mortality differences by marital status showed that mortality declined over the last three decades of the 20th century for married as well as for non-married persons. However, this decline was slightly stronger for married persons who always show

lower mortality rates than non-married persons. It is also striking that divorce rates are increasing almost everywhere.

There was a general increase of relative morality differences between married and non-married persons. The mortality advantage of married persons of all ages and both sexes was a clear fact that persisted over time. However, it is not possible to find clear patterns over time for the three non-married states single, divorced and widowed. Generally excess mortality of non-married males is higher than that of married females. It can also be said that generally mortality differences are higher in the young age group 45–54. However, there are always deviations in the changes of relative and absolute mortality differences for the different countries.

Trends in mortality differentials by education

The following part of the review gives an overview over trends in mortality differences considering different educational levels. In most cases education is grouped into low, medium and high level of school education.

Trends in mortality differences by educational level are shown for young and old people for both sexes. Young age is defined as all adult ages before retirement age. Old age is defined as all ages after retirement age 65 years.

It is a well known fact that the relation between educational level and mortality is reverse. That means that mortality decreases when the level or years of education increase and vice versa. Therefore, mortality for high educated people is in general lower than mortality for low educated people. This relation exists for all ages and sexes, in all countries that will be reviewed.

A common way to examine relative differences between socio-economic states is to calculate the Relative Index of Inequality and the Slope Index of Inequality, as most articles reviewed here did (Schwarz 2005, Kunst et al. 2004, Preston and Elo 1995, Wamala et al. 2006, Rognerud and Zahl 2005, Fawcett et al. 2005). The Relative Index of Inequality (RII) was first introduced by Preston, Haines and Pamuk in 1981 (Pamuk 1985 cited in Schwarz 2005). It is defined as "the ratio of the mortality of the hypothetically most disadvantaged to the most advantaged." (Schwarz 2005, p.11). In this case it shows the extent of excess mortality of low educated people in relation to high educated. An alternative measure, the Slope Index of Inequality (SII), can be interpreted as "the average change in standardized death rates moving from the lowest level to the highest level of education" (Schwarz 2005).

The following discussion focuses only on changes of the Relative Index of Inequality.

Most recent research is done on mortality differences by education for the countries, New Zealand, Norway, Sweden, Finland, Denmark, Austria, the Italian city Turin, and Estonia. These studies refer in almost all cases to the period between the beginning of the 1980s to the beginning or mid of the 1990s, except for Norway (1970/77–1990/97), Sweden (1980–2000), and Estonia (1989–2000).

Changes in mortality differentials by educational level in the USA

Only scarce literature was found on the latest trends in differential mortality by education for the United States. Pappas et al. (1993) already noted increasing mortality differentials by educational level between the year 1960 and 1986 for the U.S. population (age 25–64). The decrease of mortality was stronger for high educated than for low educated people. This led to the increasing mortality gap between the educational levels. In 1986, this gap was higher for males than for females. Preston and Elo (1995) found increasing differentials for white men at ages 25–64 and 65–74 for the period 1960–1985. For women their results suggested narrowing mortality differentials by education at ages 25–64, however, for women aged 65–74 absolute differentials declined and relative differentials increased. For the time between 1979 and 1989 increasing mortality differences by educational level were found for men at ages 40–54 (Kunst 1997).

Changes in mortality differentials by educational level at young ages in Europe

Males

In the early 1990s the highest mortality inequalities for males existed for the age group 30–59 in Norway, Austria, Finland, and Turin (Schwarz 2005, Doblhammer et al. 2005, Kunst et al. 2004, Fawcett et al. 2005, Rognerud and Zahl 2005). The mortality of low educated men at working age in these countries was 2 to 3.9 fold higher than for high educated men. In Sweden, Denmark, and New Zealand the inequalities were slightly lower in the early 1990s. Kunst et al. (2004) distinguished within this age range between the age groups 30–44 and 45–59. Their results for Finland, Norway and Turin show that mortality differences decrease with age. This fact is also known for Austria (Doblhammer et al. 2005)

Relative mortality differences for educational level increased for men at working age for all countries except for Sweden from the 1980s to the 1990s. Differences increased by far highest in Denmark by 71% from 1981/84 to 1991/92. Referring to Rognerud and Zahl (2005) and Fawcett et al. (2005) the relative increases of differences were at a similar level in Norway. They are high in Turin as well. In Finland, Austria, and New Zealand the relative increase of relative mortality differences was about 20 to 30% over a 10-year period. Table 13 illustrates the developments for the different countries.

