Second International Comparative Study of Mortality Tables for Pension Fund Retirees

1. Introduction

1.1 Objective

Mortality tables are used in the calculation of pensions liabilities on company balance sheets, but the assumptions made can vary considerably by country. The purpose of this study is to look at the mortality tables used throughout the EU and other selected countries, and compare them with the population tables. The aim of the study is not to move away from country specific tables, but to understand the extent to which there are systemic differences between standard European tables that could be accounted for by methodological differences in their construction or differences in the underlying data/assumptions/projections.

An aim of the study is to compare, separately for each country, the current mortality and the assumed future improvements. It also aims to deal explicitly with the impact of mortality improvements on liabilities, since one of the biggest issues going forward for actuaries is to explain how pension liability values are affected by changes in both economic and mortality assumptions. Finally the project also aims to clarify what assumptions (eg current mortality and future mortality improvements) are mandated by the authorities.

The study is an update and extension of the original study which was funded by the UK Actuarial Profession and a group of consultant actuaries, and published in 2005:
International Comparative Study of Mortality Tables for Pension Fund Retirees
Verrall et al, CASS Nov 2005
http://www.cass.city.ac.uk/media/stories/resources/mortality.pdf

The project was requested by the IAA Mortality Task Force as, since the original study, new tables have been adopted in some countries, and the population mortality data have been updated. The work is funded by the UK Actuarial Profession through the Mortality Research Steering Group.

The countries covered in the previous study are:

Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, UK and USA.

The current study covers the following countries:

Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, UK and USA.

1.2 Methodology and Data Sources

In all cases, only mortality at ages 50 and above is analysed.

In-country analysis

As in the previous study, on a country level, the report provides tabular and graphical comparisons for each country concerned in relation to the impact of the typical mortality assumptions used to assess retirement liabilities within pension fund valuations. Thus, we compare these mortality statistics to the corresponding national mortality statistics and focus on:

- the probability of death (q_x rates) for males and females;
- the expected future lifetime for an individual aged *x* years;
- probabilities of survival conditional on reaching ages 50, 60, 65 and 70;
- the expected present value of annuities at a reference rate of interest (taken to be 3% and 6%) for:
  - a male aged 50, 60, 65 and 70;
  - a female aged 50, 60, 65 and 70;
  - a male aged *x*, with a reversion of 60% to a female aged three years younger (assuming a rate of interest of 3%), *x* = 60, 65;

Cross-border analysis

The cross-border analysis provides comparisons of the country-level analysis. In particular we focus on age 65 and compare:

- national probabilities of death and probabilities of death assumed for retirement pension purposes across the countries referenced for an individual aged 65;

- expected future lifetime based on mortality tables assumed for retirement pension purposes and of the population as a whole, across the countries referenced;

- expected present value of annuities at a rate of discount of 3%;

Mortality tables assumed for retirement liability purposes for each country and details of the methodology of construction of the tables were obtained with the assistance of the IAA Mortality Task Force. The specific tables assumed in this study and those assumed in the previous study are summarised in Table 1.1.

Table **1.1:** Summary of mortality tables and/or mortality experiences used in the study

	Pension – related mortality tables			Population Data – extracted on 18/11/09
	2005 study	Current study	General Comments	
Australia	Not applicable	Mercer 0205 tables updated to 2007		2006 - HMD
Austria	AVOE 1999P – Pagler and Pagler Based on 1973-1998 Social Security Data	OVE 2008- P Pagler and Pagler. Based on Austrian social insurance data from 1973 to 2007	projected table for the 1950 generation used	2005 - HMD
Belgium	MR – male FR – female based on 1989-1991 population mortality tables	MR – male FR – female based on 1989-1991 population mortality tables	No mortality improvements assumed	2006 - HMD
Canada	RP2000 projected to 2000 Observation Period: 1983-1990	UP94 projected to 2020	Projected using US projection scale AA	2006 - HMD
Denmark	G82 Based on 1980's population	No data received		2007- HMD

	mortality			
Finland	Standard TEL – updated 19/12/2001	Standard TyEL – updated to 2008 - Rates applicable to attained age in 2008 assumed	Calculation includes an age adjustment term depending on gender and year of birth	2007- HMD
France	TPRV93 Based on female population data 1961-1987	TPG05 generation mortality tables	projected table for the 1950 generation used	2007- HMD
Germany	Richttafeln 1998 Data collection: 1995-1997	Richttafeln 2005G generation mortality tables	Smoothing by cubic splines extrapolation by a modified Gompertz approach short term and long term projections	2006 - HMD
Ireland	PMA92C2010 PFA92C2010 Based on UK pensioners' experience: 1991-1994	PMA92C2010 PFA92C2010 Based on UK pensioners' experience: 1991-1994	Amounts based experience. Projected to 2010 Approval of new basis awaited	2006 - HMD
Italy	RG48 - projected table for the 1948 generation	RG48 - projected table for the 1948 generation	IPS55 also in use – projected table for the 1955 generation	2006 - HMD
Japan	Not applicable	Standard mortality tables prescribed in 2005 based on the 19th population mortality tables	Tables developed using the 2000 Census, taking the Employees' Pension Insurance experience	2007 - HMD
Netherlands	GB 1995-2000 Based on 1995-2000 population data	Tables not provided		2006 - HMD
Norway	K-63 in use since 1963	Tables not provided		2007 - HMD
Spain	PERM/F2000 P for policies issued after 3/10/2000	PERM/F2000 P for policies issued after 3/10/2000	Projected table for the 1955 generation assumed	2007 - HMD
Sweden	FFFS 2001:13	Tables not provided		2007 - HMD
Switzerland	EVK2000	Tables not provided		2007 -

	Based on experience of the Federal Pension Fund members			HMD
UK	PMA92C2010 PFA92C2010 Pensioners' experience: 1991-1994	S1PMA and S1PFA CMI_2009 Pensioners experience of UK self administered pension schemes: 2000-2006 amounts' based experience.	S1 series tables projected using CMI_2009 Projection Model assuming Long Term Rates of Improvement of 1% and 1.25%	20006 – HMD
US	RP – 2000	RP2000 projected to 2010 Observation Period: 1983-1990	Projected using US projection scale AA	2006-HMD

The most recent national mortality experience was obtained from the Human Mortality Database (HMD) website (http://www.mortality.org) with no adjustments made to the data.

In all cases, period life tables were used to derive the relevant population mortality statistics.

1.3 Population Estimates

Table 1.2 shows the latest available census dates and mid-year population estimates for 2008 or 2009 for the countries covered in this study. The data were obtained from the United Nations Statistics Division website:

http://unstats.un.org/unsd/demographic/products/vitstats/serATab2.pdf

Table 1.2: Population estimates for 2008 or 2009 and latest available census date (*source: United Nations Statistics Division, Population and Vital Statistics Report: Series A, updated 4 May 2011*)

	Last Census date	Mid- year population estimate: 2008 or 2009
Australia	2006	21,955,256
Austria	2001	8,355,260
Belgium	2001	10,666,866
Canada	2006	33,739,859
Denmark	2001	5,519,441
Finland	2000	5,337,000
France	2006	62,277,432
Germany	2004	81,735,000
Ireland	2006	4,459,300
Italy	2001	60,199,668
Japan	2005	127,558,000
Netherlands	2002	16,514,257
Norway	2001	4,825,552
Spain	2001	45,929,476
Sweden	2003	9,292,286
Switzerland	2000	7,745,900
UK	2001	61,792,000
USA	2000	304,059,724

2. In-country analysis

For each country, a description of the population mortality used and mortality tables assumed in assessing retirement liabilities within pension funding valuations is given, where this is available. Assumptions pertaining to mortality improvements are also described. Graphical and tabular comparisons of the results are then presented.

A summary of the results obtained from an analysis of the in-country mortality data gives:

(a) the expected future lifetime at age x (e_x),

(b) the present value of an immediate annuity of 1 per annum payable in arrear to a life aged x (a_x) assuming discount rates of 3% and 6%; and

(c) the present value of an immediate annuity of 1 per annum payable in arrear to a male aged x (a_x) with a reversion of 60% payable to a widow (aged y) on the death of her husband assuming that the wife is 3 years younger than her husband (a_x+0.6$a_{x|y}$).

The values are all given at ages 50, 60, 65 and 70 with the exception of case (c), where the values are given at ages 60 and 65. The differences between the pension-related values and values derived from the population mortality experience are expressed both in absolute terms and as ratios of rates derived from the population mortality experience.

Conditional survival probabilities are also included in this report in graphical and tabular form. The graphs and associated tables show the probability that a person aged x will survive to age $x + k$ $\left({}_k p_x\right)$, where x = 50, 60, 65 or 70 and $0 \leq k \leq 100 - x$. The statistics given in the table are: the lower quartile age which indicates the age to which 75% of persons who were alive at age x are expected to survive; the median age which indicates the age to which 50% of persons who were alive at age x are expected to survive and the upper quartile age which indicates the age to which 25% of persons who were alive at age x are expected to survive. In addition, the inter-quartile range is given as a measure of variability in the age at death distribution.

2.1 Australia

In Australia superannuation benefits are predominantly in the form of lump sums, with very few schemes providing defined benefit retirement pensions and even fewer of those remaining open to new members. The most significant pension schemes are in the public sector.

In the public sector the definitive pensioner mortality work is Mercer's investigations and a database of current pensioners in most of the public sector schemes is maintained. From this has been developed a standard set of mortality rates for internal use by Mercer in pension fund valuations.

Private sector schemes probably use a diverse range of assumptions, although valuations by Mercer would use the Mercer 0205 tables, or Australian Life Tables (ALT) 2000-02 as a starting point.

A paper entitled "Mortality of Public Sector Scheme Pensioners 2005-2007 update" was presented at the 4th Financial Services Forum of the Institute of Actuaries of Australia in May 2008. The paper discusses the Australian pensioner mortality experience of major Public Sector superannuation schemes over the period 1 July 2005 to 30 June 2007 and compares the results with a previous similar study over the period 1 July 2002 to 30 June 2005 and with Australian population statistics. For Australian population mortality the standard used is Australian Life Tables 2000-2002 adjusted using the ALT 25 - year projected improvements to the relevant year.

The Mercer standard tables are due to be updated in the light of experience every three years, with 0508 tables the next update.

2.1.1 Australia: Population Mortality

The Australian Life Tables 2000-2002 together with mortality improvement factors were made available. However, in this study, the population mortality experience assumed was the experience obtained from the Human Mortality Database (HMD) pertaining to 2006.

2.1.2 Australia: mortality assumptions used to assess retirement liabilities within pension funding valuations

The standard Mercer retiree pensioner mortality tables "Mercer 0205", adjusted to apply to the year 2007 are assumed to be the mortality tables most commonly used for pensions business. In general the pensioners to which these tables apply are Australian Public Sector pensioners, that is, the pensions arise from defined benefit superannuation provided by public sector employers. Membership of schemes was usually compulsory for public sector employees, although most employers now offer defined contribution schemes only with lump sum benefits. There is a wide range of commutation options, but generally pensions are at least partly commutable after retirement age.

The four Australian Public Sector schemes whose experience provided the "Mercer 0205 Standard retiree mortality rates" consisted of the combined pensioners from NSW State Superannuation Scheme, Victorian State Superannuation Fund, Western Australian Government Superannuation Scheme and Australian Commonwealth Government schemes. The data used to construct the tables covered the period 1 July 2002 to 30 June 2005. The tables are based on lives, with about 280,000 years of exposure in respect of male retirees and 110,000 years in respect of females. The Mercer 0205 tables are used to value pension liabilities for superannuation schemes.

Graduation was achieved through a combination of manual smoothing and least squares fit (using the exponential equation $y = ce^{bx}$). The rates are derived from the Mercer Australian pensioner database, data for which are collected annually and includes retrospective updates and corrections. The tables are constructed at least a year after the end of the period of experience to be used and thus contain at least one year's updates.

Normal retirement age varies from 55 to 65 across the various Australian public sector schemes. Generally a reversionary pension of the order of 60-66% of the member pension applies. Standard mortality rates adopted for spouse pensioners are 90% of the ALT 2000-02 rates for female spouses and 100% of the ALT 2000-02 rates for male spouses.

The mortality basis assumed is intended to provide a best estimate of expected future experience. In particular the adoption of future improvement factors is designed to capitalize expected future mortality losses due to reduction in mortality rates.

2.1.3 Australia: Projected Mortality

Adjustments for future mortality improvements are made using the ALT 2000-02 improvement factors. The current standard assumption is to use the average of the 25 year average improvements and the 105 year average. For funds with significant pension liabilities, the actuary may feel that it is also appropriate to allow for higher improvement factors in the short term (eg for the 3 years following the valuation).

2.1.4 Australia: Results

A summary of the results obtained from an analysis of Australian mortality data is given in Table 2.1.1. The statistics are given at ages 51, 60, 65 and 70 years. From the table it can be seen that the present value of annuity rates derived on the basis of the Mercer 0205 mortality tables assumed for pension liability calculations are higher than annuity rates derived on the basis of the population mortality, which is consistent with lighter mortality experience for pensioners. For example, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 5.9% for males and 3.6% for females, when expressed as a percentage of the population value, and assuming a discount rate of 3% per annum. When a reversionary widow's pension of 60% of member's pension is included, the percentage difference between male annuity rates at this age is 3.6% assuming a discount rate of 3%.

From Table 2.1.2 and Figures 2.1.1 and 2.1.2, it can be seen that the Mercer 0205 mortality tables exhibit lighter mortality than the observed population mortality rates at ages x below 95 years. The ratio of the probability of death (initial rate of mortality, q_x) based on the Mercer 0205 tables, to the probability of death derived from the population mortality experience at age 60 is 47% for males and 57% for females. The corresponding ratio at age 65 is 61% for males and 73% for females. The differences between rates of mortality for the female population and the rates assumed for the female pensioners are generally lower than the corresponding differences between male rates of mortality (Figure 2.1.2).

Figure 2.1.3 shows age-related ratios of female probabilities of death to male probabilities of death based on pension-related tables and population mortality experience separately. Up to age 73, the ratios between male and female rates of mortality based on the Mercer 0205 tables are decreasing (i.e. differences increasing with age) from about 0.9 at age 51 to about 0.6 around age 73 and these ratios are higher than the corresponding ratios based on the general population. Thereafter, the ratios increase with age in both cases, that is, the difference between male and female mortality rates is then decreasing as age increases.

Table 2.1.3 and Figure 2.1.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on pension-related tables with corresponding expected future lifetime values derived from the current population mortality. Expressed as a percentage of the population value, the differences decrease with age for both males and females, with the proportional differences for an individual aged 65 being 6.7% for males and 4.2% for females (Tables 2.1.1 and 2.1.3). The life expectancy for a male aged 65 is 1.25 years longer on the basis of the Mercer 0205 mortality tables compared to the observed male population mortality. However above age 90, the Mercer 0205 tables assume higher mortality (lower expected future lifetime) than the observed population mortality.

Figures 2.1.5, 2.1.6, 2.1.7 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 60, 65 or 70 and $0 \le k \le 100 - x$. Considering the distribution of age at death given survival to age 65 (Figure 2.6 and the associated table), it is noted that based on the Mercer 0205 mortality tables, whereas a 65-year old male member of a company pension scheme is expected to live to about age 85 (1.25 years longer than a male from the general population), one quarter of those alive at age 65 would be expected to live to at least age 91 approximately (0.94 years longer than the general population). For females, while a 65 year old is expected to live to about 88 years (0.92 years longer than a female from the general population), one quarter of those alive at age 65 would be expected to live to at least age 93 (0.6 years longer than the general population).

Table 2.1.1

Australia: Summary Statistics

age x = 51

	male				Female			
	population	Mercer 0205	Difference	Percentage difference	population	Mercer 0205	Difference	Percentage difference
e_{51}	27.10	29.07	1.97	7.3	30.60	31.85	1.25	4.1
a_{51} : 3%	17.44	18.46	1.02	5.9	19.03	19.62	0.60	3.1
a_{51} : 6%	12.42	13.00	0.57	4.6	13.21	13.52	0.31	2.4

age x = 60

	male				Female			
	population	Mercer 0205	Difference	Percentage difference	population	Mercer 0205	Difference	Percentage difference
e_{60}	22.76	24.39	1.63	7.1	26.05	27.15	1.11	4.2
a_{60} : 3%	15.40	16.33	0.93	6.0	17.06	17.65	0.59	3.4
a_{60} : 6%	11.37	11.94	0.57	5.0	12.28	12.62	0.34	2.7
ax+.6ax|y:3%	18.00	18.64	0.63	3.5				

age x = 65

	male				female			
	population	Mercer 0205	Difference	Percentage difference	population	Mercer 0205	Difference	Percentage difference
e_{65}	18.66	19.91	1.25	6.7	21.68	22.59	0.92	4.2
a_{65} : 3%	13.23	14.01	0.78	5.9	14.94	15.48	0.54	3.6
a_{65} : 6%	10.14	10.66	0.51	5.1	11.17	11.50	0.33	3.0
ax+.6ax|y:3%	15.94	16.51	0.57	3.6				

age x = 70

	male				Female			
	population	Mercer 0205	Difference	Percentage difference	population	Mercer 0205	Difference	Percentage difference
e_{70}	14.85	15.71	0.86	5.8	17.48	18.21	0.73	4.2
a_{70} : 3%	11.00	11.58	0.58	5.3	12.64	13.11	0.47	3.7
a_{70} : 6%	8.76	9.17	0.41	4.7	9.83	10.15	0.32	3.2

Table 2.1.2

Australia: One-year probabilities of death (Initial rates of mortality, q_x rates

age	male			female		
	population	Mercer 0205	ratio	population	Mercer 0205	ratio
55	0.004440	0.001850	0.42	0.002540	0.001650	0.65
60	0.007520	0.003560	0.47	0.004980	0.002830	0.57
65	0.011290	0.006870	0.61	0.006650	0.004840	0.73
70	0.017900	0.013290	0.74	0.010540	0.008310	0.79
75	0.031460	0.025760	0.82	0.019070	0.015730	0.82
80	0.055890	0.050330	0.90	0.036510	0.031320	0.86
85	0.097970	0.090140	0.92	0.069600	0.062910	0.90
90	0.162860	0.160760	0.99	0.128550	0.125820	0.98
95	0.247190	0.265730	1.08	0.219060	0.236330	1.08

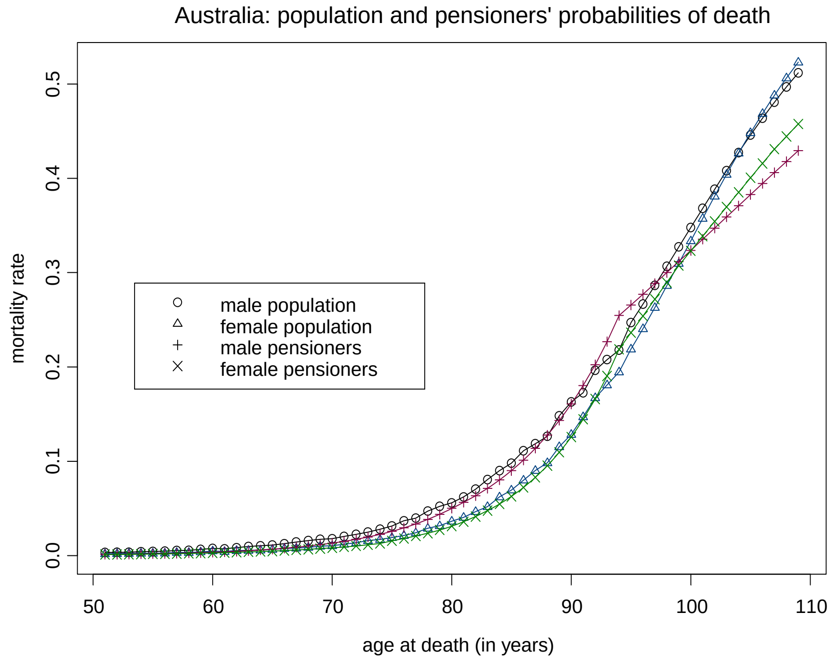


Figure 2.1.1

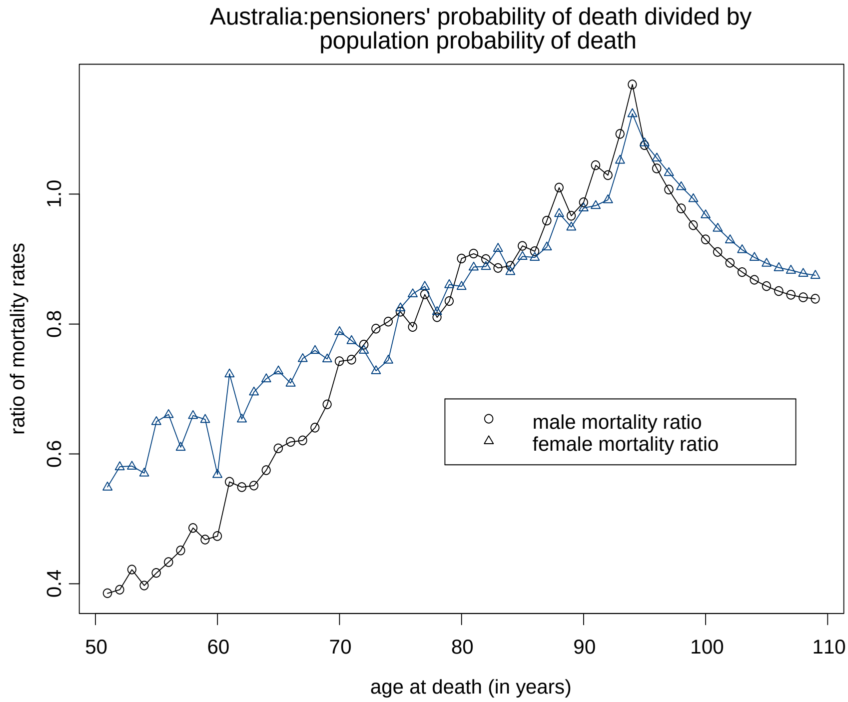


Figure 2.1.2

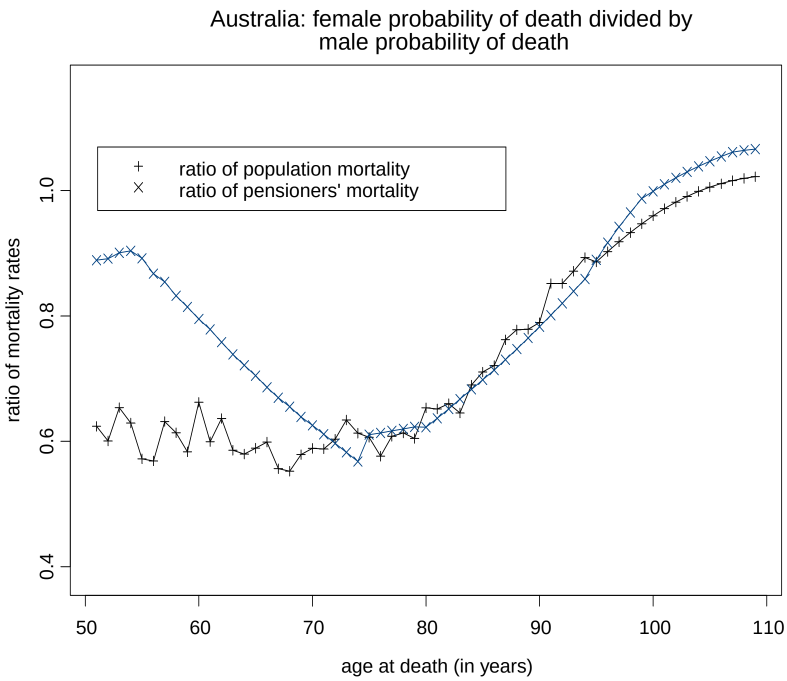


Figure 2.1.3

Table 2.1.3

Australia: Expected complete future lifetime in years

	male				Female			
age	population	Mercer 0205	difference	Percentage difference	population	Mercer 0205	difference	Percentage difference
55	27.10	29.07	1.97	7.3	30.60	31.85	1.25	4.1
60	22.76	24.39	1.63	7.1	26.05	27.15	1.11	4.2
65	18.66	19.91	1.25	6.7	21.68	22.59	0.92	4.2
70	14.85	15.71	0.86	5.8	17.48	18.21	0.73	4.2
75	11.34	11.92	0.58	5.1	13.54	14.04	0.50	3.7
80	8.39	8.67	0.28	3.4	10.00	10.32	0.31	3.1
85	6.01	6.07	0.06	1.0	7.03	7.15	0.12	1.8
90	4.22	4.09	-0.13	-3.2	4.75	4.68	-0.07	-1.5
95	2.96	2.93	-0.02	-0.8	3.21	3.13	-0.08	-2.5

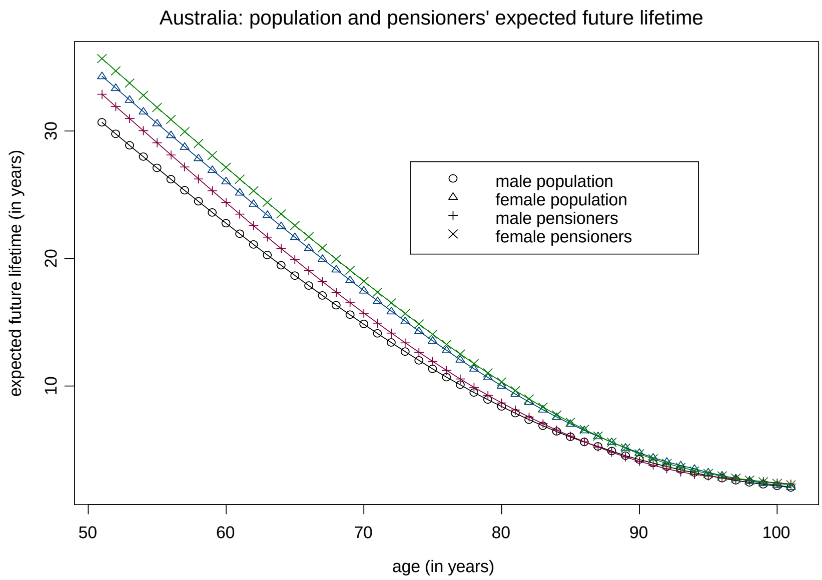


Figure 2.1.4

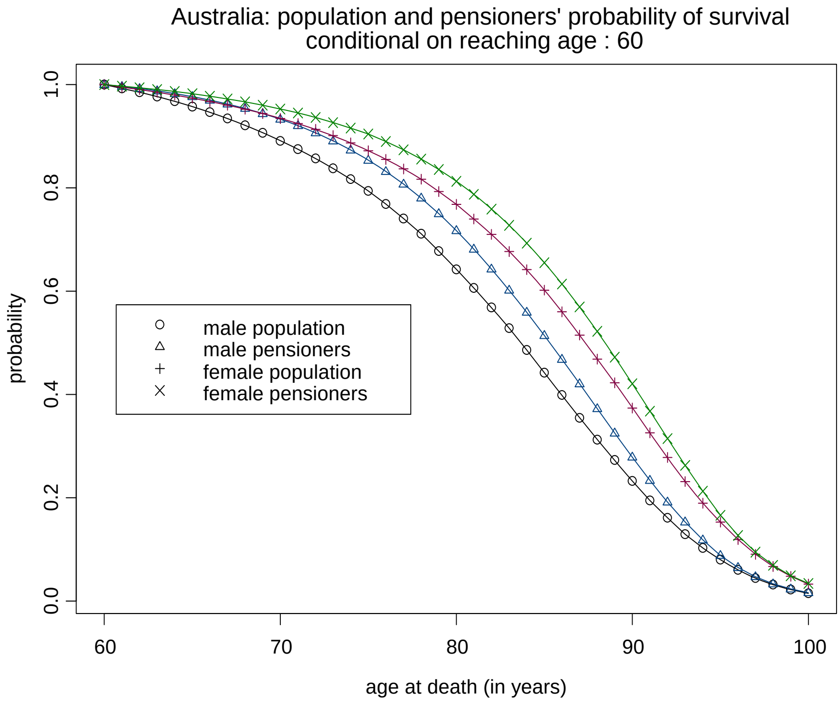


Figure 2.1.5

Australia: Distribution of age at death given survival to age 60

Summary statistics

	male			Female		
	population	Mercer 0205	Difference	population	Mercer 0205	Difference
Lower Quartile age	76.67	79.01	2.34	80.64	82.28	1.65
Median age	83.66	85.31	1.64	87.32	88.44	1.12
Upper Quartile age	89.56	90.64	1.07	92.60	93.25	0.65
Inter-quartile range	12.89	11.63	-1.26	11.96	10.97	-0.99
e_{60}	22.76	24.39	1.63	26.05	27.15	1.11

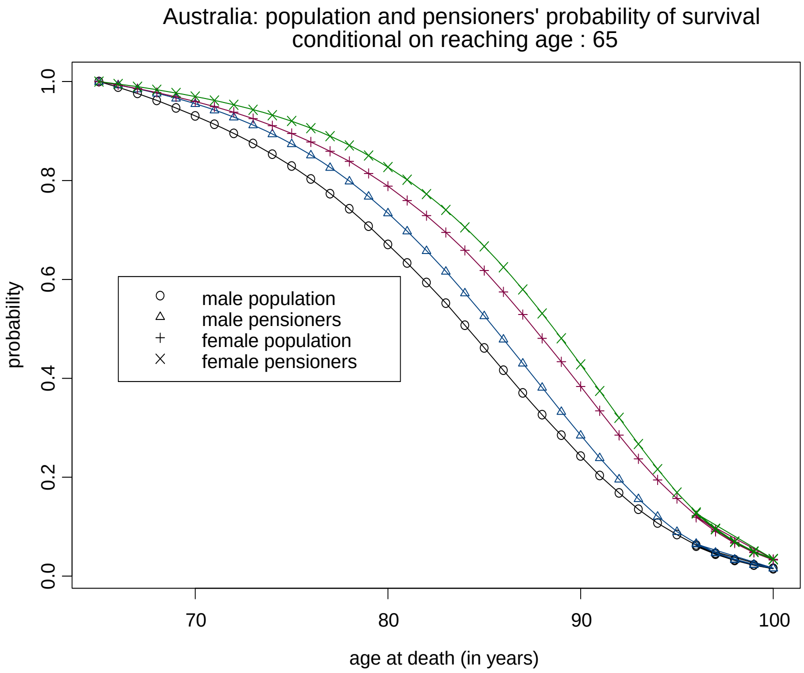


Figure 2.1.6

Australia: Distribution of age at death given survival to age 65

Summary statistics

	male			female		
	population	Mercer 0205	Difference	population	Mercer 0205	difference
Lower Quartile age	77.86	79.54	1.68	81.31	82.71	1.39
Median age	84.16	85.56	1.40	87.60	88.64	1.03
Upper Quartile age	89.83	90.77	0.94	92.74	93.34	0.60
Inter-quartile range	11.97	11.23	-0.74	11.42	10.63	-0.79
e_{65}	18.66	19.91	1.25	21.68	22.59	0.92

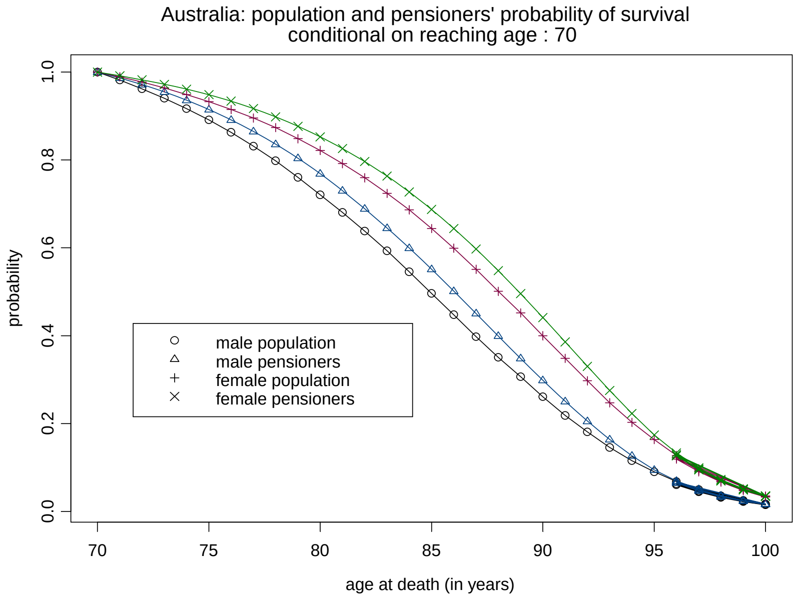


Figure 2.1.7

Australia: Distribution of age at death given survival to age 70

Summary statistics

	male			female		
	population	Mercer 0205	Difference	population	Mercer 0205	difference
Lower Quartile age	79.26	80.49	1.22	82.27	83.37	1.10
Median age	84.92	86.03	1.11	88.03	88.92	0.89
Upper Quartile age	90.26	91.01	0.75	92.95	93.48	0.53
Inter-quartile range	10.99	10.52	-0.47	10.68	10.11	-0.57
e_{70}	14.85	15.71	0.86	17.48	18.21	0.73

2.2 Austria

2.2.1 Austria: Population Mortality

The most recent population mortality experience for Austria available from the Human Mortality Database (HMD) pertains to 2006. In the previous study, the 1999 population mortality experience was used.

2.2.2 Austria: mortality assumptions used to assess retirement liabilities within pension funding valuations

The current tables commonly used in the valuation of company pension liabilities in Austria, are the "AVÖ 2008-P – basis of calculations for pension insurance", Pagler & Pagler (for ages rounded to the nearest integer) and the "AVÖ 2008-P (PK) – basis of calculations for pension insurance", Pagler & Pagler (for ages calculated to the exact day or the exact month) for males and females separately.

The basic data come from the database of the Austrian social insurance. In particular, the data are from the databases of the Pensions Insurance Institution for White Collar Employees and the Pensions Insurance Institution for Blue Collar Employees. The mortality tables are based on Social Security lives data from 1973 to 2007 and are provided separately for White Collar Employees and for Mixed White Collar and Blue Collar Employees, with the raw data smoothed using cubic splines. The tables are constructed as generation mortality tables for the period starting in 1982.

The normal retirement age for social security pensions is primarily 55 years for women and 60 years for men. Because of several changes in the legal regulations in the provision of social insurance since 2000, the earliest age of pension eligibility for men was raised to 62 (from date of birth 1/10/1943 – with requirements for exceptions). For women, the age of pension eligibility is to be raised to the same figure in a gradual process lasting until 2028 (from date of birth 1/6/1965). In the underlying data, however, this would not seem to have massive effects. The politically sensitive (in labour market terms) region shortly before the pension eligibility ages is smoothed with splines.

For a collective calculation of widows’ claims, marriage probabilities and average age of dependents in the case of death are supplied from the database of the social insurance. No prediction factors are available for these tabulated values.

The AVÖ 2008-P projected mortality tables for White Collar employees pertaining to the generation born in 1950 have been assumed in this study. The mixed tables are noted to have presented problems in recent years and hence the mixed White Collar and Blue Collar Employees’ tables have not been used here. Although separate mortality rates for widows were also provided, we have simply assumed the mortality rates for female pensioners as applicable for widows’ benefits with the further assumption that the widow is three years younger than the spouse. In addition, a widow’s pension of 60% of members’ pension has been assumed.

In the previous study, the AVÖ 1999 – P (Pagler and Pagler) generation mortality tables for males and females separately, were assumed for pension liabilities. These tables are based on Social Security data from 1973 to 1998 with the raw data similarly smoothed by means of cubic splines. The projected mortality table for “mixed white-collar and blue collar employees” pertaining to the generation born in 1950 was assumed in the study.

2.2.3 Austria: Projected Mortality

Generation mortality tables were constructed from period mortality rates using the formula:

$$q_x(\tau) = q_x(t_0)e^{-\lambda_x \times \max\{\tau - t_0 + x;0\}} ,$$

where $q_x(\tau)$ is the one-year probability of death for an individual aged x born in calendar year τ, t_0 = 1982, is the reference year and λ_x is an exponential factor individually determined for each birth cohort.

In determining the prediction factors a heavier weighting was applied to the short- and medium-term trends, which leads to a more rapid reduction in mortality in comparison with other Austrian mortality publications.

2.2.4 Austria: Results

A summary of the results obtained from an analysis of Austrian mortality data is given in Table 2.2.1. From the table it can be seen that the present value of annuity rates derived on the basis of the AVÖ 2008-P mortality tables assumed for pension liability calculations are considerably higher than annuity rates derived on the basis of the current population mortality, which is consistent with lighter mortality experience for pensioners. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 17% for males and 14.3% for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of member's pension is included, the percentage difference between male annuity rates at age 65 is 13.3% assuming a discount rate of 3%.

Figure 2.2.1 and Table 2.2.2 show comparisons of the observed probabilities of death (q_x rates) based on the most recent (2005) population experience and the AVÖ 2008-P mortality tables. It can be seen that for both males and females, the AVÖ 2008-P mortality tables exhibit considerably lighter mortality than the observed population at all ages. For example, the probability from the AVÖ 2008-P mortality tables that a 65-year male will die before his 66th birthday is 62% of the probability derived from the Austrian male population experience. The corresponding proportion for a 65-year old female is 56%. The same trends are depicted in Figure 2.2.2 which shows the ratios of probabilities of death from the AVÖ 2008-P mortality tables to probabilities of death derived from the male and female population mortality experiences respectively.

Figure 2.2.3 shows age-related ratios of female probabilities of death to male probabilities of death based on pension-related tables and population mortality experience. Similar trends are exhibited from both experiences with the difference between male and female mortality rates being generally decreasing as age increases.

Table 2.2.3 and Figure 2.2.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the AVÖ 2008-P mortality tables with corresponding expected future lifetime values for the population. Expressed as a percentage of the expected future lifetime value derived from the population mortality experience, the differences tend to increase with age for both males and females, with the proportional differences at age 65 being 22.2% for males and 19.7% for females (Tables 2.2.1 and 2.2.3). Based on the AVÖ 2008-P mortality tables, the life expectancy at age 65 is about 3.8 years longer for males and 4 years longer for females compared to the observed male and female population respectively.

Figures 2.2.5, 2.2.6, 2.2.7 and 2.2.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering age 65 (Figure 2.2.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to nearly age 86 on the basis of the AVÖ 2008-P tables and to about age 82 on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to at least age 92 on the basis of the AVÖ 2008-P tables and to about age 88 on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to at least age 89 on the basis of the AVÖ 2008-P tables and to at least age 85 on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to at least age 95 on the basis of the AVÖ 2008-P tables and to at least age 91 on the basis of the female population experience.

Table 2.2.1

Austria: Summary Statistics

age x = 50

	male				female			
	population	AVÖ 2008-P	difference	percentage difference	population	AVÖ 2008-P	difference	percentage difference
e_x	29.05	33.47	4.42	15.2	33.69	38.28	4.59	13.6
a_x : 3%	18.19	19.93	1.74	9.6	20.22	21.86	1.65	8.1
a_x : 6%	12.73	13.50	0.77	6.1	13.71	14.38	0.67	4.9

age x = 60

	male				female			
	population	AVÖ 2008-P	difference	percentage difference	population	AVÖ 2008-P	difference	percentage difference
e_x	20.78	24.88	4.10	19.7	24.67	28.90	4.24	17.2
a_x : 3%	14.33	16.37	2.05	14.3	16.44	18.36	1.92	11.7
a_x : 6%	10.74	11.85	1.11	10.4	11.97	12.93	0.95	8.0
$a_x + .6a_{x\|y}$: 3%	17.16	19.04	1.88	11.0				

age x = 65

	male				female			
	population	AVÖ 2008-P	difference	percentage difference	population	AVÖ 2008-P	difference	percentage difference
e_x	16.99	20.77	3.78	22.2	20.34	24.35	4.01	19.7
a_x : 3%	12.25	14.34	2.08	17.0	14.26	16.30	2.04	14.3
a_x : 6%	9.53	10.76	1.23	12.9	10.80	11.91	1.11	10.3
$a_x + .6a_{x\|y}$: 3%	15.10	17.11	2.00	13.3				

age x = 70

	male				female			
	population	AVÖ 2008-P	difference	percentage difference	population	AVÖ 2008-P	difference	percentage difference
e_x	13.41	16.90	3.49	26.0	16.15	19.95	3.80	23.5
a_x : 3%	10.07	12.20	2.13	21.1	11.87	14.04	2.17	18.3
a_x : 6%	8.13	9.50	1.37	16.8	9.36	10.68	1.31	14.0

Table 2.2.2

Austria: One-year probabilities of death (Initial rates of mortality, q_x rates)

	male			female		
Age	population	AVÖ 2008-P	ratio	population	AVÖ 2008-P	ratio
50	0.004160	0.003795	0.91	0.002380	0.001396	0.59
55	0.007570	0.004950	0.65	0.003510	0.001891	0.54
60	0.012560	0.006624	0.53	0.005690	0.002798	0.49
65	0.015990	0.009934	0.62	0.007830	0.004420	0.56
70	0.024350	0.015862	0.65	0.013290	0.007396	0.56
75	0.041220	0.025070	0.61	0.022410	0.012965	0.58
80	0.068640	0.040867	0.60	0.044890	0.024529	0.55
85	0.119230	0.069135	0.58	0.090610	0.048449	0.53
90	0.192110	0.117346	0.61	0.168250	0.092784	0.55
95	0.282370	0.193100	0.68	0.260250	0.162363	0.62

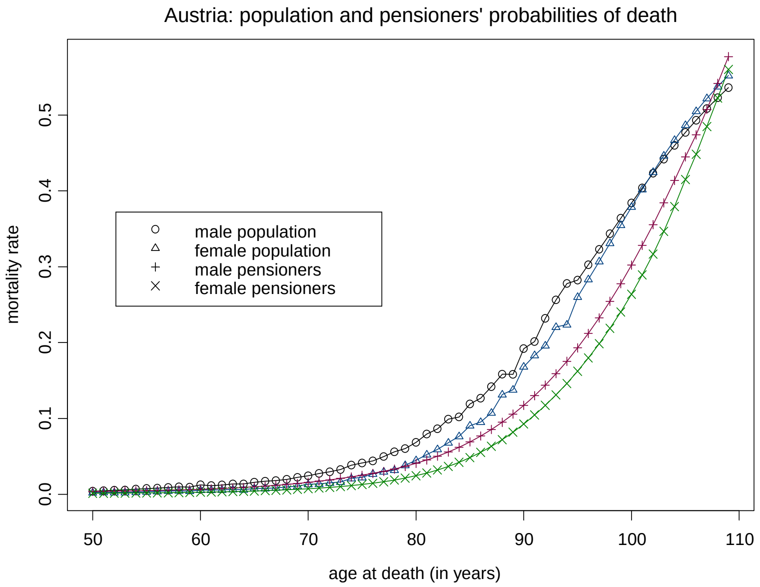


Figure 2.2.1

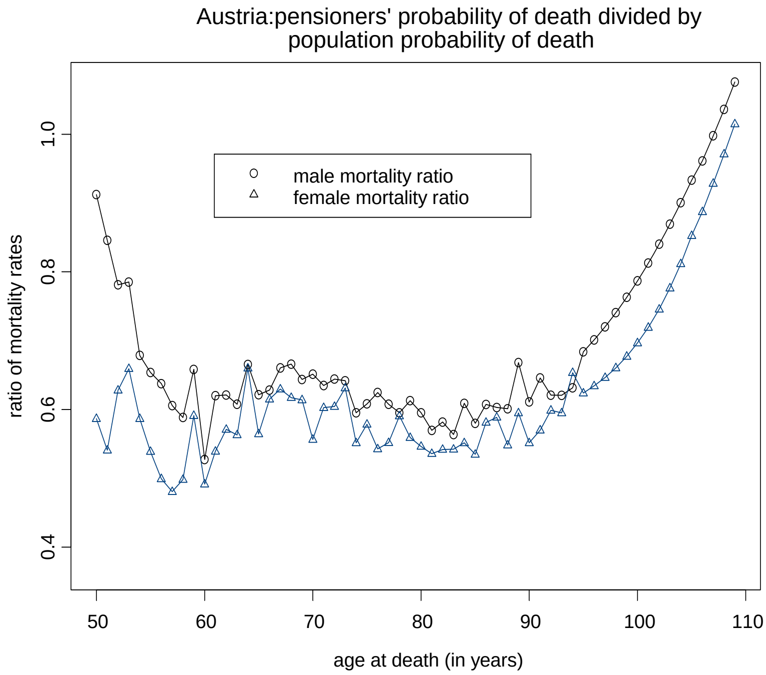


Figure 2.2.2

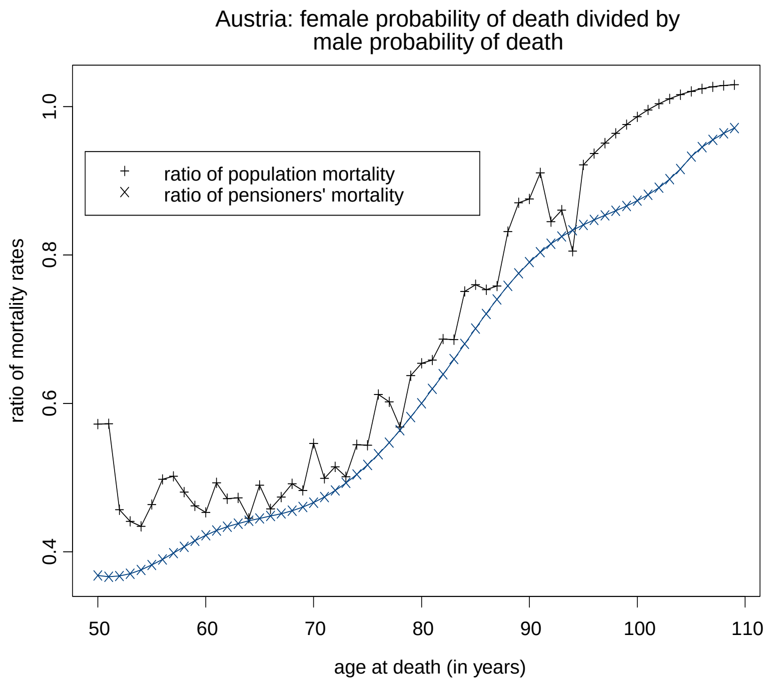


Figure 2.2.3

Table 2.2.3
Austria: Expected complete future lifetime in years

	male				female			
	population	AVÖ 2008-P	difference	percentage difference	population	AVÖ 2008-P	difference	percentage difference
50	29.05	33.47	4.42	15.2	33.69	38.28	4.59	13.6
55	24.77	29.13	4.36	17.6	29.10	33.56	4.46	15.3
60	20.78	24.88	4.10	19.7	24.67	28.90	4.24	17.2
65	16.99	20.77	3.78	22.2	20.34	24.35	4.01	19.7
70	13.41	16.90	3.49	26.0	16.15	19.95	3.80	23.5
75	10.21	13.35	3.14	30.8	12.27	15.78	3.50	28.5
80	7.46	10.16	2.71	36.3	8.85	11.94	3.09	34.9
85	5.31	7.42	2.11	39.8	6.11	8.62	2.50	41.0
90	3.65	5.21	1.56	42.7	4.06	5.97	1.91	47.0
95	2.63	3.55	0.93	35.3	2.77	4.04	1.27	45.9

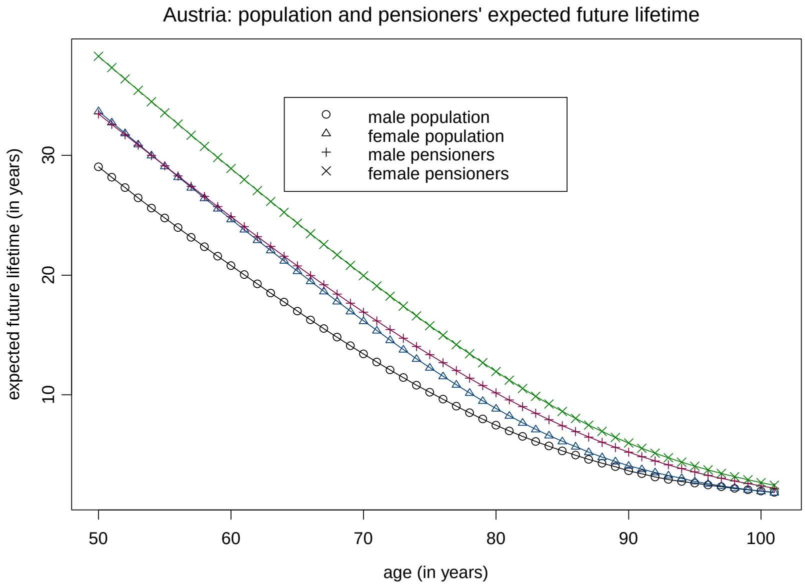


Figure 2.2.4

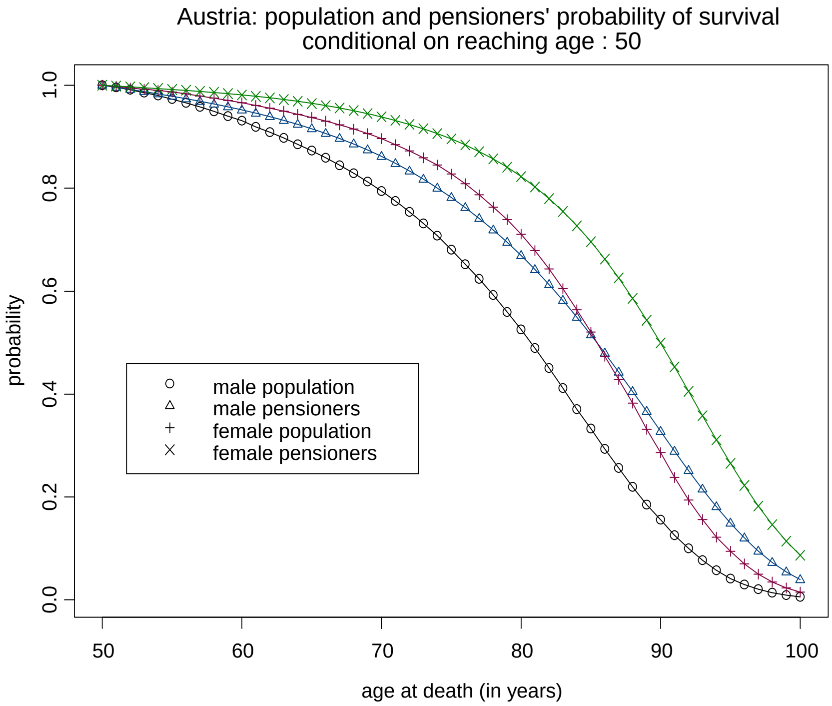


Figure 2.2.5

Austria: Distribution of age at death given survival to age 50
Summary Statistics

	male			female		
	population	AVÖ 2008-P	difference	population	AVÖ 2008-P	difference
Lower Quartile age	72.17	76.59	4.41	78.55	83.17	4.62
Median age	80.71	85.43	4.72	85.44	89.98	4.54
Upper Quartile age	87.17	92.04	4.88	90.75	95.36	4.61
Inter quartile range	14.99	15.46	0.46	12.20	12.19	-0.01
e_{50}	29.05	33.47	4.42	33.69	38.28	4.59