Mackenbach et al. (2003) calculated rate ratios to illustrate relative mortality inequalities. Their results confirm that for the male population at age 30–59 the highest increase in relative mortality differences occurred between the early 1980s and the early 1990s in Denmark. It also confirms that the increase for Turin is slightly lower than for Finland and Norway. Doblhammer et al. (2005) calculated odds ratios with Austrian data in order to compare mortality risks of low, medium, and high educated people. They found, that in 1981/82 mortality differences were highest at young age and decrease with age. In 1991/92 the differences were large even at higher ages. Since the advantage of high educated people leads to stronger mortality decreases the differences between low, medium, and high educated people increased in Austria over time.

Swedish men at working age experienced a completely different development. Their relative mortality difference was high with 2.35 in 1981/84. The change over time was a consistent downward trend and ended up with 1.47 in 1996/99. The relative decrease of mortality differences was 38% (Wamala et al. 2006).

There is only one study examining mortality differences by education in a former socialist country: Estonia in very recent time. Leinsula et al. (2003) showed that relative mortality differences (calculated with rate ratios) are especially high for very young ages 20–39. For these ages the increase in mortality differences between 1989 and 2000 was particularly high. This was due to decreasing mortality rates at high educational level and increased mortality at medium and low educational level.

Females

For young women at the ages 30–59 similar patterns of relative mortality differences between the countries were apparent. High educated women have clearly lower mortality than low educated women. For the ages 30–44 and 45–59 the relative mortality differences were highest for Finland and Norway in the early 1990s. For the younger age group mortality of low educated women was 2.5 to 3.3 fold of high educated women. Comparing the

Table 13. Change of relative mortality differences by educational level in Norway, Finland, Sweden, Denmark, Austria, Turin, and Estonia.

Author	Country	Period	Age-range	RII at first time point	RII at latest time point	Change of RII in %
		male				
Fawcett et al. (2005)	Norway	1981/84-1991/94	30-59	2.18	2.96	66
Fawcett et al. (2005)	Finland	1981/84-1991/94	30-59	2.24	2.63	31
Fawcett et al. (2005)	Denmark	1981/84-1991/94	30-59	1.55	1.94	71
Schwarz (2005	Austria	1981/82-1991/92	30-59	2.37	2.96	25
Fawcett et al. (2005)	New Zealand	1981/84-1991/94	30-59	2.03	2.33	29
Kunst et al. (2004)	Norway	1980/84-1990/94	30-44	3.16	3.85	22
Kunst et al. (2004)	Finland	1980/84-1990/94	30-44	2.87	3.36	17
Kunst et al. (2004)	Turin	1980/84-1990/94	30-44	1.92	3.02	57
Rognerud and Zahl (2005)	Norway	1970/77-1990/97	45-59	1.6	2.8	75
Kunst et al. (2004)	Norway	1980/84-1990/94	45-59	1.87	2.48	33
Kunst et al. (2004)	Finland	1980/84-1990/94	45-59	2.16	2.22	3
Kunst et al. (2004)	Turin	1980/84-1990/94	45-59	1.44	2.03	41
Wamala et al. (2006)	Sweden	1980/84-1996/99	25-77	2.35	1.47	-38
Wamala et al. (2006)	New Zealand	1980/84-1996/99	25-77	1.68	1.8	7
Kunst et al. (2004)	Norway	1980/84-1990/94	60-74	1.43	1.7	19
Kunst et al. (2004)	Finland	1980/84-1990/94	60-74	1.72	1.8	-5
Schwarz (2005	Austria	1981/82-1991/92	60-75	1.61	1.95	21
Kunst et al. (2004)	Turin	1980/84-1990/94	60-74	1.35	1.43	6
		female				
Fawcett et al. (2005)	Norway	1981/84-1991/94	30-59	1.79	2.16	47
Fawcett et al. (2005)	Finland	1981/84-1991/94	30-59	1.69	2.14	65
Fawcett et al. (2005)	Denmark	1981/84-1991/94	30-59	1.49	1.73	49
Schwarz (2005	Austria	1981/82-1991/92	30-59	1.54	1.66	8
Fawcett et al. (2005)	New Zealand	1981/84-1991/94	30-59	1.85	2.3	53
Kunst et al. (2004)	Norway	1980/84-1990/94	30-44	1.46	2.45	68
Kunst et al. (2004)	Finland	1980/84-1990/94	30-44	2.13	3.29	54
Kunst et al. (2004)	Turin	1980/84-1990/94	30-44	1.05	1.62	54
Rognerud and Zahl (2005)	Norway	1970/77-1990/97	45-59	1.5	2.1	40
Kunst et al. (2004)	Norway	1980/84-1990/94	45-59	1.63	2.01	23
Kunst et al. (2004)	Finland	1980/84-1990/94	45-59	163	1.92	17
Kunst et al. (2004)	Turin	1980/84-1990/94	45-59	1.12	1.24	11
Wamala et al. (2006)	Sweden	1980/84-1996/99	25-77	2.35	2.31	-2
Wamala et al. (2006)	New Zealand	1980/84-1996/99	25-77	1.78	1.91	7
Kunst et al. (2004)	Norway	1980/84-1990/94	60-74	1.49	1.78	19
Kunst et al. (2004)	Finland	1980/84-1990/94	60-74	1.67	1.61	-4
Schwarz (2005	Austria	1981/82-1991/92	60-74	1.53	1.66	8
Kunst et al. (2004)	Turin	1980/84-1990/94	60-74	1.45	1.36	-6

differences over the whole age range of 30–59, New Zealand, Finland, Norway, and Sweden (for the age range 25–77) showed the highest relative mortality differences. They were slightly lower in Denmark, Austria, and Turin.

At the ages 30–44 the increases were highest for Norway (68%), however, they were also high in Finland and Turin with increases by 54%. At the ages 45–59 the increases of relative mortality differentials by education between the early 1980s and the early 1990s were lower than for the ages 30–44. They ranged between 11% in Turin and 23% for Norway. Comparing countries for the age group 30–59 the same pattern appears: between the beginning of the 1980s and the beginning of the 1990s relative mortality differences increased for women at working age between 47% and 65% in Norway, Denmark, New Zealand, Turin, and Finland. Mackenbach et al. (2003) confirmed these trends for the ages 30–74 in Finland, Norway, Denmark and Turin.

Rognerud and Zahl (2005) showed that remarkable differences at ages 45–59 for Norwegian women already existed in 1970/77. But the relative differences did not start to increase until the beginning of the 1980s. The relative mortality difference in Austria increased by only 8% to a moderate level of 1.66 at the ages 30–59 (Schwarz 2005) for the period 1981/82–1991/92. However, for the ages 35–49 Doblhammer et al. (2005) found narrowing mortality differentials for the same period. Further, at ages 50–74 the mortality gap increased in Austria (Doblhammer et al. 2005).

As well as for men, differences by education of women decreased with age (Kunst et al. 2004). In contrast, for Austria this was not true in 1991/92. No distinctions between the age groups were found (Doblhammer et al. 2005).

Wamala and colleagues (2006) examined mortality differences by education in Sweden and New Zealand for the age range 25–77 and for the period 1980–2000. They did not find consistent trends in the change of differences. However, there were clear differences between high educated and low educated women as shown in Table 13. In Sweden there was nearly no change over time. In New Zealand relative mortality differentials were slightly higher in the late 1990s than in the early 1980s.

Especially sharp increases of the mortality differences between educational levels occurred for Estonian women between 1989 and 2000. Mortality rates increased slightly for high educated women at the ages 20–39 and decreased slightly at the ages 40–54. For medium and low educated women rates increased clearly. Therefore, the gap between educational groups increased over time. The life expectancy at age 25 showed a difference of 8.6 years between low and high educated women in the year 2000 (Leinsula et al. 2003).

Changes in mortality differentials by educational level at old ages in Europe

Males

Kunst et al. (2004) and Schwarz (2005) examined mortality differences by education for older ages 60–74 in Finland, Norway, Austria, and Turin. Doblhammer et al. (2005) went further up to age 89 for Austria. Leinsula et al. (2003) studied them at ages 55–69 and 70+ in Estonia. Relative mortality differences for older men were still sharp. They ranged between 1.4 in Austria and 1.95 in Norway in the early 1990s.