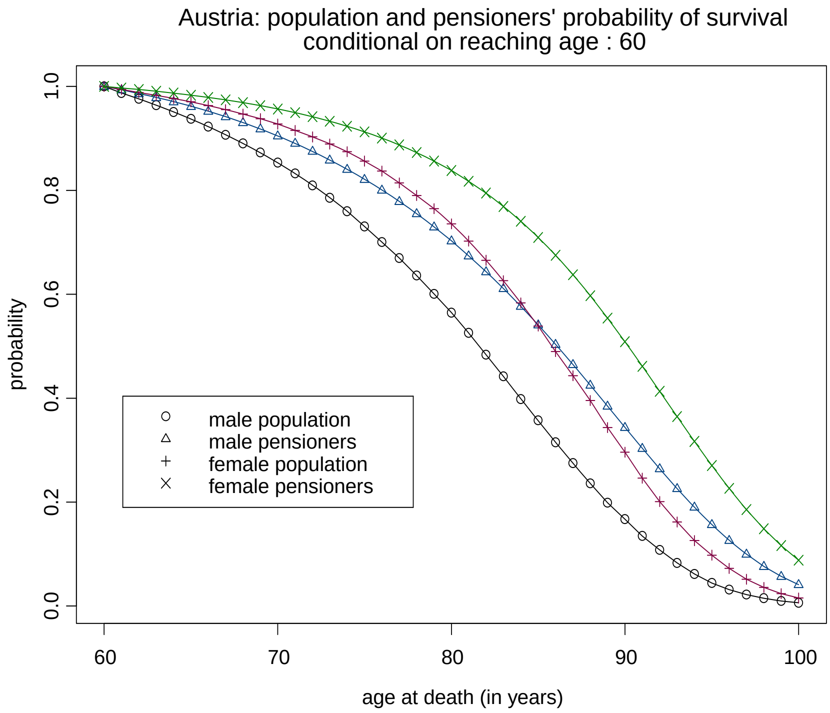


Figure 2.2.6

Austria: Distribution of age at death given survival to age 60
Summary Statistics

	male			female		
	population	AVÖ 2008-P	difference	population	AVÖ 2008-P	difference
Lower Quartile age	74.34	78.20	3.86	79.51	83.67	4.17
Median age	81.61	86.10	4.48	85.80	90.18	4.39
Upper Quartile age	87.64	92.37	4.73	90.93	95.47	4.54
Inter quartile range	13.30	14.17	0.87	11.42	11.79	0.37
e_{60}	20.78	24.88	4.10	24.67	28.90	4.24

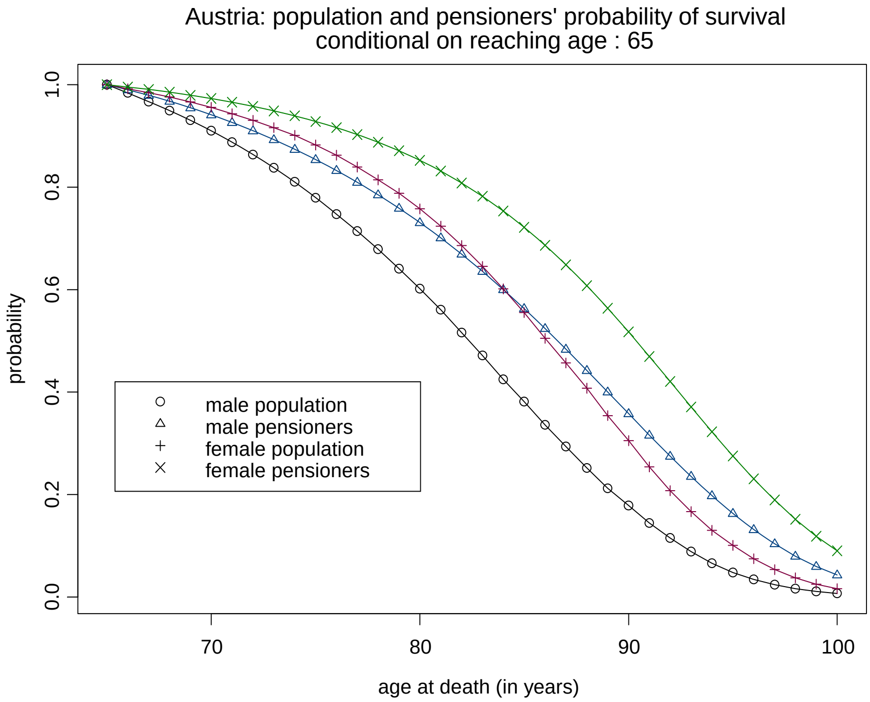


Figure 2.2.7

Austria: Distribution of age at death given survival to age 65
Summary Statistics

	male			female		
	population	AVÖ 2008-P	difference	population	AVÖ 2008-P	difference
Lower Quartile age	75.91	79.32	3.41	80.23	84.11	3.88
Median age	82.36	86.59	4.23	86.10	90.36	4.26
Upper Quartile age	88.04	92.63	4.58	91.08	95.56	4.48
Inter quartile range	12.13	13.31	1.18	10.85	11.46	0.60
e_{65}	16.99	20.77	3.78	20.34	24.35	4.01

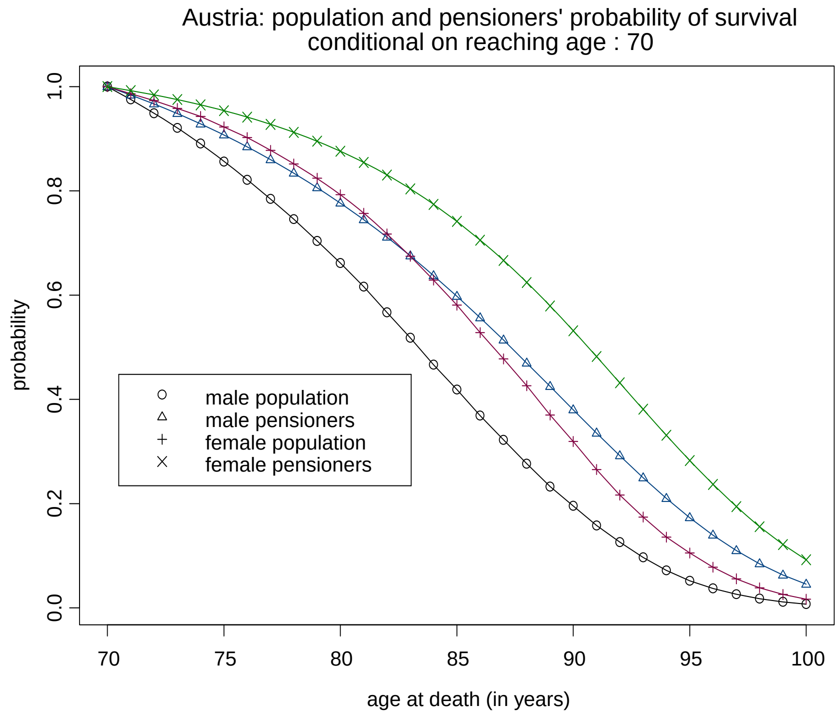


Figure 2.2.8

Austria: Distribution of age at death given survival to age 70
Summary Statistics

	male			female		
	population	AVÖ 2008-P	difference	population	AVÖ 2008-P	difference
Lower Quartile age	77.89	80.84	2.95	81.18	84.74	3.56
Median age	83.35	87.31	3.96	86.56	90.64	4.08
Upper Quartile age	88.61	93.00	4.39	91.32	95.71	4.40
Inter quartile range	10.72	12.16	1.44	10.14	10.97	0.83
e_{70}	13.41	16.90	3.49	16.15	19.95	3.80

2.2.5 Austria Results: Comparison with previous study

Figures 2.2.9 and 2.2.10 compare the probabilities of death shown in Figure 2.2.1 with probabilities of death assumed in the previous study, that is, probabilities based on the 1999 Austrian population experience and the AVÖ 1999-P mortality tables, for males and females separately. The expected future lifetimes are compared in Figures 2.2.11 and 2.2.12. Clearly, there has been an improvement in the population mortality between the 1999 experience and the 2006 experience at all ages for both males and females. From the annualised percentage changes in expected future lifetime for the population shown in Tables 2.2.4 and 2.2.5, it is apparent that the rate of improvement in population mortality at each age is slightly higher for males. On the other hand, the absolute differences at each age between the AVÖ 1999-P and the AVÖ 2008-P mortality tables assumed for pension-related benefits would appear to indicate an even greater improvement in mortality. However, these differences need to be regarded with caution as there is some inconsistency in the comparison in that in the previous study, the mortality tables assumed were for Mixed Blue Collar and White Collar employees whereas in this study, the mortality tables assumed are for White Collar employees.

Table 2.2.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the 2006 Austrian male population would be expected to live to age 88 years, the same proportion of 65-year old males from the 1999 male population would be expected to live to age 86.5 years approximately, the actual difference being about 1.6 years. For females, the difference from a similar comparison is higher: 25% of the 2006 female Austrian population alive at age 65 is expected to live to about age 91 years while the same proportion from the 1999 Austrian female population is expected to live to age 89.2 years, the actual difference being nearly two years. The corresponding differences in expected future lifetimes derived from the AVÖ 2008-P and the AVÖ 1999-P mortality tables assumed for pensioners are considerably greater: on the basis of the AVÖ 2008-P mortality tables, the upper 25% of 65-year old males would be expected to live more than 3.5 years longer than on the basis of the AVÖ 1999-P (to at least age 92.6), whilst the upper 25% of females would be expected to live about 1.8 years longer to at least age 95.5.

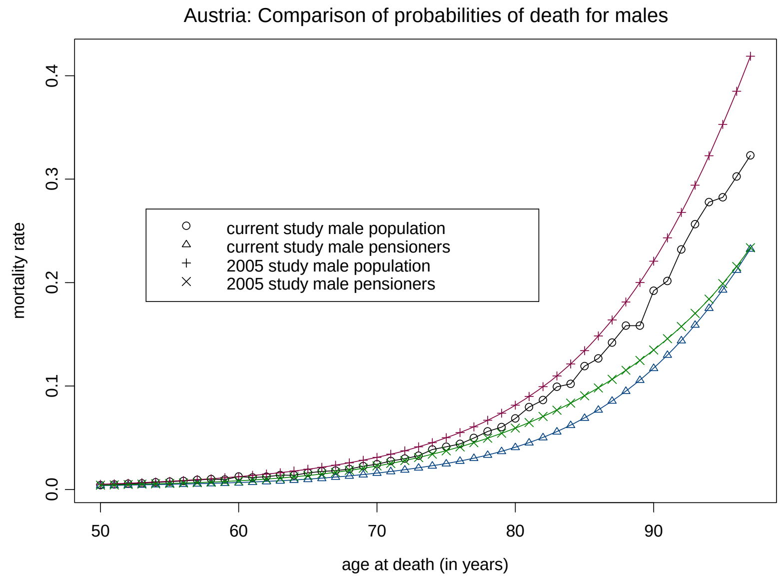


Figure 2.2.9

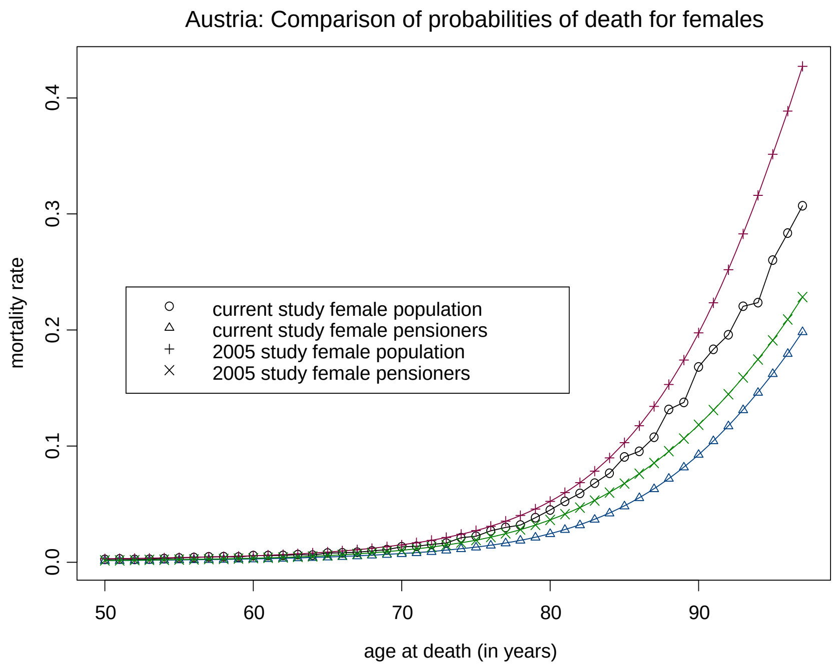


Figure 2.2.10

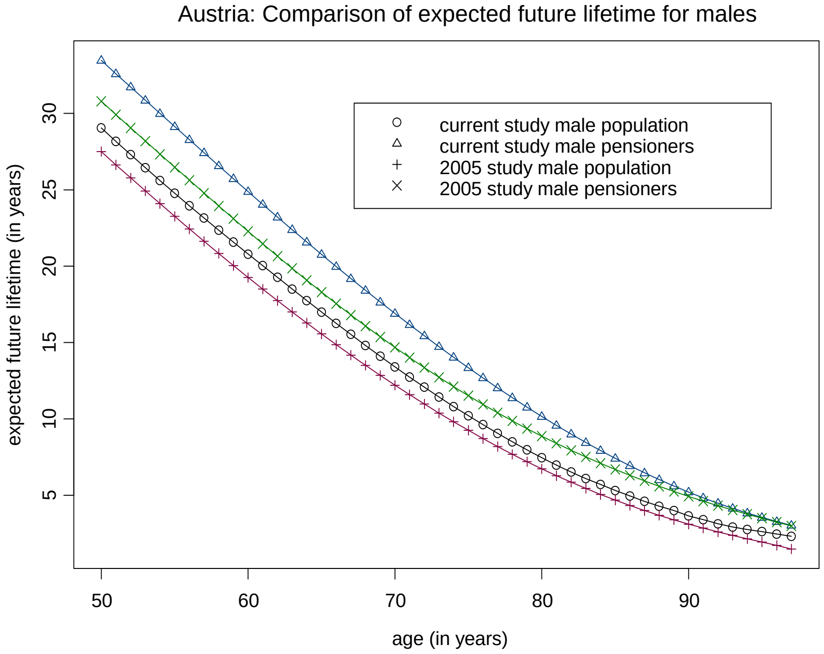


Figure 2.2.11

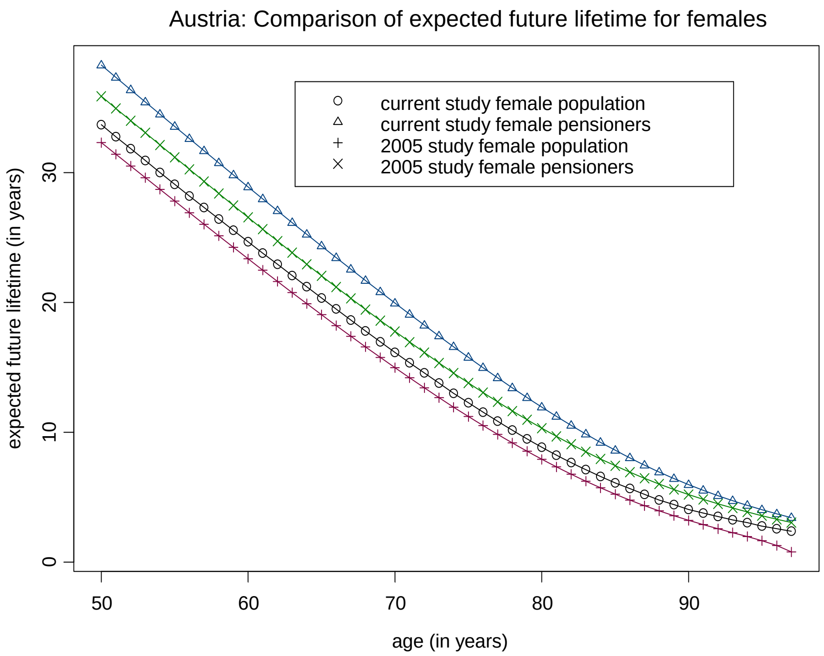


Figure 2.2.12

Table 2.2.4
Austria: Comparison of expected complete future lifetime for males

age	male pensioners			male population			
	AVÖ 2008-P	AVÖ 1999-P	difference	2006	1999	difference	Annualised percentage difference
50	33.47	30.80	2.67	29.05	27.50	1.55	0.8%
55	29.13	26.47	2.66	24.77	23.26	1.52	0.9%
60	24.88	22.28	2.60	20.78	19.26	1.52	1.1%
65	20.77	18.30	2.47	16.99	15.56	1.43	1.3%
70	16.90	14.68	2.22	13.41	12.21	1.20	1.4%
75	13.35	11.53	1.83	10.21	9.25	0.97	1.5%
80	10.16	8.87	1.29	7.46	6.73	0.73	1.5%
85	7.42	6.69	0.72	5.31	4.68	0.62	1.9%
90	5.21	4.93	0.28	3.65	3.11	0.54	2.5%
95	3.55	3.50	0.05	2.63	1.94	0.69	5.1%

Table 2.2.5
Austria: Comparison of expected complete future lifetime for females

age	female pensioners			female population			
	AVÖ 2008-P	AVÖ 1999-P	difference	2006	1999	difference	Annualised percentage difference
50	38.28	35.89	2.39	33.69	32.31	1.37	0.6%
55	33.56	31.18	2.38	29.10	27.80	1.29	0.7%
60	28.90	26.55	2.35	24.67	23.37	1.30	0.8%
65	24.35	22.05	2.29	20.34	19.06	1.28	1.0%
70	19.95	17.77	2.18	16.15	14.97	1.18	1.1%
75	15.78	13.81	1.97	12.27	11.22	1.06	1.3%
80	11.94	10.31	1.63	8.85	7.93	0.92	1.7%
85	8.62	7.43	1.19	6.11	5.24	0.87	2.4%
90	5.97	5.21	0.77	4.06	3.22	0.84	3.7%
95	4.04	3.58	0.46	2.77	1.66	1.11	9.6%

Table 2.2.6
Austria: Distribution of age at death given survival to age 65
Summary Statistics for the population experience

	Male			Female		
	2006 population	1999 population	difference	2006 population	1999 population	difference
Lower Quartile age	75.91	74.53	1.38	80.23	79.98	0.25
Median age	82.36	80.24	2.12	86.10	84.03	2.07
Upper Quartile age	88.04	86.46	1.58	91.08	89.22	1.86
Inter quartile range	12.13	11.92	0.21	10.85	9.24	1.61
e_{65}	16.99	15.56	1.43	20.34	19.06	1.28

Summary Statistics based on the Pagler and Pagler Mortality Tables

	Male			Female		
	AVÖ 2008-P	AVÖ 1999-P	difference	AVÖ 2008-P	AVÖ 1999-P	difference
Lower Quartile age	79.32	76.47	2.85	84.11	81.52	2.59
Median age	86.59	83.59	3.00	90.36	87.21	3.15
Upper Quartile age	92.63	89.06	3.56	95.56	93.77	1.80
Inter quartile range	13.31	12.59	0.72	11.46	12.25	-0.79
e_{65}	20.77	18.30	2.47	24.35	22.05	2.29

2.3 Belgium

2.3.1 Belgian population mortality

Mortality tables of the Belgian population in 2006, available from the Human Mortality Database have been used in this study without any adjustments. In the previous study, the 2002 Belgian population mortality experience from the Human Mortality Database was used for comparison with pension related mortality tables.

2.3.2 Belgium: Mortality assumptions used to assess retirement liabilities within pension funding valuations

In Belgium, the standard tables used for valuing both voluntary and compulsory annuities and pensions are the MR (Male) or FR (Female) mortality tables. The same MR and FR tables assumed in the previous study are assumed in this study and hence most of the description that follows is the same as in the previous study.

The MR and FR tables assumed are the official mortality tables given in the Royal Decree of 14 November 2003. The tables are built from the Belgian population mortality tables (1989-1991) using a Makeham formula:

$$l_x = ks^x g^{c^x} \tag{2.3.1}$$

where l_x is the number of lives expected to survive to age x, out of a cohort of l_0 lives, the number of lives assumed to be alive at age 0. Mortality tables provided are in the form of the function l_x and the parameter values applied to obtain the MR and FR tables are shown in Table 2.3.1.

The above formula (2.3.1) is equivalent to:

$$\mu_x = A + Bc^x , \tag{2.3.2}$$

with the relevant parameter values given in Table 2.3.2.

In constructing the MR and FR tables, the specific mortality experience of pensioners or annuitants is not taken into account. However, for the calculation of annuities it is common to assume that the annuitant is younger by 3 years, 5 years or 7 years.

It is generally assumed that the use of the MR and FR tables without any adjustments leads to mortality losses.

The normal retirement age for pension schemes is now 65. For older schemes, a normal retirement age of 60 was common.

The same tables MR and FR tables are used for the widower and widow's benefits respectively. There is no generally accepted assumption about the age difference between spouses. In this study, we have assumed that the wife is 3 years younger than her husband.

Table 2.3.1 Mortality assumptions used to derive the MR and FR tables (equation 2.3.1)

Parameter	MR tables	FR tables
k	1000266.63	1000048.56
s	0.999441703848	0.999669730966
g	0.999733441115	0.999951440172
c	1.101077536030	1.116792453830

Table 2.3.2 Mortality assumptions used to derive the MR and FR tables (equation 2.3.2)

Parameter	Males	females
A	0.000558452	0.000330324
B	0.000025670	0.000005364
c	1.101077536	1.116792454

2.3.3 Belgium: Projected Mortality

The MR and FR tables do not incorporate future changes (improvements) in mortality and hence in this study, no mortality improvements are assumed.

2.3.4 Belgium: results

A summary of the results obtained from an analysis of Belgian mortality data is given in Table 2.3.3. From the table it can be seen that the present value of annuity rates derived on the basis of the MR or FR mortality tables assumed for pension liability calculations are higher than annuity rates derived on the basis of the current population mortality, which is consistent with lighter mortality experience for pensioners. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 5.5% for males and 3% for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of member's pension is included, the percentage difference between male annuity rates at age 65 is 4.3% assuming a discount rate of 3%.

Table 2.3.4 and Figure 2.3.1 show a comparison of the observed probabilities of death (q_x rates) based on the most recent (2006) population experience and the MR and FR mortality tables. It can be seen that the MR tables exhibit lighter mortality than the observed male population except for extreme old age above 105 years. On the other hand the FR tables exhibit lighter mortality than the observed female population at ages up to 65 years and from age 80 to 105 years. Between ages 65 and 80, the observed female population exhibits lighter mortality than the FR tables. The same trends are depicted in Figure 2.3.2 which shows the ratios of probabilities of death from the MR and FR tables to probabilities of death derived from the male and female population mortality experiences respectively.

Figure 2.3.3 shows age-related ratios of female probabilities of death to male probabilities of death based on pension-related tables and population mortality experience. From the graph, it can be seen that in both cases, the difference between male and female mortality rates is generally decreasing as age increases with the ratio of pension related mortality rates exhibiting an approximately linear pattern while the ratio of population mortality rates exhibit a non-linear curve.

Table 2.3.5 and Figure 2.3.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the MR and FR tables with corresponding expected future lifetime values for the population mortality. Expressed as a percentage of the population value, the differences tend to increase with age for both males and females, with the proportional differences at age 65 being 7.6% for males and 4.9% for females (Tables 2.3.3 and 2.3.5). The life expectancy at age 65 is about 1.3 years longer on the basis of the MR mortality tables and 1 year longer on the basis of the FR tables compared to the observed male and female population respectively. It is interesting to note that although the observed female population experiences lighter mortality between ages 65 and 80 years, the expected future lifetime at these ages is still lower than that derived from the FR mortality tables.

Figures 2.3.5, 2.3.6, 2.3.7 and 2.3.8 and the associated tables show conditional survival probabilities for an individual aged x ($_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering age 65 (Figure 2.3.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to at least age 83 on the basis of the MR tables and to about age 82 on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to about age 90 on the basis of the MR tables and to about age 88 on the basis of the male population mortality experience. For females, it is noted that, whereas a 65-year old female would be expected to live to at least age 86 on the basis of the FR tables and to at least age 85 on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to at least age 93 on the basis of the FR tables and at least age 91 on the basis of the female population experience.

Table 2.3.3

Belgium: Summary Statistics

age x = 50

	Male				Female			
	population	MR tables	difference	percentage difference	population	FR tables	difference	Percentage difference
e_x	29.02	30.51	1.49	5.1	33.69	35.01	1.32	3.9
a_x : 3%	18.20	18.78	0.57	3.1	20.18	20.64	0.47	2.3
a_x : 6%	12.75	13.00	0.25	2.0	13.68	13.87	0.20	1.5

age x = 60

	Male				Female			
	population	MR tables	difference	percentage difference	population	FR tables	difference	Percentage difference
e_x	20.65	22.02	1.37	6.6	24.78	25.83	1.06	4.3
a_x : 3%	14.27	14.92	0.66	4.6	16.47	16.89	0.42	2.5
a_x : 6%	10.71	11.06	0.34	3.2	11.97	12.15	0.18	1.5
$a_x + .6a_{x\|y}$: 3%	17.15	17.76	0.61	3.6				

age x = 65

	Male				Female			
	population	MR tables	difference	percentage difference	population	FR tables	difference	Percentage difference
e_x	16.86	18.13	1.28	7.6	20.50	21.51	1.01	4.9
a_x : 3%	12.19	12.85	0.67	5.5	14.33	14.77	0.44	3.0
a_x : 6%	9.50	9.86	0.37	3.9	10.83	11.03	0.20	1.8
$a_x + .6a_{x\|y}$: 3%	15.09	15.74	0.65	4.3				

age x = 70

	Male				Female			
	population	MR tables	difference	percentage difference	population	FR tables	difference	Percentage difference
e_x	13.27	14.57	1.31	9.8	16.38	17.45	1.07	6.5
a_x : 3%	9.99	10.76	0.77	7.7	12.00	12.54	0.54	4.5
a_x : 6%	8.08	8.55	0.48	5.9	9.44	9.72	0.28	3.0

Table 2.3.4
Belgium: One-year probabilities of death (Initial rates of mortality, q_x rates)

Age	Male			female		
	population	MR tables	ratio	population	FR tables	ratio
50	0.004310	0.003872	0.90	0.002810	0.001749	0.62
55	0.007080	0.005917	0.84	0.004090	0.002794	0.68
60	0.011410	0.009217	0.81	0.005660	0.004605	0.81
65	0.015650	0.014535	0.93	0.008710	0.007745	0.89
70	0.023640	0.023079	0.98	0.012770	0.013178	1.03
75	0.041390	0.036750	0.89	0.022570	0.022544	1.00
80	0.072670	0.058475	0.80	0.042780	0.038604	0.90
85	0.121070	0.092597	0.76	0.082910	0.065881	0.79
90	0.196140	0.145227	0.74	0.148050	0.111439	0.75
95	0.291880	0.223998	0.77	0.248560	0.185364	0.75

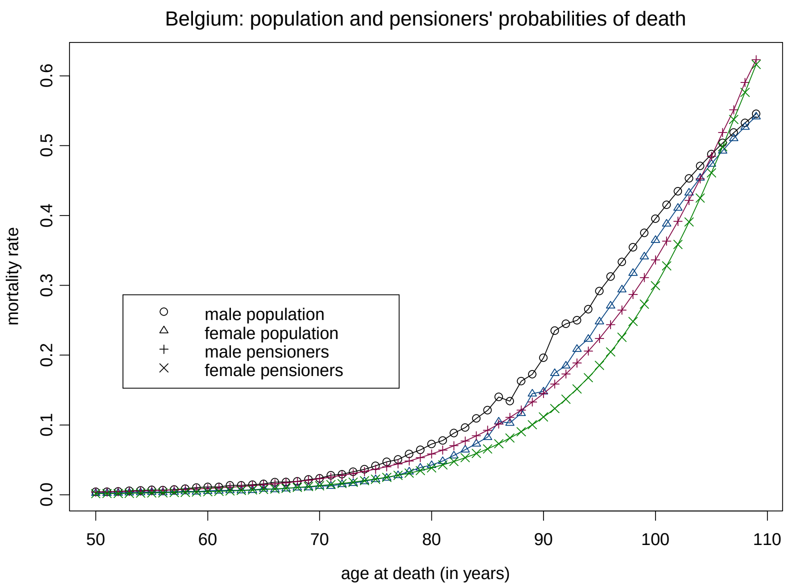


Figure 2.3.1

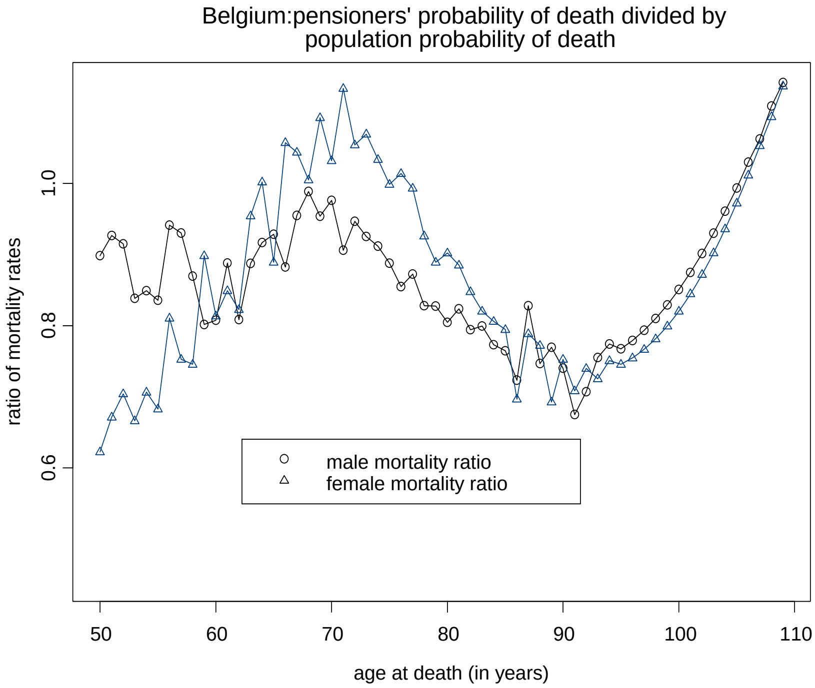


Figure 2.3.2

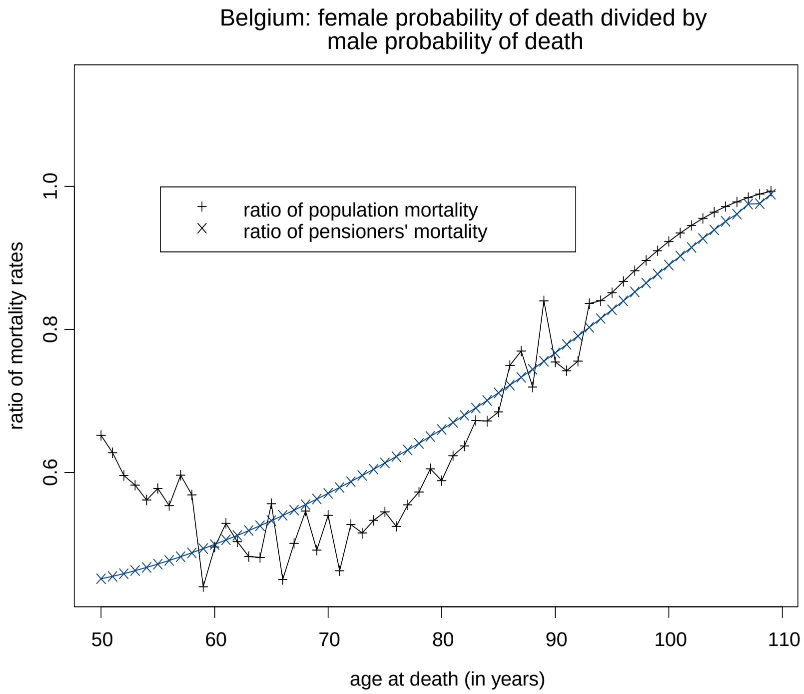


Figure 2.3.3

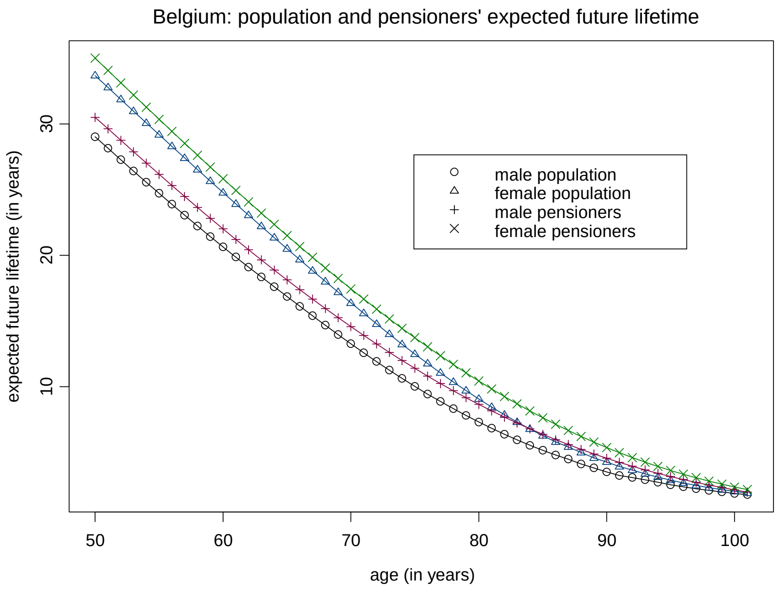


Figure 2.3.4

Table 2.3.5
Belgium: Expected complete future lifetime in years

	Male				female			
	population	MR tables	difference	percentage difference	population	FR tables	difference	percentage difference
50	29.02	30.51	1.49	5.1	33.69	35.01	1.32	3.9
55	24.72	26.16	1.44	5.8	29.18	30.35	1.17	4.0
60	20.65	22.02	1.37	6.6	24.78	25.83	1.06	4.3
65	16.86	18.13	1.28	7.6	20.50	21.51	1.01	4.9
70	13.27	14.57	1.31	9.8	16.38	17.45	1.07	6.5
75	10.02	11.40	1.38	13.7	12.49	13.73	1.24	9.9
80	7.31	8.66	1.34	18.4	9.08	10.44	1.36	15.0
85	5.15	6.38	1.22	23.7	6.28	7.64	1.36	21.7
90	3.51	4.55	1.05	29.8	4.27	5.37	1.09	25.6
95	2.54	3.16	0.62	24.5	2.89	3.63	0.74	25.6

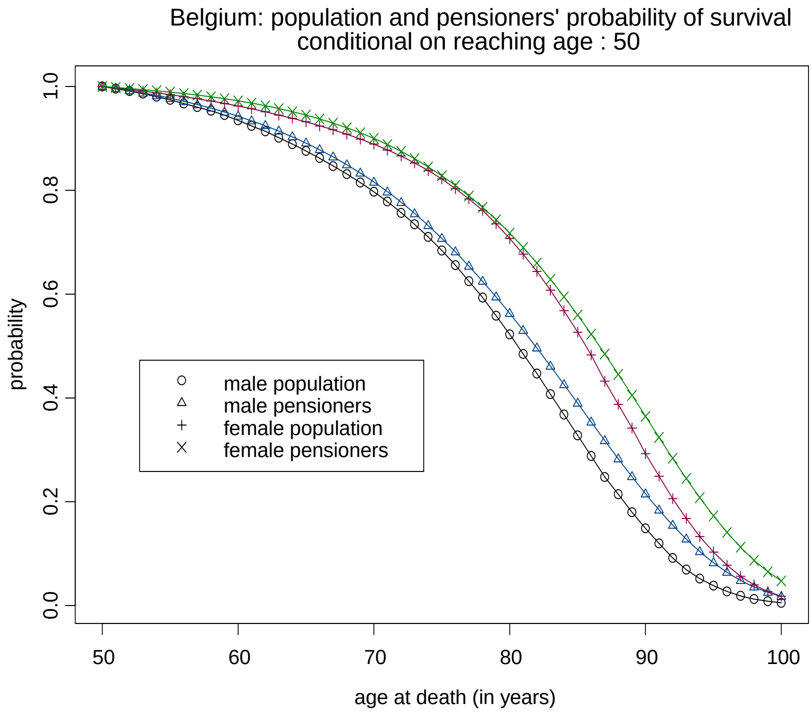


Figure 2.3.5

Belgium: Distribution of age at death given survival to age 50

Summary Statistics

	male			female		
	population	MR tables	difference	population	FR tables	difference
Lower Quartile age	72.30	73.22	0.92	78.45	78.72	0.27
Median age	80.59	81.88	1.29	85.61	86.60	0.99
Upper Quartile age	86.94	88.95	2.00	90.98	92.87	1.88
Inter quartile range	14.64	15.73	1.08	12.54	14.15	1.61
e_{50}	29.02	30.51	1.49	33.69	35.01	1.32

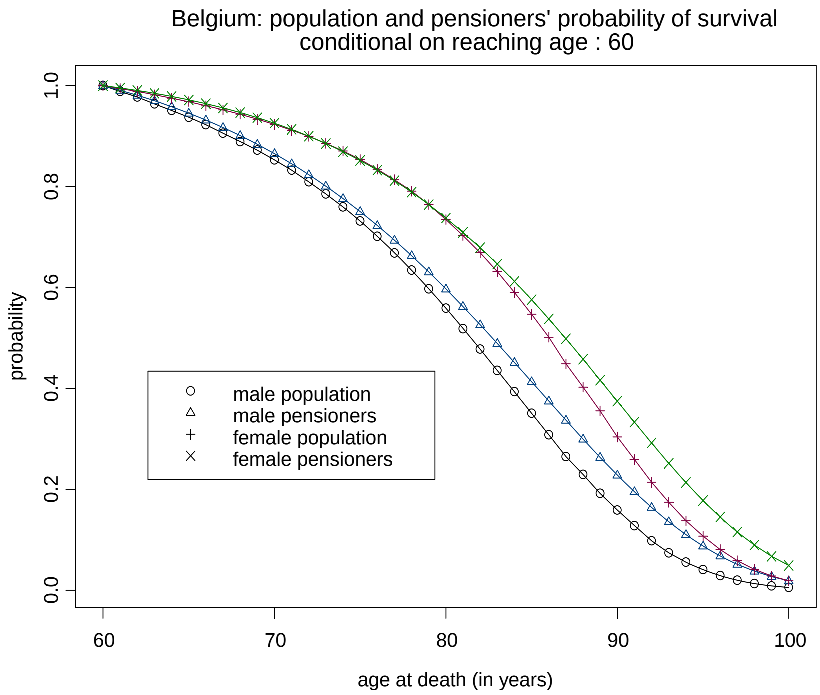


Figure 2.3.6

Belgium: Distribution of age at death given survival to age 60

Summary Statistics

	male			female		
	population	MR tables	difference	population	FR tables	difference
Lower Quartile age	74.35	75.01	0.67	79.48	79.54	0.06
Median age	81.45	82.71	1.26	86.03	86.96	0.93
Upper Quartile age	87.42	89.38	1.96	91.20	93.05	1.85
Inter quartile range	13.07	14.36	1.29	11.72	13.51	1.79
e_{60}	20.65	22.02	1.37	24.78	25.83	1.06

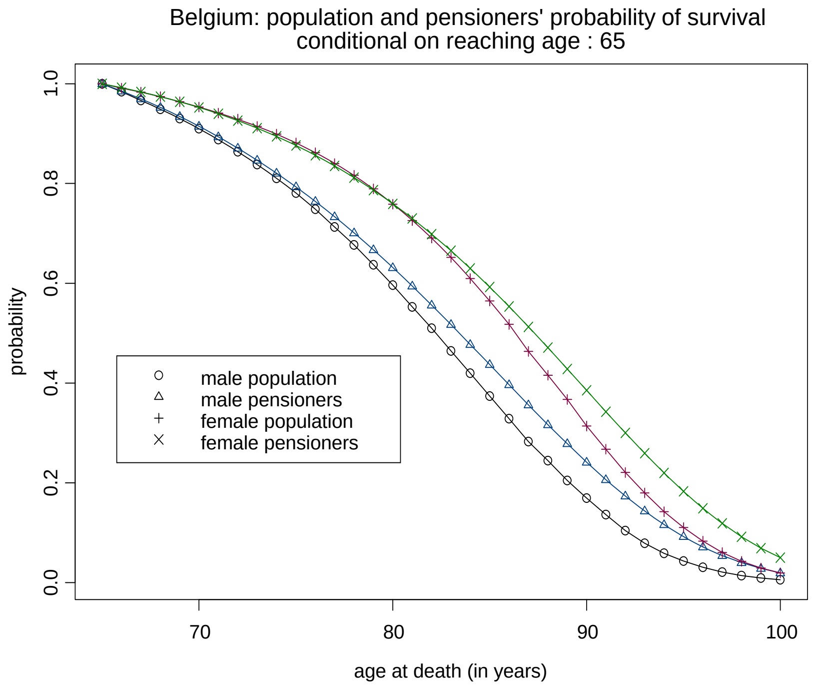


Figure 2.3.7

Belgium: Distribution of age at death given survival to age 65

Summary Statistics

	Male			female		
	population	MR tables	difference	population	FR tables	difference
Lower Quartile age	75.95	76.47	0.51	80.26	80.31	0.05
Median age	82.22	83.43	1.21	86.33	87.31	0.98
Upper Quartile age	87.86	89.77	1.90	91.37	93.18	1.81
Inter quartile range	11.91	13.30	1.39	11.11	12.87	1.75
e_{65}	16.86	18.13	1.28	20.50	21.51	1.01

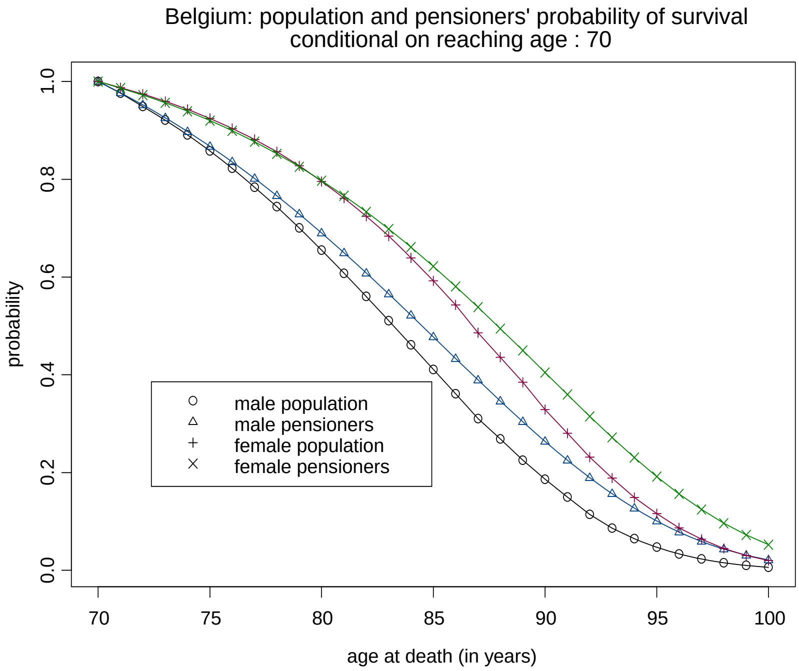


Figure 2.3.8

Belgium: Distribution of age at death given survival to age 70

Summary Statistics

	male			female		
	population	MR tables	difference	population	FR tables	difference
Lower Quartile age	77.85	78.44	0.59	81.31	81.49	0.19
Median age	83.22	84.50	1.28	86.76	87.88	1.12
Upper Quartile age	88.43	90.36	1.93	91.62	93.50	1.88
Inter quartile range	10.58	11.92	1.34	10.31	12.01	1.70
e_{70}	13.27	14.57	1.31	16.38	17.45	1.07

2.3.5 Belgium results: comparison with previous study

Figures 2.3.9 and 2.3.10 compare the probabilities of death shown in Figure 2.3.1 with probabilities of death for the population in 2002, the population experience used in the previous study, for males and females separately. The expected future lifetimes are compared in Figures 2.3.11 and 2.3.12. Clearly, there has been an improvement in the population mortality between 2002 and 2006 at all ages for both males and females. From the annualised percentage changes in expected future lifetime shown in Tables 2.3.6 and 2.3.7, it is apparent that:

- the rate of improvement in mortality is higher for males; and
- the rate of improvement increases with age.

It is worth noting that although the basis assumed for pension benefits is the same as that assumed in the previous study, the MR and FR tables assumed still exhibit lighter mortality than that of the general Belgian population.

Table 2.3.8 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the 2006 Belgian male population would be expected to live to about age 88, the same proportion of 65-year old males from the 2002 Belgian male population would be expected to live to age 87 approximately, the actual difference being more than a year. For females, the difference from a similar comparison is lower: 25% of the 2006 female Belgian population alive at age 65 is expected to live to at least age 91 while the same proportion from the 2002 Belgian female population is expected to live to just under age 91, the actual difference being less than one year.

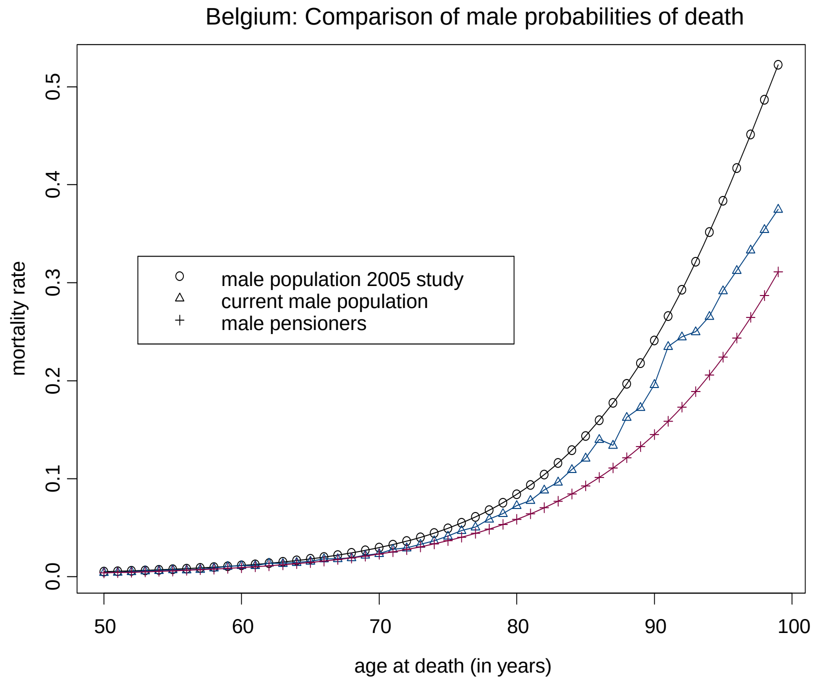


Figure 2.3.9

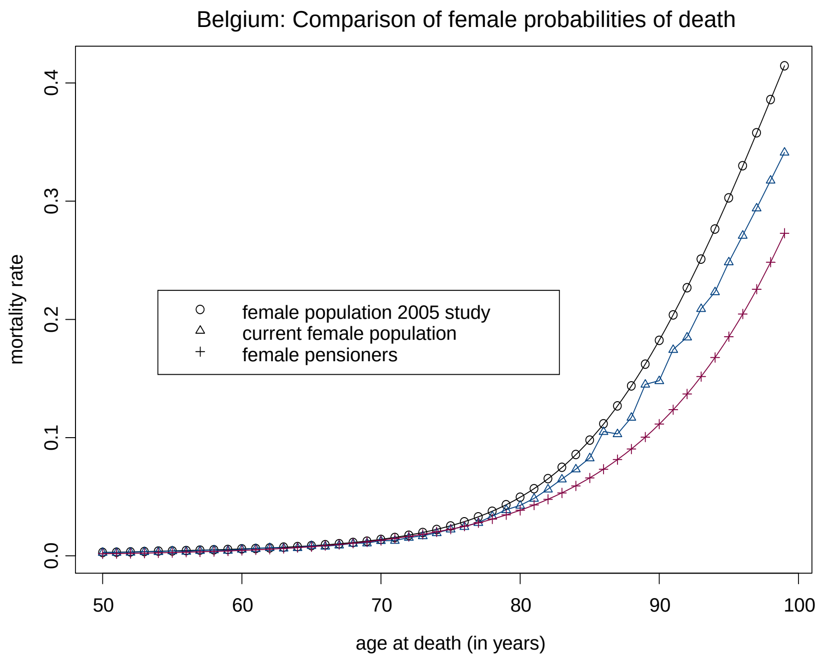


Figure 2.3.10

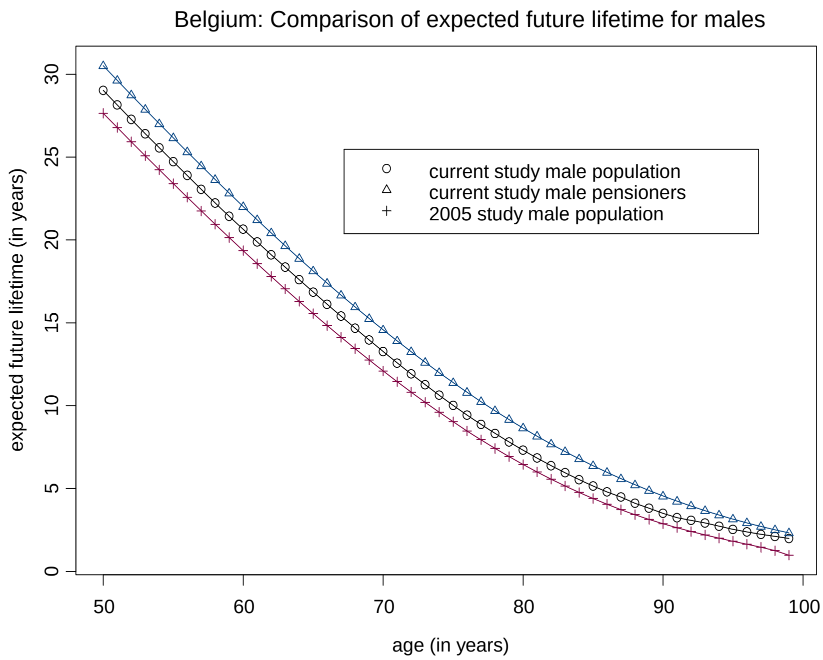


Figure 2.3.11

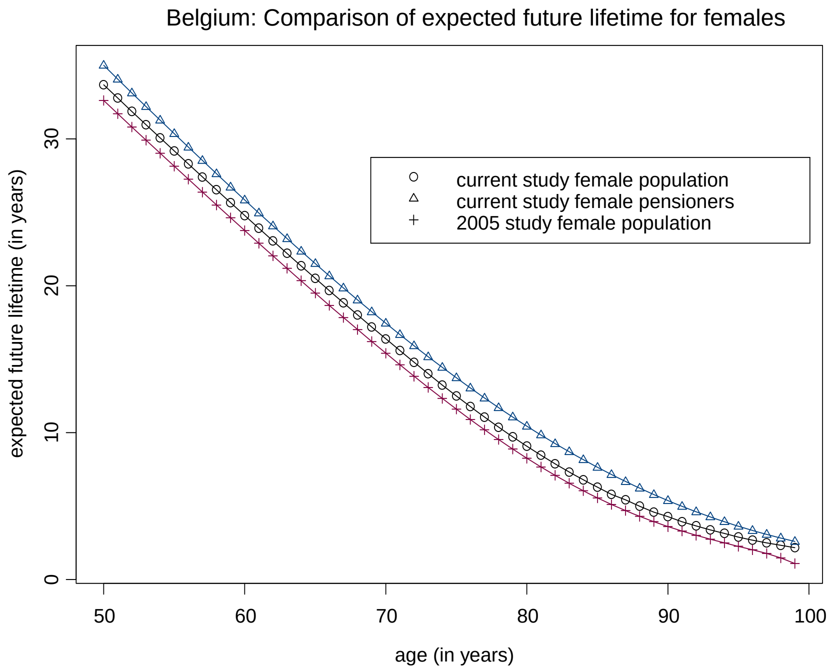


Figure 2.3.12

Table 2.3.6
Belgium: Comparison of expected complete future lifetime for males

	MR tables	Male population			
		2006 population	2002 population	difference	Annualised percentage difference
50	30.51	29.02	27.64	1.38	1.3%
55	26.16	24.72	23.40	1.32	1.4%
60	22.02	20.65	19.35	1.29	1.7%
65	18.13	16.86	15.56	1.30	2.1%
70	14.57	13.27	12.10	1.17	2.4%
75	11.40	10.02	9.04	0.99	2.7%
80	8.66	7.31	6.45	0.86	3.3%
85	6.38	5.15	4.40	0.75	4.3%
90	4.55	3.51	2.88	0.63	5.5%
95	3.16	2.54	1.82	0.72	9.9%

Table 2.3.7
Belgium: Comparison of expected complete future lifetime for females

	FR tables	Female population			
		2006 population	2002 population	difference	Annualised percentage difference
50	35.01	33.69	32.62	1.07	0.8%
55	30.35	29.18	28.13	1.05	0.9%
60	25.83	24.78	23.76	1.01	1.1%
65	21.51	20.50	19.50	1.00	1.3%
70	17.45	16.38	15.40	0.97	1.6%
75	13.73	12.49	11.60	0.89	1.9%
80	10.44	9.08	8.26	0.82	2.5%
85	7.64	6.28	5.56	0.72	3.2%
90	5.37	4.27	3.60	0.67	4.7%
95	3.63	2.89	2.26	0.63	7.0%

Table 2.3.8
Belgium: Distribution of age at death given survival to age 65
Summary Statistics

	Male			Female		
	2006 population	2002 population	difference	2006 population	2002 population	difference
Lower Quartile age	75.95	74.24	1.71	80.26	79.57	0.69
Median age	82.22	80.13	2.09	86.33	85.64	0.69
Upper Quartile age	87.86	86.66	1.20	91.37	90.79	0.58
Inter quartile range	11.91	12.41	-0.50	11.11	11.21	-0.10
e_{65}	16.86	15.56	1.30	20.50	19.50	1.00

2.4 Canada

A study published in July 2009 by the Office of the Chief Actuary, Canada, (Canada Pension Plan Mortality Study, Actuarial Study No. 7) provides an overview of historical and future mortality trends in Canada assumed under the Twenty-Third Canada Pension Plan (CPP) Actuarial Report. The study also reviews the mortality experience of Canada Pension Plan retirement and survivor beneficiaries by gender and level of pension. However, in this study, although we have taken note of the Canada Pension Plan Mortality Study, Actuarial Study No. 7, the results of that study have not been used specifically.