Results for Austria show that relative mortality differences from age 65 on were stable with increasing age (Doblhammer et al. 2005).

Between the early 1980s and early 1990s relative mortality differences for old men increased by about 20% in Norway and Austria and by 6% in Turin. In Finland the difference decreased by 5%. In the case of Estonia there were still large differences in the progress of mortality improvement. Mortality of high educated decreased steeply in contrast to medium (slight increase) and low educated men (slight decrease). That is why the mortality difference at high age increased over time (Leinsula et al. 2003).

Females

In the early 1990s the level of excess mortality of low educated old women was similar to that of old men. The changes of mortality differences were nearly similar between men and women in Finland and Norway. In Norway the relative difference increased by 19% and in Finland it decreased by 5%. The difference also decreased in Turin by 6%. In Austria the increase of the relative mortality difference was with 8% increase not as strong as for old men (21%).

In Estonia the educational differences in mortality of old women decreased clearly with age. At least for age 70+ there were very small differences between the educational groups in 1989. But the differences increased moderately over time.

The values of the Relative Index of Inequality for the beginning and last time points of the observations and the relative change over time are given in Table 13 for young and old ages for both sexes.

Summary

To sum up, for young ages, except for Estonia total mortality decreased in all countries mentioned above for men and women. It also decreased for all ages, except for women in Denmark, Finland, and Norway, where no changes occurred. The decreases of mortality in general were highest for high educated people and lowest for low educated people in all countries (Fawcett et al. 2005, Rognerud and Zahl 2005, Kunst et al. 2004, Doblhammer et al. 2005, Schwarz 2005).The decreases of mortality were higher for men than for women whereas the relative mortality differences were clearly lower for women at all time. They were largest at young ages. Furthermore, the increase of relative mortality differences was highest at young ages over time.

Relative differences in mortality at old age increased over time in Norway, increased slightly in Austria and decreased in Finland for both sexes. In Turin, it increased for old males and decreased for old women from the 1980s to the 1990s. At old ages clear mortality differences between education levels existed. Low educated people had higher mortality than high educated people. Old men had higher relative mortality differences than women, however, the differences between old men and women were not as high as at young ages.

Conclusion

This review was conducted to inform about trends in morbidity and mortality. Disability was considered to reflect morbidity. Its trends were distinguished by measures and levels of disability. An overview was given over the trends in functional limitations, mild disability that was measured with items of instrumental activities of daily living, moderate and severe disability that was measured with items of activities of daily living and instrumental activities of daily living, and severe and cognitive limitations. Most studies were performed for the United States. Nevertheless, trends were also reviewed for Sweden, Finland, Denmark, The Netherlands, France, Spain and Japan. The results showed a common improvement of health. In general disability declined in most of all countries at older ages.

The part of the review on mortality was split up into trends in all-cause mortality and trends in mortality differentials by determining factors. These were sex, marital status and education.

All-cause mortality showed declines at all ages. However, declines since the 1950s were different over time between countries and sexes. Here, mortality changes in low-mortality countries like most European countries, the United States and Japan were reviewed. It was shown, that France, and Japan reached the highest life expectancy at birth due to sustained mortality declines over all ages. A striking point of mortality decline over the second half of the last century was the decline at very high ages. It was shown, that this decline had an important impact on the increase of life expectancy and on the number of people reaching older and very old ages. Due to the positive trend of mortality development not only increasing numbers of people reached ages over 80, 90, 100 and even over 110 but also the highest age at death was increasing over time. The highest age at death ever recorded was 122 reached by a French woman.

Striking mortality differences were found between Western and Eastern European countries. Eastern European countries did not experience mortality declines over a long period. Only recent trends since the mid-1990s let suggest that there might be a sustained mortality decline in future.

The review of trends in differential mortality showed that sex differences have been increasing for a long time. Females show at all ages lower mortality than men. However, some countries experiences turning points due to converging mortality of the sexes. In countries like the USA and the United Kingdom the sex ratios of mortality were slightly decreasing.

It could be shown that marriage always had protective characteristics. Married people experienced stronger mortality declines than non-married people. There was a common trend of increasing mortality differences between married and non-married people. It was found that these differences were higher at younger ages than at older ages.

For mortality by educational level increasing relative differences were found. High educated people always had higher chances of survival than low educated people. In most European countries they experiences stronger mortality declines than low educated people.

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