2.4.1 Canadian population mortality

The Canadian Human Mortality Database (CHMD) Life Tables are used in the Canada Pension Plan Mortality Study, Actuarial Study No. 7. The latest Life Tables referenced in that study are for the Canadian population in 2005. The 2006 Canada population mortality experience is available from the Human Mortality Database (HMD) and hence the 2006 Canada Life Tables from the HMD are used in this study.

In the previous study, the population mortality tables published by Statistics Canada based on the 1995-1997 population mortality experience were used.

2.4.2 Canada: Mortality assumptions used to assess retirement liabilities within pension funding valuations

The most recent Canadian Institute of Actuaries Standard of Practice specific to pension plans states that:

'*Except for situations specifically noted below, the actuary should assume,*
separate mortality rates for male and female members, and
if the valuation date is on or before January 31, 2011, mortality rates equal to the UP-94 Table projected forward to the year 2020 using mortality projection Scale AA (UP-94@2020), or
if the valuation date is on or after February 1, 2011, mortality rates equal to the UP-94 Table with generational projection using mortality projection scale AA' (http://www.asb-cna.ca).

In this study, the UP-94 mortality table (the 1994 Uninsured Pensioner Mortality Table) projected to 2020 has been assumed for pension benefits in Canada. The underlying data were based on the Civil Service Retirement System (CSRS) mortality for lives under age 66 and group annuity mortality at ages 66 and over. In the previous study, the RP-2000 mortality tables were assumed for pension benefits in Canada.

A study on the mortality of retirement beneficiaries by level of pension is carried out in the Canada Pension Plan Mortality Study, Actuarial Study No. 7. The study covers the ten-year period from 1996 to 2005 and compares the results to the 2005 Canadian Human Mortality Database Life Tables.

For the Canada Pension Plan (CPP) a person age 60 or over with contributory earnings in at least one past calendar year becomes eligible for a retirement pension upon application. An applicant for a retirement pension that becomes payable before the age of 65 must have wholly or substantially ceased to be engaged in paid employment or self-employment. A person ceases to contribute to the CPP once a retirement pension becomes payable or, in any event, after attaining age 70.

The initial amount of monthly survivor benefit for the Canada Pension Plan depends on the age of the survivor, the survivor’s disability status and the presence of dependent children. If the survivor is receiving a retirement pension or a disability benefit, the monthly amount of the surviving spouse benefit may be reduced. In this study we restrict ourselves to a widow’s benefit only of 60% of the male contributor’s pension.

2.4.3 Canada: Projected mortality

The UP-94 mortality tables assumed are projected to 2020 using mortality projection scale AA. Scale AA is wholly based on the historic experience of the CSRS and of Social Security 1977 to 1993 by age and sex, with a minimum 0.5% per year improvement at ages under 85.

2.4.4 Canada: results

A summary of the results obtained from an analysis of Canadian mortality data is given in Table 2.4.1. The statistics are given at ages 50, 60, 65 and 70 years. From the table it can be seen that the present value of annuity rates derived on the basis of the projected UP-94 mortality table assumed for pension liability calculations are higher than annuity rates derived on the basis of the 2006 population mortality for both males and females, with the proportional differences being higher for males. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate derived for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 5.7% for males and 1.9% for females, when expressed as a proportion of the population value. When a reversionary widow's pension of 60% of member's pension is included, the percentage difference between male annuity rates at age 65 is 3.4% assuming a discount rate of 3%.

Figure 2.4.1 and Table 2.4.2 compare the observed probabilities of death (q_x rates) based on the most recent (2006) population mortality experience with probabilities of death from the UP-94 mortality table assumed for pension benefits. It can be seen that the UP-94 mortality table for males exhibits lighter mortality than the observed male population at all ages. On the other hand the UP-94 mortality table for females exhibits lighter mortality than the observed female population for most of the ages considered. The same trends are depicted in Figure 2.4.2 which shows the ratios of probabilities of death from the UP-94 mortality table to probabilities of death derived from the male and female population mortality experiences as appropriate.

Figure 2.4.3 shows age-related ratios of female probabilities of death to male probabilities of death based on the UP-94 pension-related tables and the 2006 Canadian population mortality experience. From the graph, it can be seen that for both the population mortality experience and the assumed table for pension benefits, the differences between male and female mortality rates exhibit a generally decreasing pattern, characterised by ratios increasing towards a value of 1.

Table 2.4.3 and Figure 2.4.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the UP-94 mortality table with corresponding expected future lifetime values for the 2006 population. On the basis of the UP-94 table, male and female pensioners are expected to live longer than males and females of the same age from the 2006 Canadian population, with the differences decreasing as age decreases.

Figures 2.4.5, 2.4.6, 2.4.7 and 2.4.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering age 65 (Figure 2.4.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to age 84.4 years on the basis of the UP-94 mortality table and to age 83.15 years on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to age 90.77 years on the basis of the UP-94 table and to 89.51 years on the basis of the population experience. For females, it is noted that whereas a 65-year old female would be expected to live to age 86.8 on the basis of the pension-related UP-94 table and to age 86.25 on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to about age 93.4 on the basis of the UP-94 table and about age 92.8 on the basis of the female population experience.

Table 2.4.1

Canada: Summary Statistics

Comparison of Canadian population mortality statistics with UP-94 mortality tables

age x = 50

	male				Female			
	population	UP-94	difference	percentage difference	population	UP-94	difference	Percentage difference
e_x	30.72	32.78	2.06	6.7	34.51	35.52	1.02	2.9
a_x : 3%	18.91	19.84	0.93	4.9	20.43	20.87	0.44	2.1
a_x : 6%	13.08	13.56	0.47	3.6	13.77	13.99	0.22	1.6

age x = 60

	male				Female			
	population	UP-94	difference	percentage difference	population	UP-94	difference	Percentage difference
e_x	22.10	23.60	1.50	6.8	25.50	26.13	0.63	2.5
a_x : 3%	15.01	15.82	0.80	5.4	16.73	17.03	0.30	1.8
a_x : 6%	11.13	11.60	0.47	4.2	12.07	12.23	0.16	1.3
$a_x + .6a_{x\|y}$: 3%	17.73	18.28	0.55	3.1				

age x = 65

	male				Female			
	population	UP-94	difference	percentage difference	population	UP-94	difference	Percentage difference
e_x	18.15	19.40	1.25	6.9	21.25	21.80	0.55	2.6
a_x : 3%	12.91	13.64	0.73	5.7	14.64	14.92	0.28	1.9
a_x : 6%	9.92	10.38	0.45	4.6	10.96	11.11	0.15	1.4
$a_x + .6a_{x\|y}$: 3%	15.69	16.22	0.53	3.4				

age x = 70

	male				female			
	population	UP-94	difference	percentage difference	population	UP-94	difference	percentage difference
e_x	14.49	15.59	1.10	7.6	17.23	17.79	0.56	3.3
a_x : 3%	10.74	11.45	0.71	6.6	12.44	12.77	0.33	2.6
a_x : 6%	8.57	9.05	0.48	5.6	9.67	9.88	0.20	2.1

Table 2.4.2
Canada: One-year probabilities of death (Initial rates of mortality, q_x rates)

Age	male			female		
	population	UP-94	ratio	population	UP-94	ratio
50	0.003470	0.001729	0.50	0.002170	0.000984	0.45
55	0.005480	0.002889	0.53	0.003230	0.002001	0.62
60	0.008680	0.005638	0.65	0.004930	0.004190	0.85
65	0.013840	0.010833	0.78	0.007910	0.008151	1.03
70	0.022400	0.017225	0.77	0.013540	0.012959	0.96
75	0.035230	0.027733	0.79	0.021820	0.019796	0.91
80	0.059020	0.051359	0.87	0.038570	0.035290	0.91
85	0.096300	0.087105	0.90	0.069050	0.062286	0.90
90	0.160730	0.148168	0.92	0.121270	0.115622	0.95
95	0.244630	0.238449	0.97	0.203390	0.190073	0.93

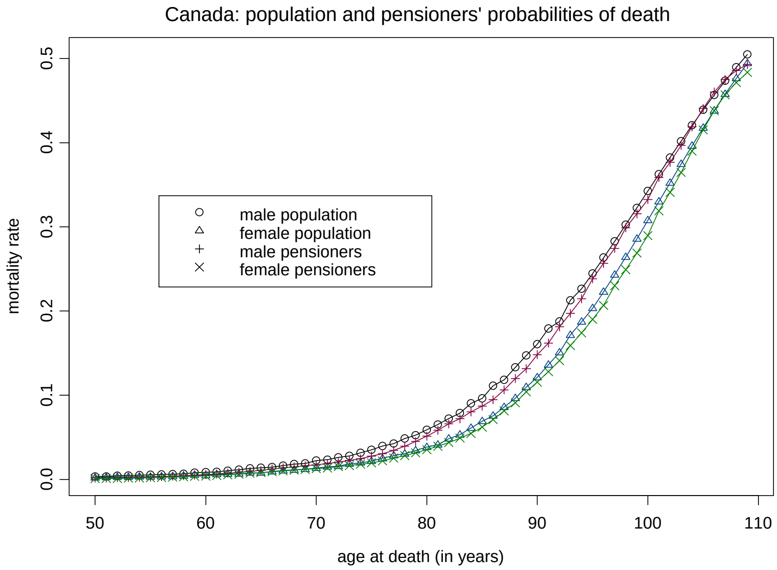


Figure 2.4.1

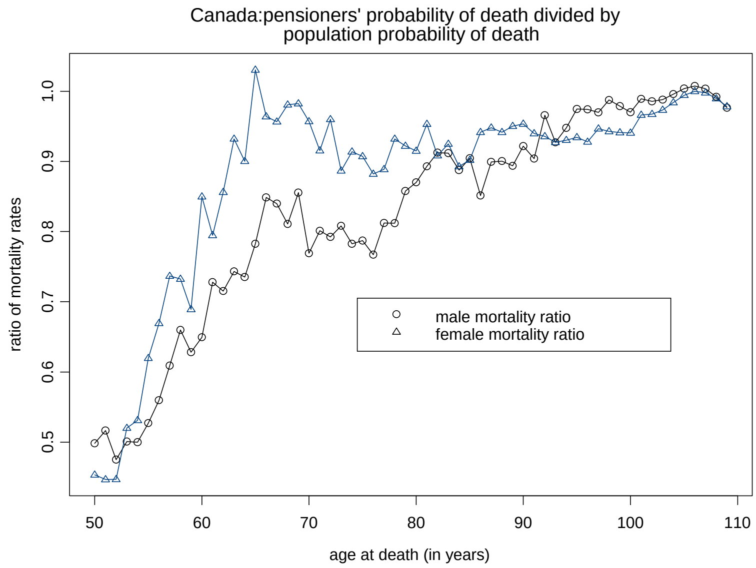


Figure 2.4.2

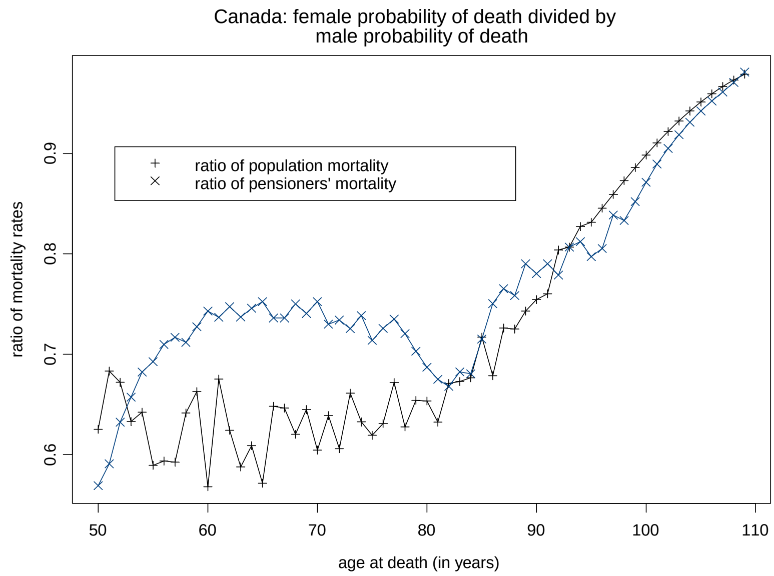


Figure 2.4.3

Table 2.4.3
Canada, Expected complete future lifetime in years

	Male				female			
	population	UP-94 tables	difference	percentage difference	population	UP-94 tables	difference	percentage difference
50	30.72	32.78	2.06	6.7	34.51	35.52	1.02	2.9
55	26.32	28.10	1.78	6.8	29.95	30.74	0.79	2.7
60	22.10	23.60	1.50	6.8	25.50	26.13	0.63	2.5
65	18.15	19.40	1.25	6.9	21.25	21.80	0.55	2.6
70	14.49	15.59	1.10	7.6	17.23	17.79	0.56	3.3
75	11.18	12.02	0.84	7.5	13.50	14.01	0.51	3.7
80	8.33	8.87	0.54	6.5	10.16	10.57	0.41	4.0
85	6.00	6.41	0.41	6.9	7.29	7.60	0.31	4.3
90	4.22	4.43	0.21	5.0	5.03	5.27	0.25	4.9
95	3.00	3.06	0.07	2.3	3.44	3.63	0.19	5.4

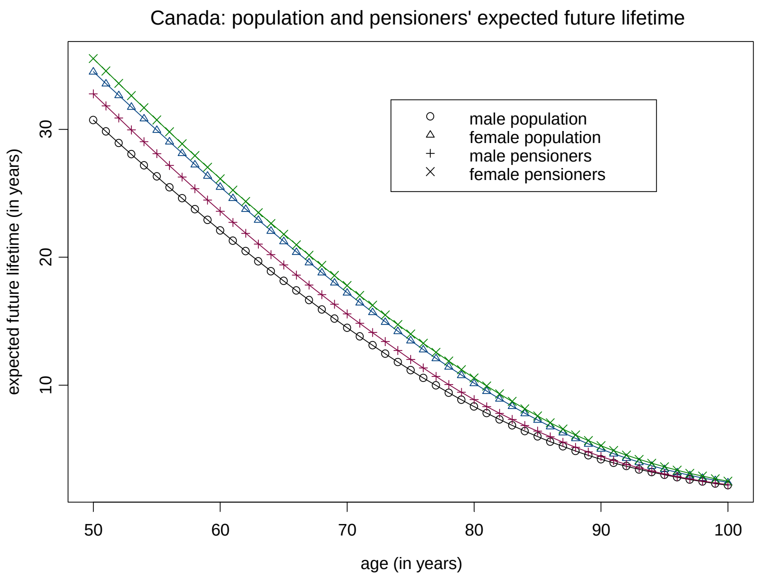


Figure 2.4.4

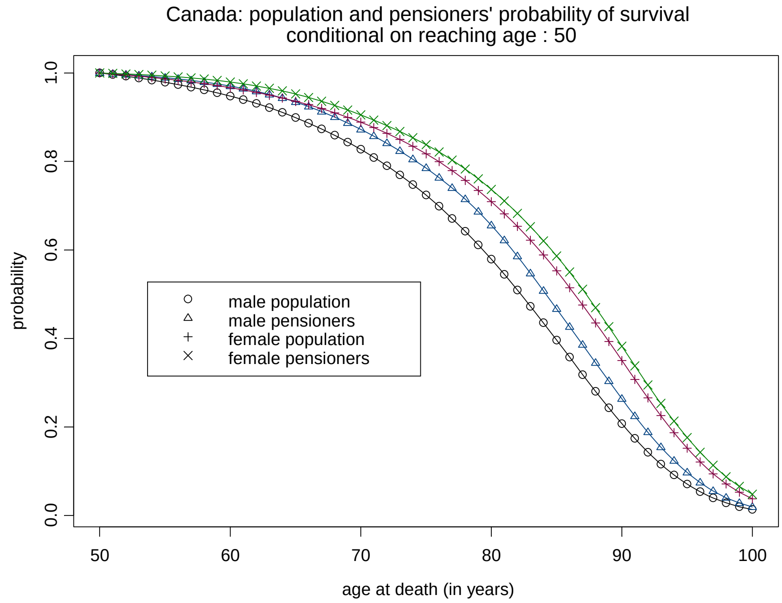


Figure 2.4.5

Canada: Distribution of age at death given survival to age 50

Summary Statistics

	Male			female		
	population	UP-94 table	difference	population	UP-94 table	difference
Lower Quartile age	73.90	76.58	2.68	78.32	79.44	1.13
Median age	82.26	84.19	1.93	86.38	87.26	0.89
Upper Quartile age	88.81	90.35	1.53	92.39	93.08	0.69
Inter quartile range	14.91	13.76	-1.15	14.07	13.64	-0.44
e_{50}	30.72	32.78	2.06	34.51	35.52	1.02

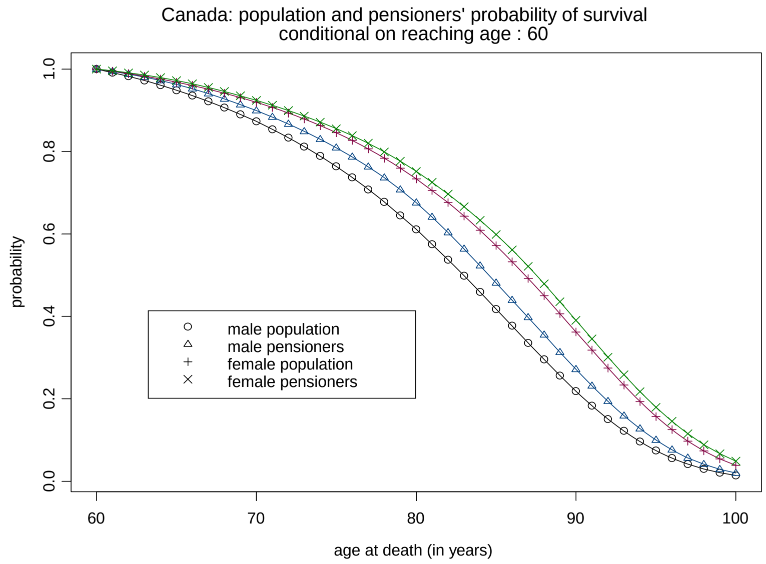


Figure 2.4.6

Canada: Distribution of age at death given survival to age 60

Summary Statistics

	Male			female		
	population	UP-94 table	difference	population	UP-94 table	difference
Lower Quartile age	75.52	77.49	1.96	79.36	80.07	0.71
Median age	82.96	84.55	1.59	86.80	87.51	0.70
Upper Quartile age	89.17	90.54	1.37	92.60	93.21	0.61
Inter quartile range	13.64	13.05	-0.60	13.23	13.13	-0.10
e_{60}	22.10	23.60	1.50	25.50	26.13	0.63

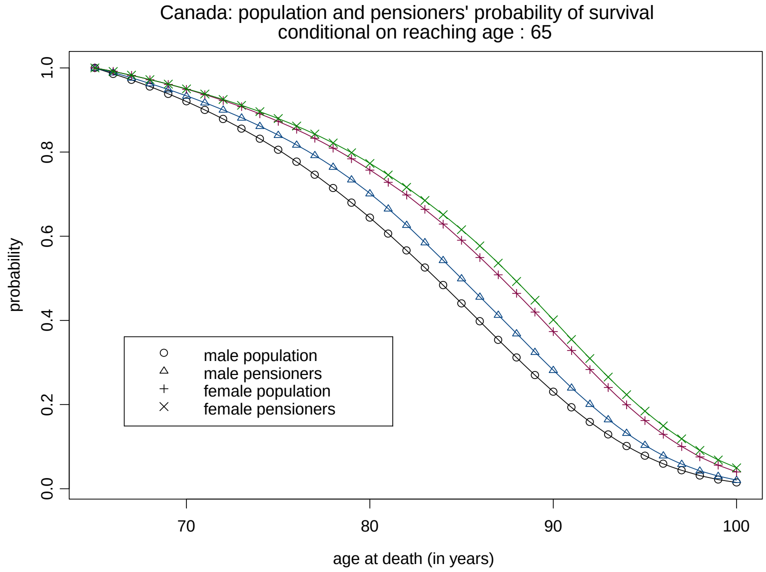


Figure 2.4.7

Canada: Distribution of age at death given survival to age 65

Summary Statistics

	Male			female		
	population	UP-94 table	difference	population	UP-94 table	difference
Lower Quartile age	76.88	78.49	1.61	80.26	80.85	0.60
Median age	83.62	84.99	1.38	87.19	87.83	0.64
Upper Quartile age	89.51	90.77	1.26	92.79	93.37	0.59
Inter quartile range	12.63	12.27	-0.36	12.53	12.52	-0.01
e_{65}	18.15	19.40	1.25	21.25	21.80	0.55

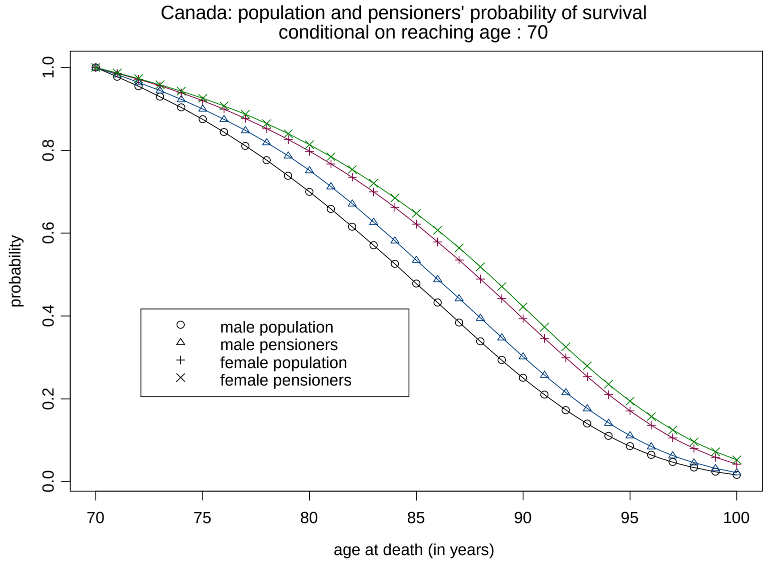


Figure 2.4.8

Canada: Distribution of age at death given survival to age 70

Summary Statistics

	Male			female		
	population	UP-94 table	difference	population	UP-94 table	difference
Lower Quartile age	78.70	80.04	1.34	81.54	82.12	0.58
Median age	84.54	85.75	1.21	87.77	88.39	0.62
Upper Quartile age	90.01	91.18	1.17	93.09	93.64	0.55
Inter quartile range	11.31	11.14	-0.18	11.55	11.52	- 0.03
e_{70}	14.49	15.59	1.10	17.23	17.79	0.56

2.4.5 Canada results: comparison with previous study

Figures 2.4.9 and 2.4.10 compare the probabilities of death shown in Figure 2.4.1 with probabilities of death based on the 1995-1997 Canadian population experience, and the RP-2000 mortality table, for males and females separately. The expected future lifetimes are compared in Figures 2.4.11 and 2.4.12.

Clearly, there has been an improvement in the population mortality between the 1995-1997 experience and the 2006 experience at all ages for both males and females. From the annualised percentage changes in expected future lifetime for the population shown in Tables 2.4.4 and 2.4.5, it is apparent that the annual rate of improvement in population mortality is higher for males. On the other hand, the absolute differences at each age between the RP-2000 and the UP-94 mortality tables assumed for pension-related benefits would appear to indicate an even greater improvement in mortality.

Table 2.4.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the 2006 Canadian male population would be expected to live to age 89.5 years, the same proportion of 65-year old males from the 1995-1997 male population would be expected to live to age 87.9 years approximately, the actual difference being more than 1.5 years. For females, the difference from a similar comparison is lower: 25% of the 2006 female Canadian population alive at age 65 is expected to live to about age 92.8 years while the same proportion from the 1995-1997 Canadian female population is expected to live to age 91.7 years, the actual difference being just over one year. The corresponding differences in expected future lifetimes derived from the UP-94 and the RP-2000 mortality tables assumed for pension benefits are considerably greater for males: on the basis of the UP-94 mortality table, the upper 25% of 65-year old males would be expected to live 2.4 years longer than on the basis of the RP-2000 (to age 90.77), whilst the upper 25% of females would be expected to live 2 years longer, to age 92.37.

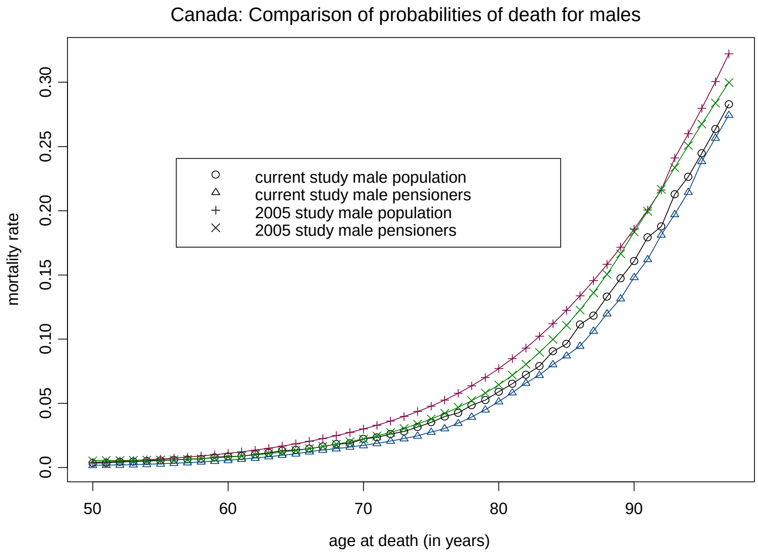


Figure 2.4.9

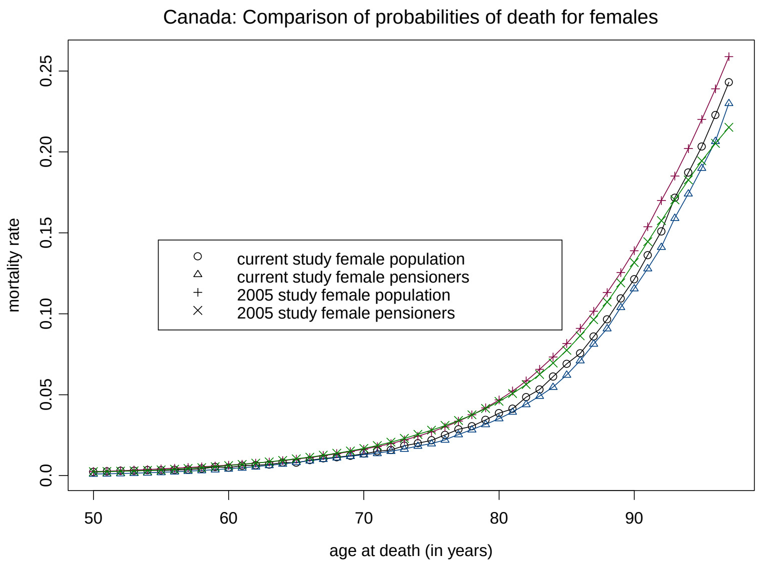


Figure 2.4.10

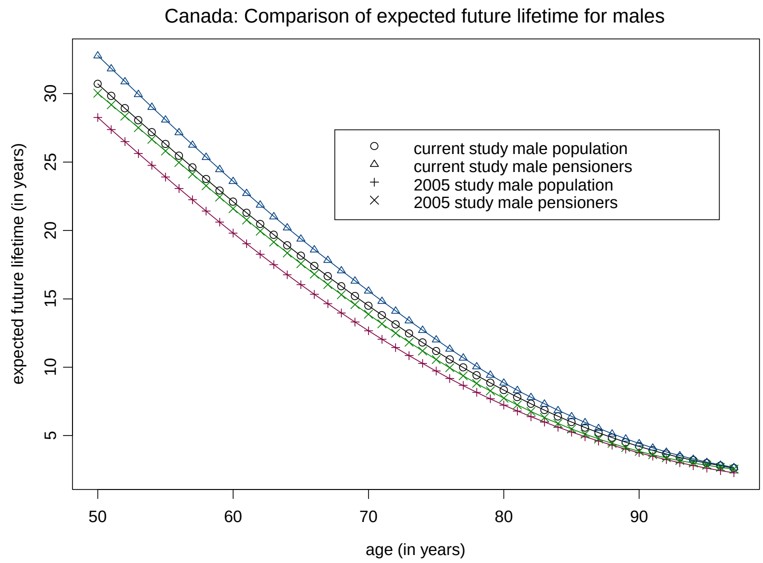


Figure 2.4.11

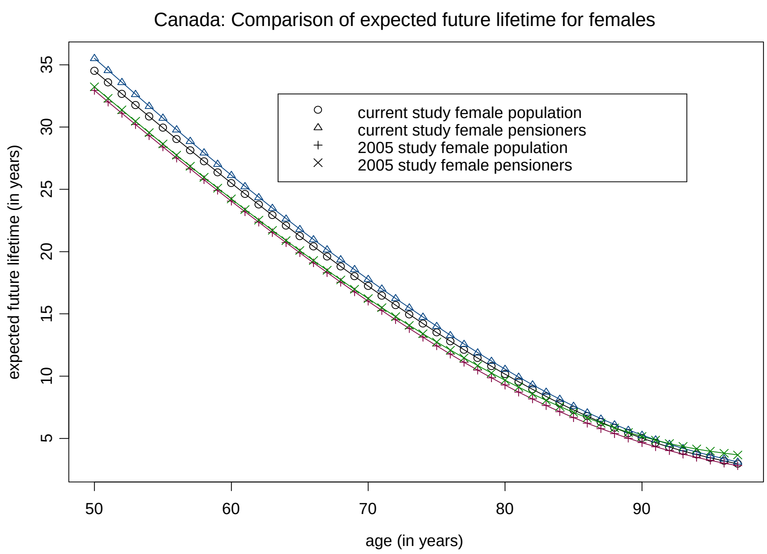


Figure 2.4.12

Table 2.4.4
Canada: Comparison of expected complete future lifetime for males

age	male pensioners			male population			
	UP-94 projected to 2020	RP-2000 projected to 2000	difference	2006	1996	difference	Annualised percentage difference
50	32.78	30.03	2.75	30.72	28.26	2.46	0.9%
55	28.10	25.82	2.28	26.32	23.91	2.40	1.0%
60	23.60	21.59	2.00	22.10	19.81	2.29	1.2%
65	19.40	17.57	1.83	18.15	16.04	2.11	1.3%
70	15.59	13.88	1.71	14.49	12.67	1.82	1.4%
75	12.02	10.57	1.46	11.18	9.73	1.45	1.5%
80	8.87	7.75	1.12	8.33	7.24	1.09	1.5%
85	6.41	5.49	0.92	6.00	5.26	0.74	1.4%
90	4.43	3.86	0.58	4.22	3.76	0.46	1.2%
95	3.06	2.84	0.22	3.00	2.62	0.37	1.4%

Table 2.4.5
Canada: Comparison of expected complete future lifetime for females

age	female pensioners			female population			
	UP-94 projected to 2020	RP-2000 projected to 2000	difference	2006	1996	difference	Annualised percentage difference
50	35.52	33.23	2.29	34.51	32.94	1.57	0.5%
55	30.74	28.64	2.09	29.95	28.40	1.54	0.5%
60	26.13	24.23	1.90	25.50	24.05	1.44	0.6%
65	21.80	20.08	1.71	21.25	19.90	1.34	0.7%
70	17.79	16.23	1.57	17.23	16.02	1.22	0.8%
75	14.01	12.74	1.27	13.50	12.44	1.07	0.9%
80	10.57	9.68	0.89	10.16	9.28	0.88	0.9%
85	7.60	7.09	0.51	7.29	6.67	0.62	0.9%
90	5.27	5.15	0.12	5.03	4.66	0.37	0.8%
95	3.63	3.97	-0.34	3.44	3.24	0.20	0.6%

Table 2.4.6
Canada: Distribution of age at death given survival to age 65
Summary Statistics for the population experience

	Male			female		
	2006 population	1996 population	difference	2006 population	1996 population	difference
Lower Quartile age	76.88	74.30	2.58	80.26	78.16	2.10
Median age	83.62	81.87	1.74	87.19	85.39	1.80
Upper Quartile age	89.51	87.89	1.62	92.79	91.67	1.12
Inter quartile range	12.63	13.59	-0.96	12.53	13.51	-0.98
e_{65}	18.15	16.04	2.11	21.25	19.90	1.34

Summary Statistics based on the mortality tables assumed for pension benefits

	Male			female		
	UP-94 projected to 2020	RP-2000 projected to 2000	difference	UP-94 projected to 2020	RP-2000 projected to 2000	difference
Lower Quartile age	78.49	76.41	2.08	80.85	78.37	2.48
Median age	84.99	83.99	1.00	87.83	85.31	2.52
Upper Quartile age	90.77	88.37	2.40	93.37	91.38	2.00
Inter quartile range	12.27	11.95	0.32	12.52	13.00	-0.48
e_{65}	19.40	17.57	1.83	21.80	20.08	1.71

2.5 Denmark

The mortality assumed in the previous study for the population and for pensioners is compared with the most recent population mortality experience available from the Human Mortality Database for Denmark. An update of the mortality experience most commonly assumed for pensions in Denmark has not been made available.

2.5.1 Denmark: population mortality

The Denmark population mortality experience in 2007 available on the Human Mortality Database has been used in this study, without any adjustments. In the previous study, the most recent population mortality experience available from the Human Mortality Database was for 2002.

2.5.2 Denmark: Mortality assumptions used to assess retirement liabilities within pension funding valuations

The description in this section is largely reproduced from the previous report (Verrall et al, Cass, Nov 2005).

The G82 mortality tables assumed for pension benefits in the previous study were constructed in 1982 from the mortality experience of the Danish population. However, the tables were said to underestimate mortality at the oldest ages.

The data were graduated using a Gompertz-Makeham formula:

$$\mu_x = \alpha + 10^{\beta - 10 + \gamma x},\ x \geq 0$$

where μ_x is the force of mortality at age x. The parameter values applied to obtain the forces of mortality given in the G82 tables are shown in Table 2.5.1.

Table 2.5.1

Denmark: Assumptions used to derive the G82 mortality tables

Parameter	Males	females
α	0.0005	0.0005
β	5.8800	5.728
γ	0.038	0.038

Since 1999 the use of unisex mortality for all new compulsory business has been mandatory. Each insurance company has constructed mortality tables to comply with the regulations. The major companies took the opportunity to construct new mortality tables for males and females, taking into account longevity. These mortality tables are used for new business. One major company is said to use their new unisex mortality table for compulsory business, the new sex-differentiated mortality table for pure annuity business and the G82 mortality tables for voluntary business. Hence, there is no longer a common mortality table.

However, all business written up until 1999 is based on the G82 mortality table, so that this mortality basis was expected to be in effect for many years. It is also noted that, although new business written after 1999 now varies from company to company, examples show that new voluntary insurances can still be written on the G82 basis.

The current retirement age is 65 years but this will be increased gradually to age 67 in the period 2024-27. Widow/widower's pension in Denmark can be a lump sum or a proportion of the spouse's pension. When a widow/widower's pension is written on a collective basis (common for pension funds), the expected age of the spouse is calculated from a distribution depending on the age of the insured. In this study, we focus only on the widow's pension (ignoring the widower's pension) and assume that the widow is three years younger than her husband.

2.5.3 Denmark: Projected mortality

The G82 tables have no built-in mechanisms to take into account future changes in mortality.

2.5.4 Denmark: Results

A summary of the results obtained from an analysis of Danish mortality data is given in Table 2.5.2. Clearly, annuity rates based on the G82 mortality tables are lower than annuity rates evaluated on the basis of the 2007 population mortality experience in all cases, so that using the G82 mortality tables for evaluating pension-related benefits is likely to lead to losses.

A comparison of probabilities of death (initial rates of mortality, q_x rates) based on the G82 tables with corresponding probabilities of death derived from the 2007 population mortality experience shows that population mortality is lighter at all ages other than extreme old age (Table 2.5.3 and Figure 2.5.1). A more detailed examination of the q_x rates shows that the population mortality rates are lower at ages up to 86 years for both males and females. The ratio of initial rates of mortality based on the G82M table to initial rates of mortality derived from the population experience is as high as 1.49 (that is 49% higher) at age 60. The difference between female rates of mortality is generally higher with the mortality rate based on the G82K tables being 78% higher than the female population mortality rate at age 50.

Figure 2.5.2 shows ratios of female probabilities of death (q_x rates) to male probabilities of death based on the G82 mortality tables and population mortality experience separately. As would be expected, in both cases (G82 basis and population experience), the females experience lighter mortality. However, the proportional difference between the female population mortality and the male population mortality decreases with age while the corresponding proportional differences based on the G82 mortality tables are relatively constant.

As would be expected, the differences between values of the expected future lifetime at each age x (e_x values) based on the G82 mortality tables and expected future lifetime values based on the current population mortality experience (Tables 2.5.2, 2.5.4 and Figure 2.5.3) reflect the corresponding differences in mortality rates shown in Table 2.5.3. The differences that exist between annuity values are consistent with the differences in expected future lifetime (e_x) values shown.

Figures 2.5.4, 2.5.5, 2.5.6 and 2.5.7 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \le k \le 100 - x$. Considering the distribution of age at death given survival to age 65 (Figure 2.5.6 and the associated table), it is noted that whereas a 65-year old male would is expected to live to at least age 81 years on the basis of the 2007 Denmark male population mortality experience and to about age 80 on the basis of the G82 mortality tables, one quarter of the females alive at age 65 would be expected to live to at least age 90 years based on the female population mortality experience and to at least age 89 based on the G82 mortality tables, the actual difference being less than a year. It is further noted that a 65-year old female from the 2007 Denmark population is expected to survive three years longer than a 65-year old male from the population.

These results seem to indicate that the use of the G82 mortality basis to assess retirement liabilities is likely to result in mortality losses. It should be emphasised here that the G82 mortality tables have been used in this study as a reference point rather than as an assertion of the actual tables currently in use for pension-related benefits in Denmark. As observed in Section 2.5.2 above, the major companies have constructed new mortality tables for males and females, taking into account longevity so that there is no longer a common mortality table for new business.

Table 2.5.2

Denmark: Summary Statistics

age x = 50

	Male				female			
	population	G82M	difference	percentage difference	population	G82K	difference	percentage difference
e_x	28.45	26.31	-2.14	-7.5	31.95	29.65	-2.30	-7.2
a_x : 3%	17.93	16.90	-1.03	-5.8	19.44	18.34	-1.10	-5.6
a_x : 6%	12.60	12.06	-0.54	-4.3	13.33	12.76	-0.57	-4.3

age x = 60

	Male				female			
	population	G82M	difference	percentage difference	population	G82K	difference	percentage difference
e_x	20.24	18.52	-1.72	-8.5	23.20	21.47	-1.74	-7.5
a_x : 3%	14.04	13.01	-1.03	-7.3	15.61	14.58	-1.02	-6.6
a_x : 6%	10.58	9.93	-0.65	-6.2	11.47	10.84	-0.64	-5.6
$a_x + .6a_{x\|y}$: 3%	16.75	15.87	-0.89	-5.3				

age x = 65

	Male				female			
	population	G82M	difference	percentage difference	population	G82K	difference	percentage difference
e_x	16.45	15.07	-1.38	-8.4	19.11	17.76	-1.35	-7.1
a_x : 3%	11.93	11.02	-0.91	-7.6	13.48	12.60	-0.88	-6.6
a_x : 6%	9.32	8.70	-0.62	-6.7	10.29	9.68	-0.60	-5.9
$a_x + .6a_{x\|y}$: 3%	14.66	13.86	-0.80	-5.5				

age x = 70

	Male				female			
	population	G82M	difference	percentage difference	population	G82K	difference	percentage difference
e_x	12.93	11.98	-0.94	-7.3	15.23	14.38	-0.85	-5.6
a_x : 3%	9.75	9.07	-0.67	-6.9	11.22	10.61	-0.61	-5.5
a_x : 6%	7.90	7.40	-0.50	-6.3	8.89	8.43	-0.45	-5.1

Table 2.5.3

Denmark: One-year probabilities of death (initial rates of mortality, q_x rates)

	Male			Female		
age	population	G82M	Ratio	population	G82K	Ratio
50	0.005100	0.006774	1.33	0.002770	0.004925	1.78
55	0.006970	0.010201	1.46	0.004600	0.007346	1.60
60	0.010400	0.015484	1.49	0.007100	0.011083	1.56
65	0.017120	0.023613	1.38	0.011660	0.016843	1.44
70	0.026530	0.036069	1.36	0.018540	0.025699	1.39
75	0.047340	0.055049	1.16	0.031510	0.039258	1.25
80	0.071920	0.083711	1.16	0.050770	0.059886	1.18
85	0.122550	0.126397	1.03	0.092410	0.090965	0.98
90	0.199960	0.188617	0.94	0.147390	0.137085	0.93
95	0.288620	0.276354	0.96	0.240350	0.203941	0.85

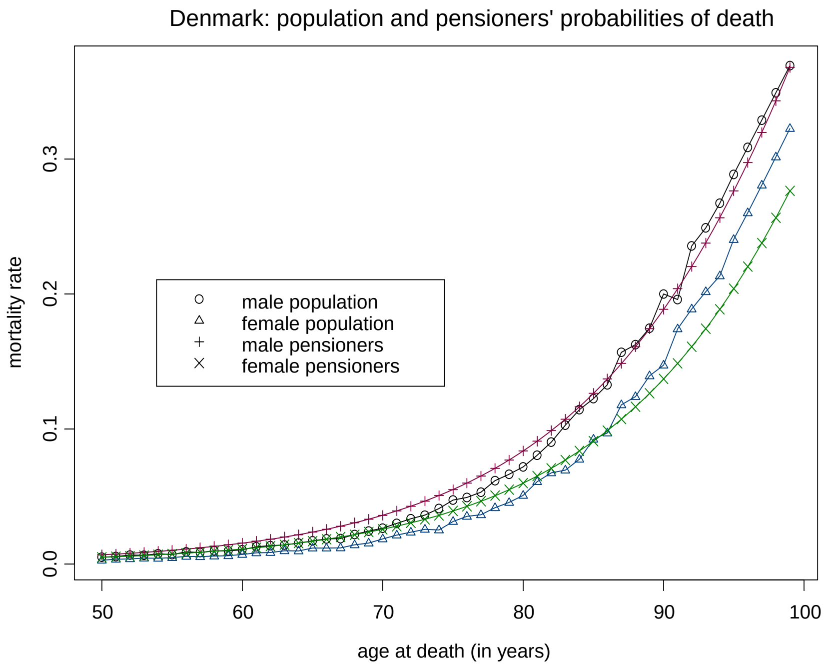


Figure 2.5.1

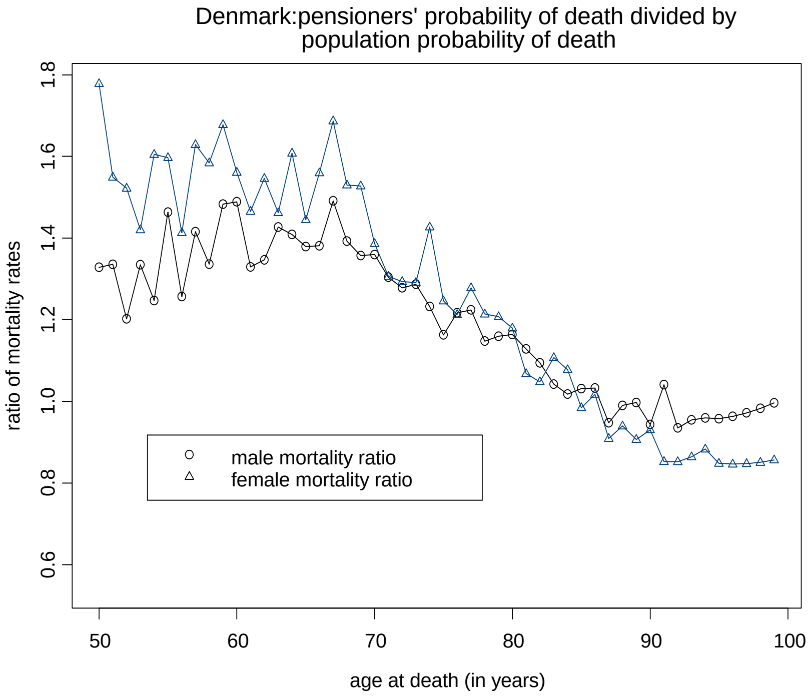


Figure 2.5.2

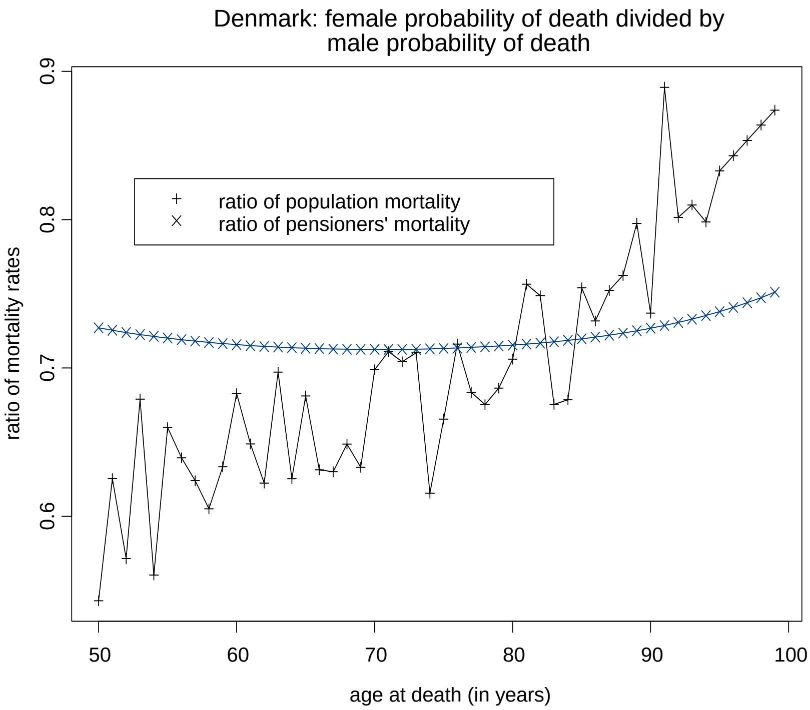


Figure 2.5.3

Table 2.5.4

Denmark: Expected complete future lifetime in years

	male				female			
age	population	G82M	difference	percentage difference	population	G82K	difference	percentage difference
50	28.45	26.31	-2.14	-7.5	31.95	29.65	-2.30	-7.2
55	24.27	22.28	-1.98	-8.2	27.51	25.45	-2.06	-7.5
60	20.24	18.52	-1.72	-8.5	23.20	21.47	-1.74	-7.5
65	16.45	15.07	-1.38	-8.4	19.11	17.76	-1.35	-7.1
70	12.93	11.98	-0.94	-7.3	15.23	14.38	-0.85	-5.6
75	9.83	9.30	-0.54	-5.5	11.78	11.36	-0.42	-3.5
80	7.24	7.03	-0.21	-2.9	8.74	8.74	0.00	0.0
85	5.15	5.17	0.02	0.3	6.22	6.52	0.30	4.8
90	3.64	3.69	0.05	1.4	4.35	4.67	0.32	7.4
95	2.58	2.45	-0.13	-4.9	3.02	3.00	-0.02	-0.7

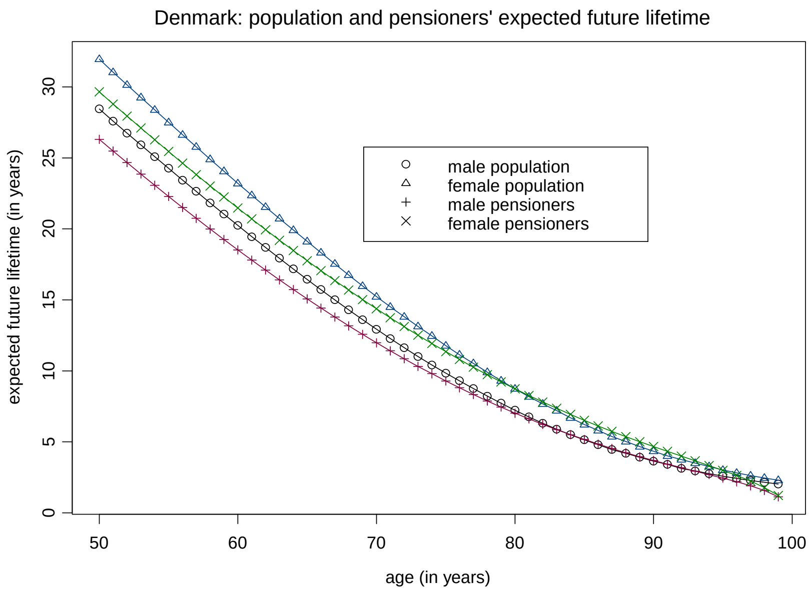


Figure 2.5.4

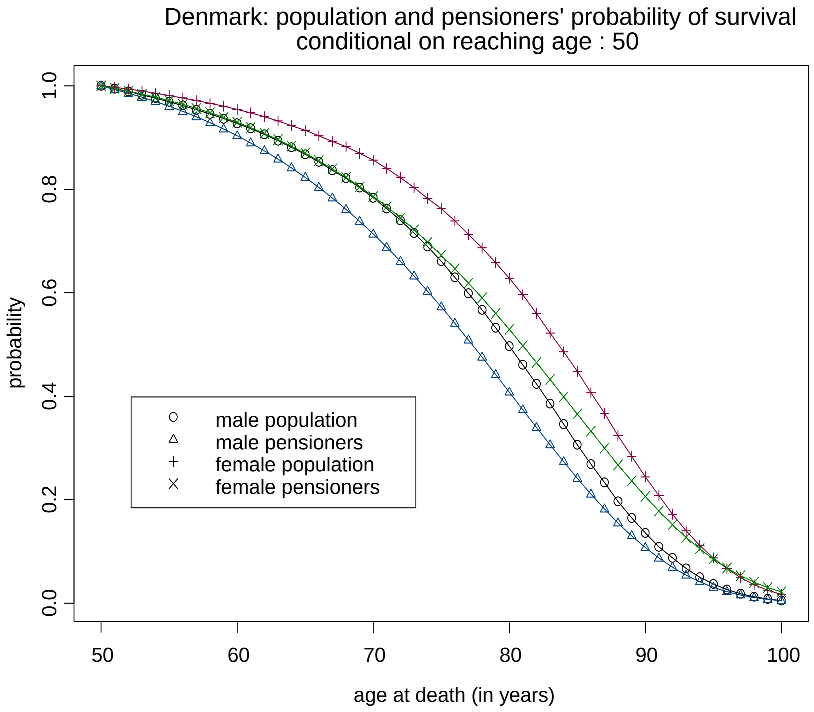


Figure 2.5.5

Denmark: Distribution of age at death given survival to age 50

Summary Statistics

	male			female		
	population	G82M	difference	population	G82K	difference
Lower Quartile age	71.57	68.49	-3.08	75.53	71.74	-3.79
Median age	79.91	77.26	-2.64	83.61	80.92	-2.69
Upper Quartile age	86.42	84.73	-1.69	89.85	88.56	-1.30
Inter quartile range	14.85	16.25	1.39	14.32	16.82	2.50
e_{50}	28.45	26.31	-2.14	31.95	29.65	-2.30

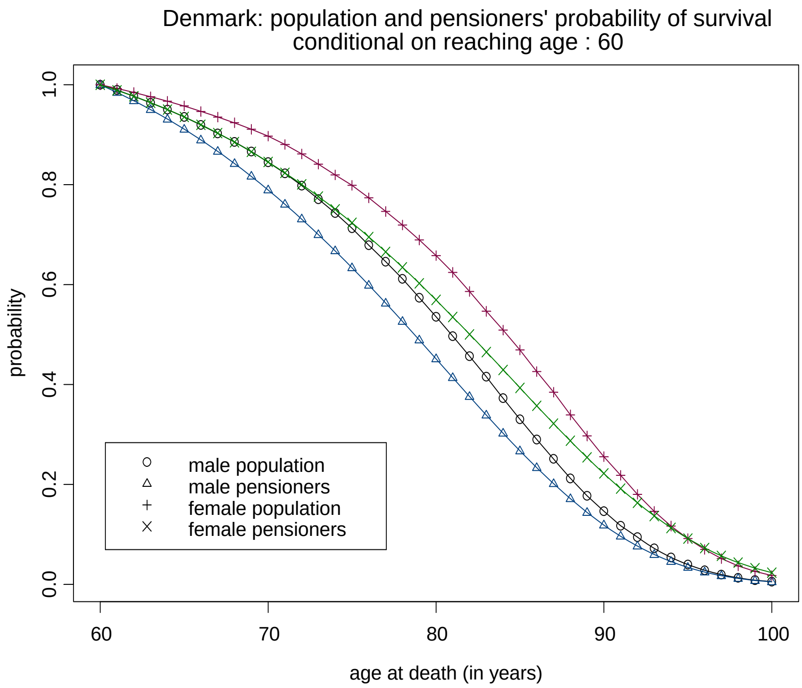


Figure 2.5.6

Denmark: Distribution of age at death given survival to age 60

Summary Statistics

	male			female		
	population	G82M	difference	population	G82K	difference
Lower Quartile age	73.76	71.38	-2.39	76.87	74.02	-2.85
Median age	80.92	78.71	-2.21	84.22	82.01	-2.21
Upper Quartile age	87.03	85.51	-1.52	90.15	89.12	-1.03
Inter quartile range	13.27	14.13	0.86	13.28	15.10	1.82
e_{60}	20.24	18.52	-1.72	23.20	21.47	-1.74

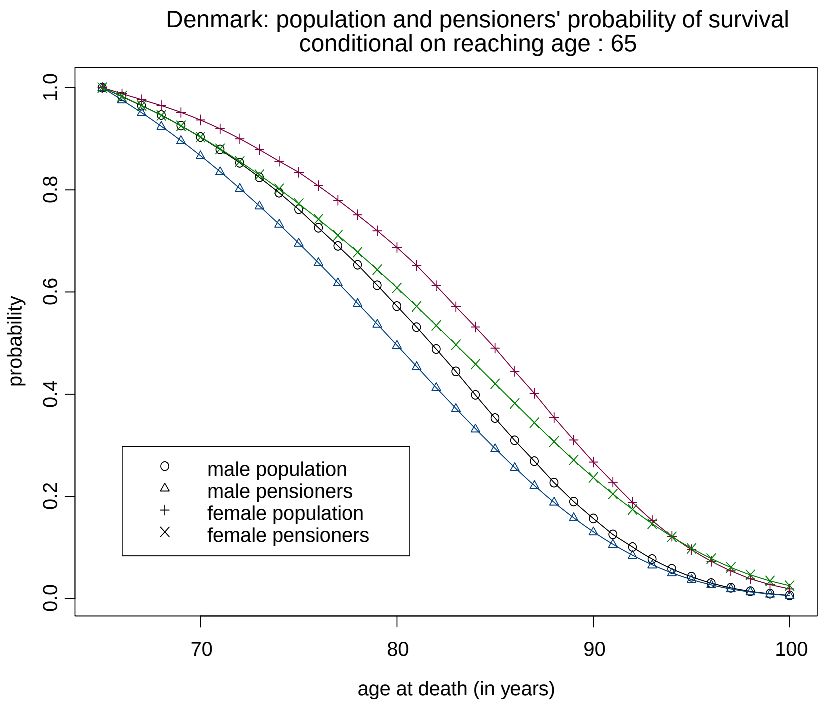


Figure 2.5.7

Denmark: Distribution of age at death given survival to age 65
Summary Statistics

	male			female		
	population	G82M	difference	population	G82K	difference
Lower Quartile age	75.33	73.52	-1.81	78.20	75.76	-2.43
Median age	81.73	79.89	-1.84	84.72	82.91	-1.81
Upper Quartile age	87.44	86.18	-1.26	90.44	89.62	-0.81
Inter quartile range	12.11	12.66	0.55	12.24	13.86	1.62
e_{65}	16.45	15.07	-1.38	19.11	17.76	-1.35

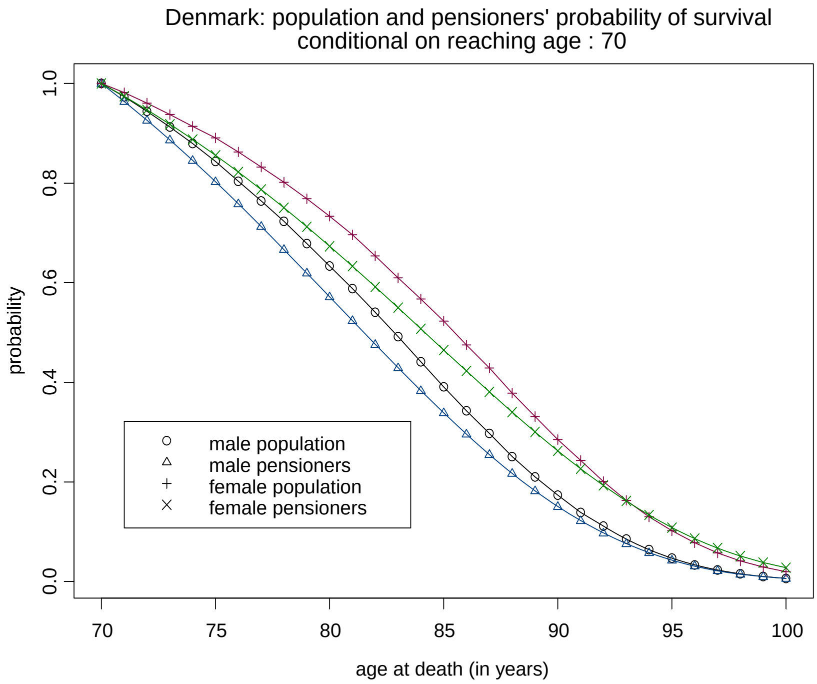


Figure 2.5.8

Denmark: Distribution of age at death given survival to age 70
Summary Statistics

	male			female		
	population	G82M	difference	population	G82K	difference
Lower Quartile age	77.34	76.18	-1.16	79.53	78.01	-1.52
Median age	82.83	81.50	-1.33	85.48	84.18	-1.30
Upper Quartile age	88.02	87.13	-0.88	90.83	90.35	-0.49
Inter quartile range	10.67	10.95	0.28	11.31	12.33	1.03
e_{70}	12.93	11.98	-0.94	15.23	14.38	-0.85

2.5.5 Denmark Results: Comparison with previous study

Figures 2.5.9 and 2.5.10 compare the probabilities of death shown in Figure 2.5.1 with probabilities of death for the population in 2002, the population experience used in the previous study, for males and females separately. The expected future lifetimes are compared in Figures 2.5.11 and 2.5.12. Clearly, there has been an improvement in the population mortality between 2002 and 2007 at all ages for both males and females. From the annualised percentage changes in expected future lifetime shown in Tables 2.5.5 and 2.5.6, it is apparent that:

- the rate of improvement in mortality is generally higher for males; and
- the rate of improvement increases with age.

We reiterate that although the G82 mortality tables have been assumed for pension benefits, in the submission from Denmark for the previous study it was noted that there is no longer a common mortality table used by companies for pension benefits in Denmark.

Table 2.5.7 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the 2007 male population in Denmark would be expected to live to at least age 87 years, the same proportion of 65-year old males from the 2002 male population in Denmark would be expected to live to age 85 approximately, the actual difference being more than two years. For females, the difference from a similar comparison is lower: 25% of the 2007 female population in Denmark alive at age 65 is expected to live to at least age 90 while the same proportion from the 2002 female population in Denmark is expected to live to just under age 90, the actual difference being less than one year.

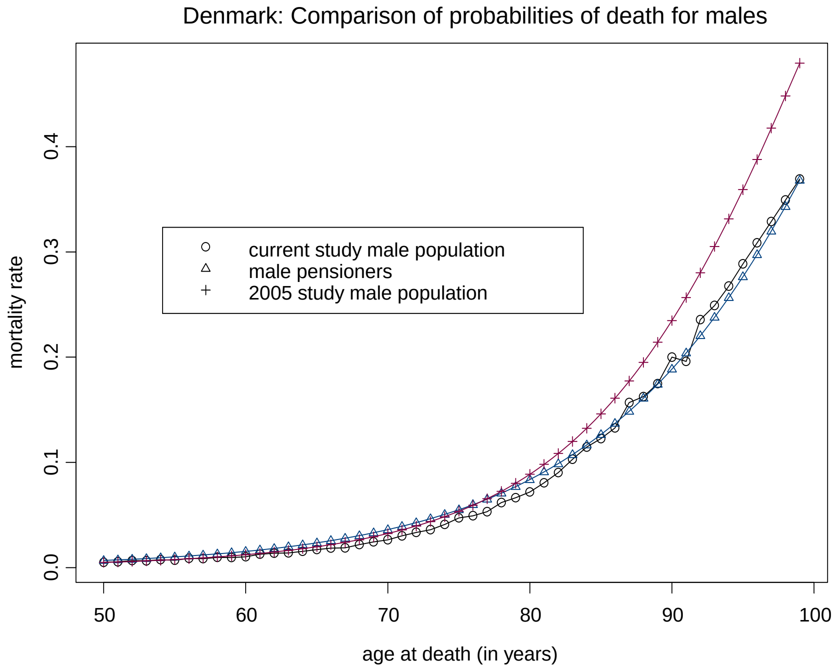


Figure 2.5.9

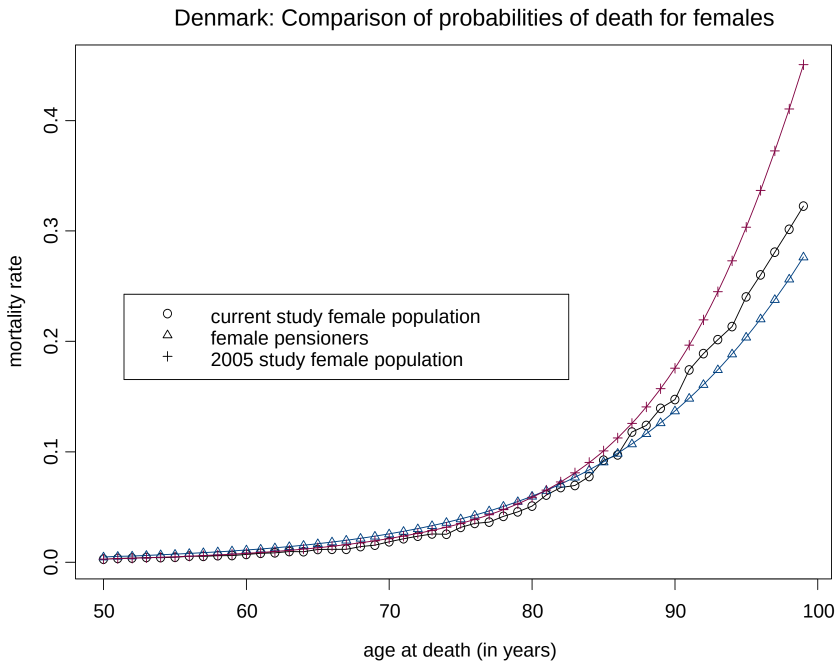


Figure 2.5.10

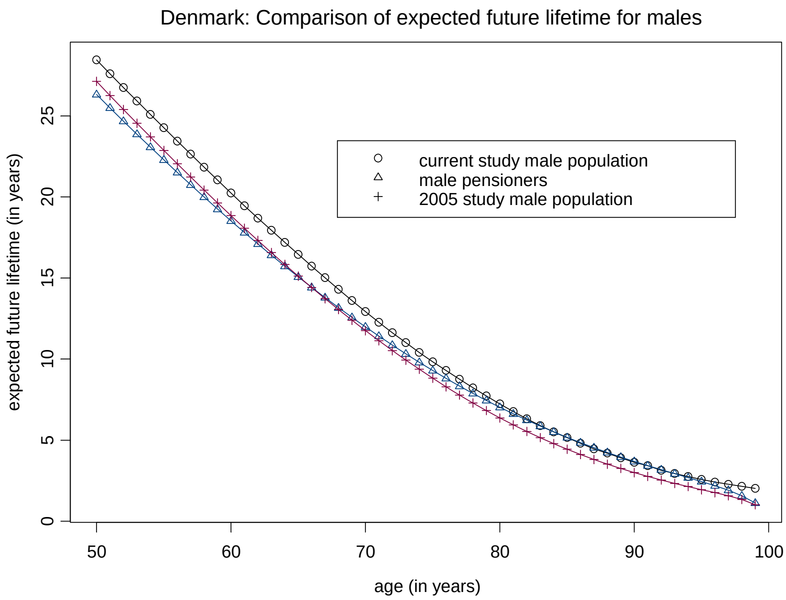


Figure 2.5.11

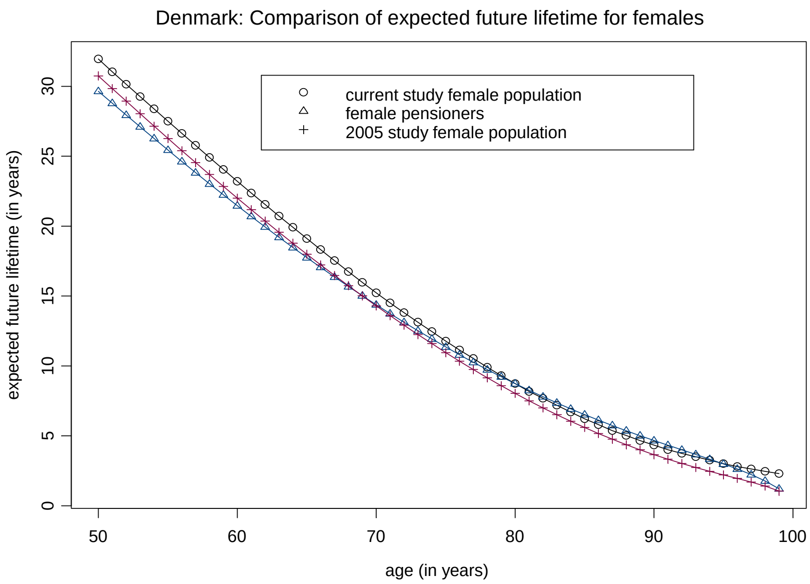


Figure 2.5.12

Table 2.5.5
Denmark: Comparison of expected complete future lifetime for males

	G82M tables	Male population			
		2007 population	2002 population	difference	Annualised percentage difference
50	26.31	28.45	27.12	1.33	1.0%
55	22.28	24.27	22.86	1.40	1.2%
60	18.52	20.24	18.84	1.39	1.5%
65	15.07	16.45	15.11	1.33	1.8%
70	11.98	12.93	11.75	1.18	2.0%
75	9.30	9.83	8.82	1.02	2.3%
80	7.03	7.24	6.37	0.87	2.7%
85	5.17	5.15	4.44	0.71	3.2%
90	3.69	3.64	3.00	0.64	4.3%
95	2.45	2.58	1.95	0.62	6.4%

Table 2.5.6
Denmark: Comparison of expected complete future lifetime for females

	G82K tables	Female population			
		2007 population	2002 population	difference	Annualised percentage difference
50	29.65	31.95	30.75	1.20	0.8%
55	25.45	27.51	26.27	1.23	0.9%
60	21.47	23.20	22.01	1.20	1.1%
65	17.76	19.11	18.00	1.11	1.2%
70	14.38	15.23	14.30	0.93	1.3%
75	11.36	11.78	10.96	0.81	1.5%
80	8.74	8.74	8.04	0.70	1.7%
85	6.52	6.22	5.60	0.63	2.2%
90	4.67	4.35	3.66	0.68	3.7%
95	3.00	3.02	2.21	0.81	7.3%

Table 2.5.7
Denmark: Distribution of age at death given survival to age 65
Summary Statistics

	Male			female		
	2007 population	2002 population	difference	2007 population	2002 population	difference
Lower Quartile age	75.33	74.80	0.53	78.20	76.06	2.14
Median age	81.73	80.75	0.98	84.72	83.37	1.35
Upper Quartile age	87.44	85.14	2.30	90.44	89.67	0.77
Inter quartile range	12.11	10.34	1.77	12.24	13.61	-1.37
e_{65}	16.45	15.11	1.33	19.11	18.00	1.11

2.6 Finland

2.6.1 Finland: population mortality

The most recent population mortality experience for Finland available from the Central Bureau of Statistics in Finland and the Human Mortality Database (HMD) pertains to 2007. In the previous study, the most recent population mortality experience available from the HMD was for 2002 and this was the experience used for comparison with mortality rates assumed for pension related benefits.

2.6.2 Finland: Mortality assumptions used to assess retirement liabilities within pension funding valuations

The Standard TyEL mortality tables updated technically in 2008 are the tables most commonly used for retirement liability calculations. The tables, based on amounts, are derived separately for males and females and apply to pensioners of the private sector statutory, earnings-related pension schemes, governed by the Employees' Pensions Act (TyEL). TyEL is the broadest earnings-related pension scheme, the provision of which affects over 50% of the employed labour force.

Forces of mortality are derived using a Gomperzt-type formula as given below:

$$\mu = 0.00005e^{-0.57+0.95(x+b2)}$$

where x is age and b2 is a factor that depends on year of birth and gender. All mortality tables for male and female cohorts are derived using the above formula. The values for $b2$ assumed in the Standard TyEL mortality basis updated in 2008 are given in Table 2.6.1 below. In the table, v-x is the year of birth of a person aged x and v is the calculation year.

Table 2.6.1
Finland: Standard TyEL tables, values of *b*2 updated in 2008

Year of birth ($v-x$)	Male	Female
$v-x<1940$	0	-7
$1940\le v-x<1950$	-1	-8
$1950\le v-x<1960$	-2	-9
$1960\le v-x<1970$	-3	-10
$1970\le v-x<1980$	-4	-11
$1980\le v-x<1990$	-5	-12
$1990\le v-x$	-6	-13

In the previous study, the Standard TyEL mortality tables updated in 2001 were the tables assumed for retirement liability calculations. For these tables, the forces of mortality were derived using the following Gomperzt-type formula:

$$\mu_x = 0{,}00005e^{0{,}095(x+(b2))},$$

where, as above, x is age and $b2$ is a factor that depends on year of birth and gender.

The values for $b2$ assumed in the Standard TyEL mortality basis updated in 2001 are given in Table 2.6.2 with x, v and v-x, defined as above.

Table 2.6.2
Finland: Standard TyEL tables, values of *b*2 updated 19/12/01

Year of birth ($v-x$)	Male	Female
$v-x<1940$	-6	-13
$1940\le v-x<1950$	-7	-14
$1950\le v-x<1960$	-8	-15
$1960\le v-x<1970$	-9	-16
$1970\le v-x<1980$	-10	-17
$1980\le v-x$	-11	-18

2.6.3 Finland: projected mortality

The Standard TyEL mortality tables are generation mortality tables and hence projected mortality rates can be derived directly. However, in this study, comparisons with population mortality are on the basis of attained age in 2008, i.e. $v = 2008$. The previous study was on the basis of attained age in 2003 for the Standard TyEL tables.

2.6.4 Finland: results

Table 2.6.3 gives summary results from an analysis of the population mortality of Finland based on the 2007 mortality experience available from the Human Mortality Database and the Standard TyEL mortality tables used in the valuation of pension - related benefits in Finland. From the table, it can be seen that the present value of annuity rates derived on the basis of the Standard TyEL mortality tables are higher than annuity rates derived on the basis of the current population mortality, which is consistent with lighter mortality experience for pensioners. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 6.6% for males and 8.7% for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of member's pension is included, the percentage difference between male annuity rates at age 65 is 7.2% assuming a discount rate of 3%.

A comparison of the Standard TyEL mortality tables with population mortality rates shows that although the TyEL tables exhibit lighter mortality in general, at ages between 69 and 75 the female TyEL tables exhibit heavier mortality whilst mortality rates from the male TyEL tables are close to the population rates at these ages (Table 2.6.4, Figures 2.6.1 and 2.6.2). The ratio of initial rates of mortality (q_x rates) based on the TyEL male mortality tables to initial rates of mortality derived from the male population mortality experience is 68% at age 60, 72% at age 65 and 87% at age 70. The corresponding ratios for females are 76% at age 60, 82% at age 65 and 120% at age 70. The ratio of 120% at age 70 for females implies that the mortality rate derived from the TyEL female tables for a life aged 70 is 20% higher than the corresponding mortality rate derived from the female population experience.

Figure 2.6.3 shows age-related ratios of female probabilities of death to male probabilities of death based on pension-related tables and population mortality experience separately. From the graph, it can be seen that, the difference between male and female population mortality rates is generally decreasing as age increases while the proportional difference in mortality rates based on the Standard TyEL table is approximately constant over all ages at which comparisons have been made.

Table 2.6.5 and Figure 2.6.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the Standard TyEL mortality tables with corresponding expected future lifetime values for the population. Expressed as a percentage of the expected future lifetime value derived from the population mortality experience, the differences tend to increase with age for both males and females, with the proportional differences at age 65 being 8.6% for males and 14% for females (Tables 2.6.3 and 2.6.5). Based on the Standard TyEL mortality tables, the life expectancy at age 65 is about 1.5 years longer for males and 2.9 years longer for females compared to the observed male and female population mortality experiences respectively.

Figures 2.37, 2.38, 2.39 and 2.40 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering the distribution of age at death given survival to age 65 (Figure 2.39 and the associated table), it is noted that the Standard TyEL tables for both males and females have a greater spread than the corresponding population tables, as measured by the inter-quartile range. It is further noted that whereas a male 65-year old member of a company pension scheme is expected to live to about age 83.3 years, one quarter of those alive at age 65 would be expected to live to at least age 89 years.

Figures 2.6.5, 2.6.6, 2.6.7 and 2.6.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering age 65 (Figure 2.6.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to age 83.4 years on the basis of the Standard TyEL mortality tables and to about age 82 on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to at least age 90 approximately on the basis of the Standard TyEL tables and to about age 88 on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to at least age 89 approximately on the basis of the Standard TyEL tables and to at least age 86 approximately on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to at least age 96 on the basis of the Standard TyEL tables and to at least age 91.7 on the basis of the female population experience.

Table 2.6.3

Finland: Summary Statistics

age x = 50

	male				female			
	population	TyEL male	difference	percentage difference	population	TyEL female	Difference	percentage difference
e_x	28.70	31.20	2.50	8.7	34.29	37.50	3.20	9.3
a_x : 3%	17.99	19.12	1.13	6.3	20.43	21.43	1.00	4.9
a_x : 6%	12.61	13.19	0.59	4.6	13.80	14.16	0.36	2.6

age x = 60

	male				female			
	population	TyEL male	difference	percentage difference	population	TyEL female	difference	percentage difference
e_x	20.65	22.39	1.74	8.4	25.28	28.25	2.97	11.8
a_x : 3%	14.24	15.14	0.90	6.3	16.73	17.87	1.14	6.8
a_x : 6%	10.68	11.19	0.51	4.8	12.12	12.59	0.47	3.9
ax+.6ax|y: 3%	17.24	18.29	1.05	6.1				

age x = 65

	male				female			
	population	TyEL male	difference	percentage difference	population	TyEL female	difference	percentage difference
e_x	16.92	18.38	1.46	8.6	20.96	23.91	2.94	14.0
a_x : 3%	12.20	13.01	0.80	6.6	14.60	15.87	1.28	8.7
a_x : 6%	9.49	9.97	0.48	5.0	11.00	11.58	0.59	5.3
ax+.6ax|y: 3%	15.21	16.30	1.09	7.2				

age x = 70

	male				female			
	population	TyEL male	difference	percentage difference	population	TyEL female	difference	percentage difference
e_x	13.42	14.71	1.28	9.6	16.80	19.81	3.01	17.9
a_x : 3%	10.08	10.84	0.76	7.5	12.28	13.77	1.49	12.2
a_x : 6%	8.13	8.60	0.47	5.8	9.63	10.41	0.78	8.1

Table 2.6.4
Finland: One-year probabilities of death (initial rates of mortality, q_x rates)

age	male			Female		
	population	TyEL-male	ratio	population	TyEL-female	Ratio
50	0.005640	0.002831	0.50	0.002080	0.001457	0.70
55	0.008800	0.004549	0.52	0.003650	0.002342	0.64
60	0.011890	0.008029	0.68	0.005410	0.004137	0.76
65	0.017430	0.012880	0.74	0.008090	0.006645	0.82
70	0.026080	0.022662	0.87	0.009770	0.011720	1.20
75	0.039420	0.036190	0.92	0.020200	0.018778	0.93
80	0.071330	0.057550	0.81	0.038920	0.030022	0.77
85	0.116410	0.090910	0.78	0.083540	0.047834	0.57
90	0.184890	0.142094	0.77	0.150800	0.075792	0.50
95	0.281460	0.218427	0.78	0.256290	0.119038	0.46

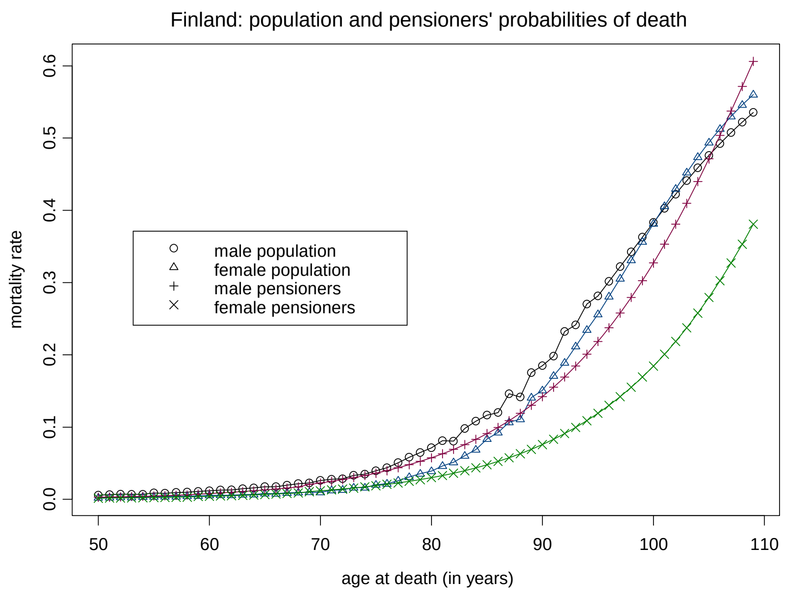
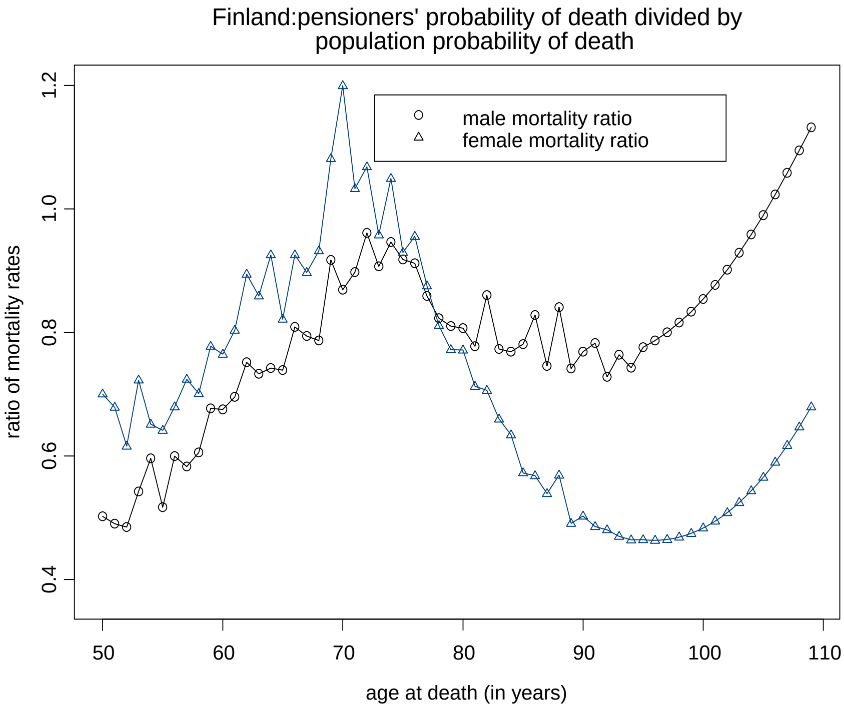


Figure 2.6.1



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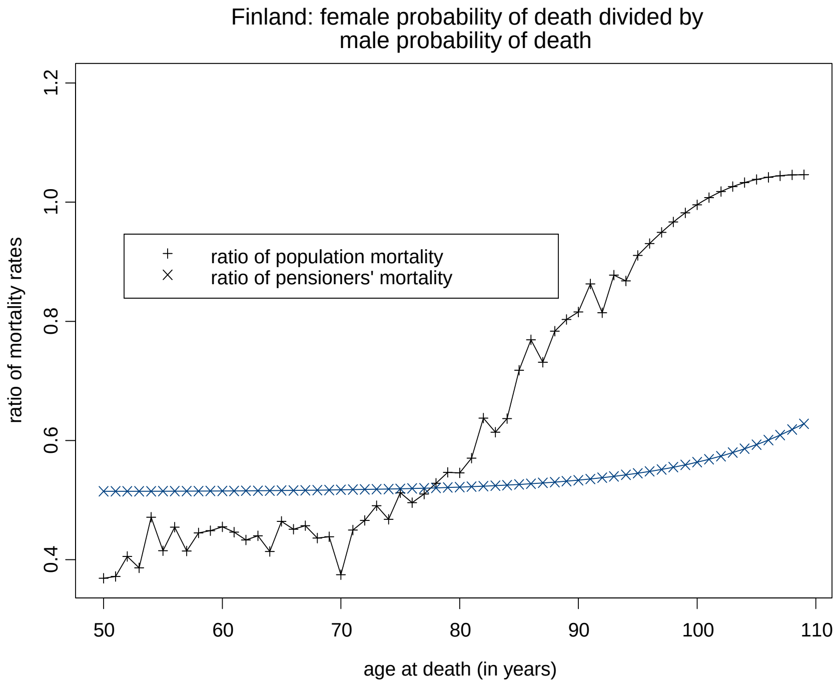


Figure 2.6.3

Table 2.6.5

Finland: Expected complete future lifetime in years

age	Male				female			
	population	TyEL-male	difference	percentage difference	population	TyEL-female	difference	percentage difference
50	28.70	31.20	2.50	8.7	34.29	37.50	3.20	9.3
55	24.58	26.70	2.12	8.6	29.71	32.81	3.09	10.4
60	20.65	22.39	1.74	8.4	25.28	28.25	2.97	11.8
65	16.92	18.38	1.46	8.6	20.96	23.91	2.94	14.0
70	13.42	14.71	1.28	9.6	16.80	19.81	3.01	17.9
75	10.21	11.52	1.31	12.8	12.80	16.09	3.29	25.7
80	7.49	8.77	1.28	17.1	9.26	12.73	3.48	37.6
85	5.38	6.48	1.10	20.4	6.32	9.80	3.48	55.0
90	3.72	4.65	0.92	24.8	4.21	7.32	3.12	74.1
95	2.63	3.24	0.61	23.1	2.79	5.30	2.51	90.2

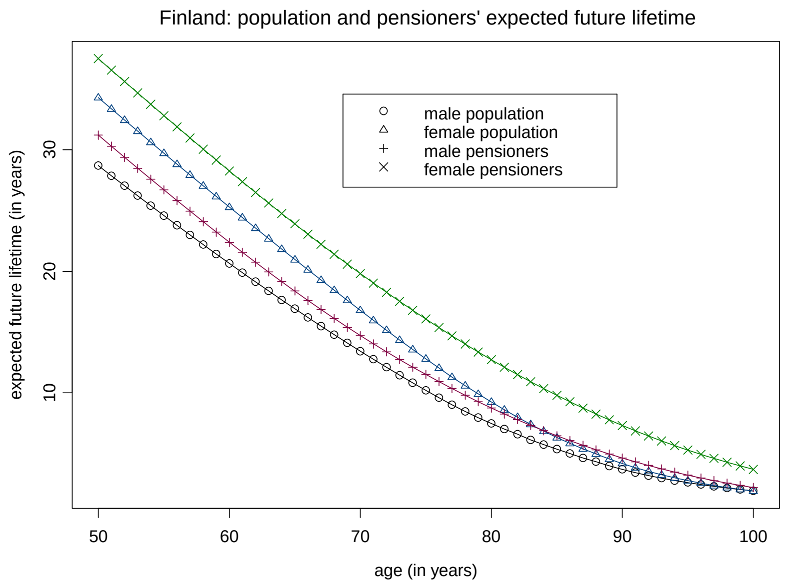


Figure 2.6.4

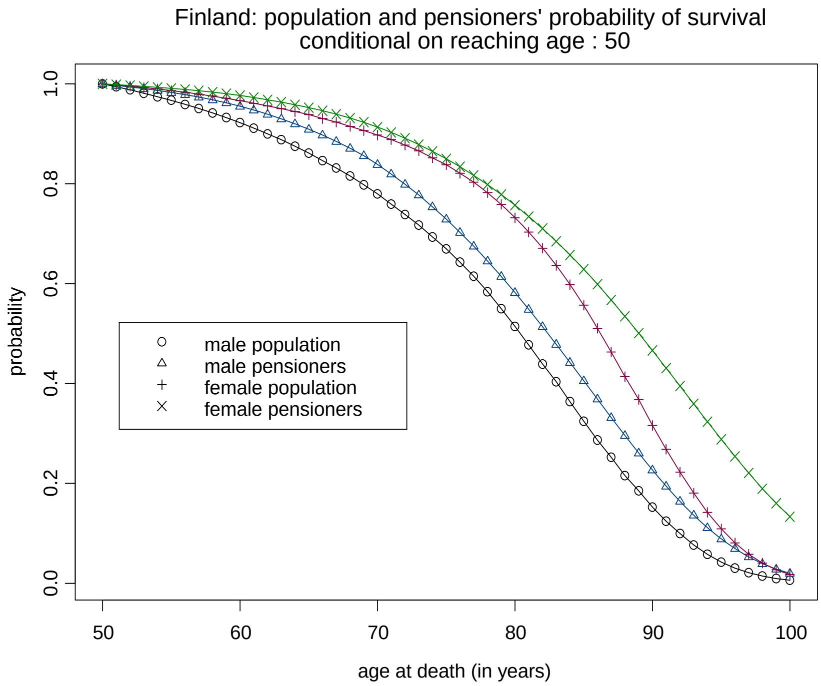


Figure 2.6.5

Finland: Distribution of age at death given survival to age 50
Summary Statistics

	Male			female		
	population	TyEL-male	difference	population	TyEL-female	difference
Lower Quartile age	71.45	74.16	2.71	79.32	80.32	1.00
Median age	80.39	82.40	2.01	86.22	89.03	2.80
Upper Quartile age	87.07	89.32	2.25	91.40	96.12	4.72
Inter quartile range	15.61	15.15	-0.46	12.08	15.80	3.72
e_{50}	28.70	31.20	2.50	34.29	37.50	3.20

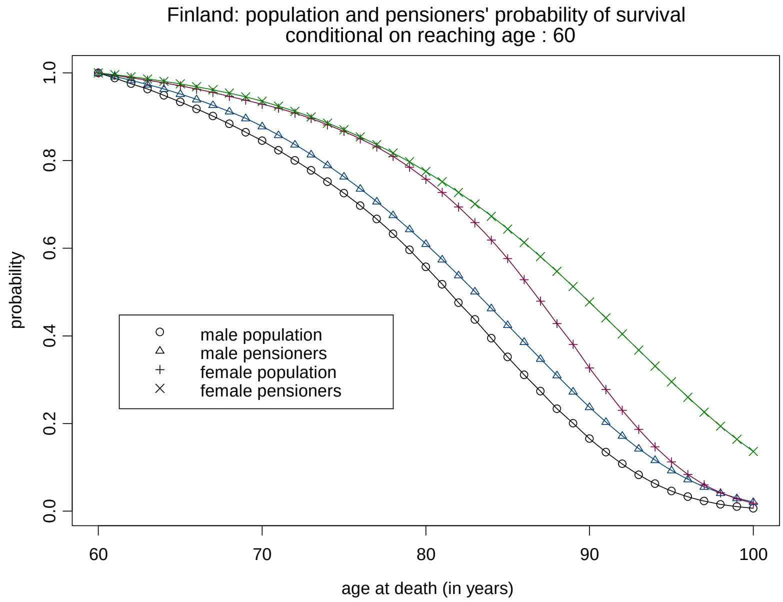


Figure 2.6.6

Finland: Distribution of age at death given survival to age 60
Summary Statistics

	Male			female		
	population	TyEL-male	difference	population	TyEL-female	difference
Lower Quartile age	74.07	75.48	1.41	80.24	81.08	0.84
Median age	81.42	83.03	1.60	86.58	89.36	2.79
Upper Quartile age	87.59	89.65	2.05	91.58	96.30	4.71
Inter quartile range	13.52	14.16	0.64	11.34	15.21	3.87
e_{60}	20.65	22.39	1.74	25.28	28.25	2.97

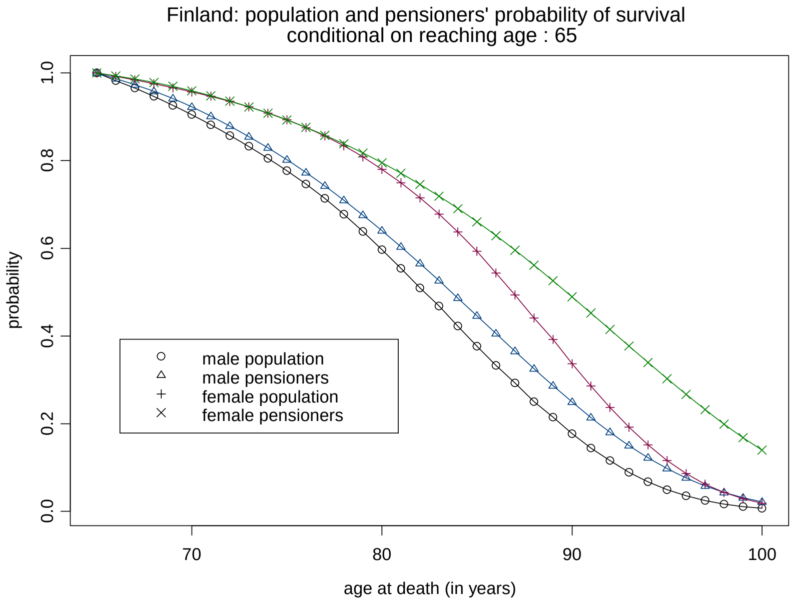


Figure 2.6.7

Finland: Distribution of age at death given survival to age 65
Summary Statistics

	Male			Female		
	population	TyEL-male	difference	population	TyEL-female	difference
Lower Quartile age	75.88	76.74	0.86	80.98	81.84	0.85
Median age	82.23	83.66	1.43	86.88	89.71	2.84
Upper Quartile age	88.01	89.98	1.98	91.74	96.48	4.74
Inter quartile range	12.12	13.24	1.12	10.75	14.64	3.89
e_{65}	16.92	18.38	1.46	20.96	23.91	2.94

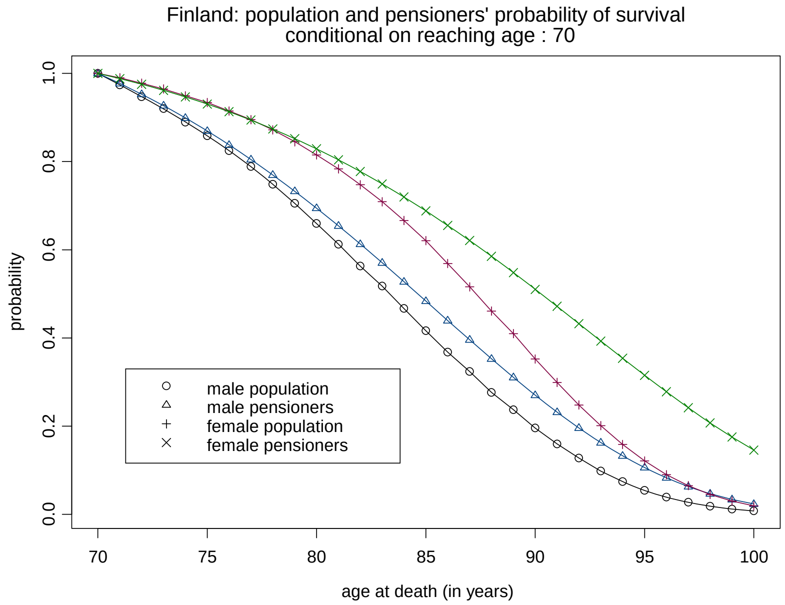


Figure 2.6.8

Finland: Distribution of age at death given survival to age 70
Summary Statistics

	Male			female		
	population	TyEL-male	difference	population	TyEL-female	difference
Lower Quartile age	77.97	78.53	0.57	81.93	82.98	1.05
Median age	83.35	84.63	1.28	87.29	90.27	2.98
Upper Quartile age	88.68	90.53	1.85	91.96	96.77	4.81
Inter quartile range	10.71	12.00	1.29	10.03	13.79	3.76
e_{70}	13.42	14.71	1.28	16.80	19.81	3.01

2.6.5 Finland results: Comparison with previous study

Figures 2.6.9 and 2.6.10 compare the probabilities of death shown in Figure 2.6.1 with probabilities of death for the population in 2002 and probabilities of death derived from the Standard TyEL mortality tables in 2003, for males and females separately. The expected future lifetimes are compared in Figures 2.6.11 and 2.6.12.

It is apparent that probabilities of death (and hence expected future lifetime values) derived from the 2008 and the 2003 Standard TyEL Mortality Tables assumed for pension-related benefits are essentially the same. Clearly, there has been an improvement in the population mortality between 2002 and 2007 at all ages for both males and females. From the annualised percentage changes in expected future lifetime shown in Tables 2.6.6 and 2.6.7, it is apparent that:

- at each age, the rate of improvement in population mortality is approximately the same for males and females; and
- the rate of improvement in population mortality increases with age.

Table 2.6.8 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the male population in Finland in 2007 would be expected to live to about age 88, the same proportion of 65-year old males from the male population in 2002 would be expected to live to age 86.7 years, the actual difference being more than a year. For females, the difference from a similar comparison is considerably higher: 25% of the female population in Finland in 2007 alive at age 65 is expected to live to at least age 91.7 while the same proportion from the 2002 female population is expected to live to about age 89, the actual difference being about 2.7 years. On the other hand the corresponding differences in expected future lifetimes derived from the Standard TyEL mortality tables assumed for pensioners are much smaller: on the basis of the Standard TyEL Tables updated in 2008, 25% of 65-year old males would be expected to live about a year longer (to age 90 approximately), than on the basis of the Standard TyEL Tables updated in 2003, whilst 25% of females would be expected to live to about age 96.5 on either basis.

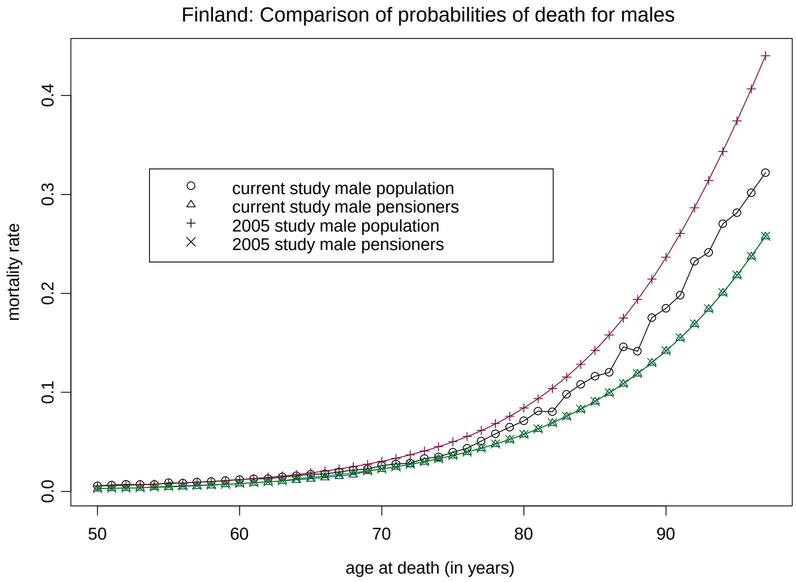


Figure 2.6.9

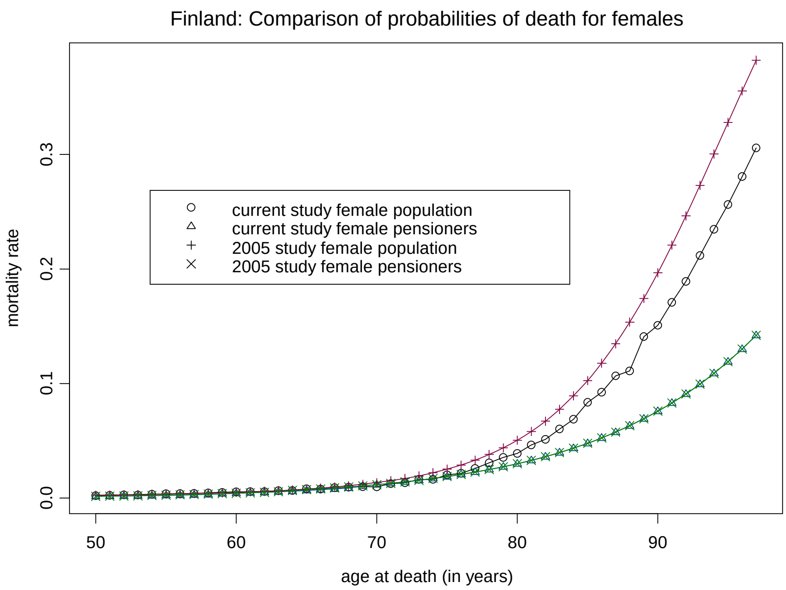


Figure 2.6.10

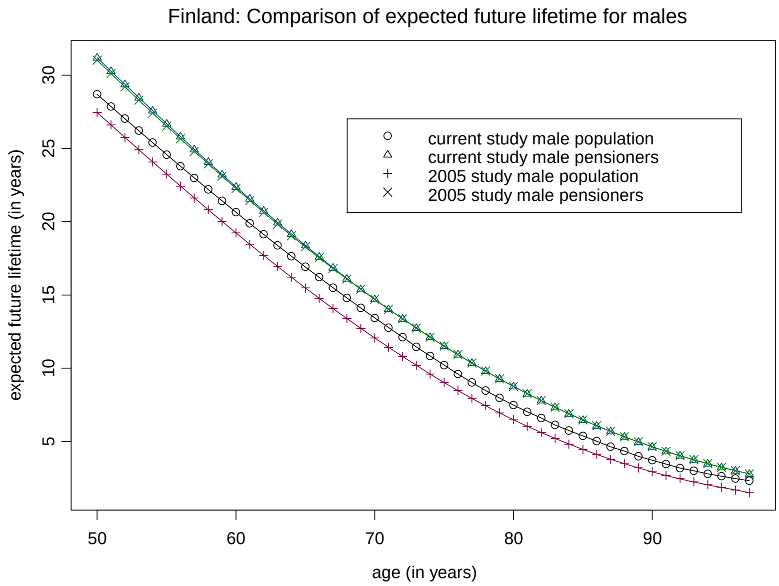


Figure 2.6.11

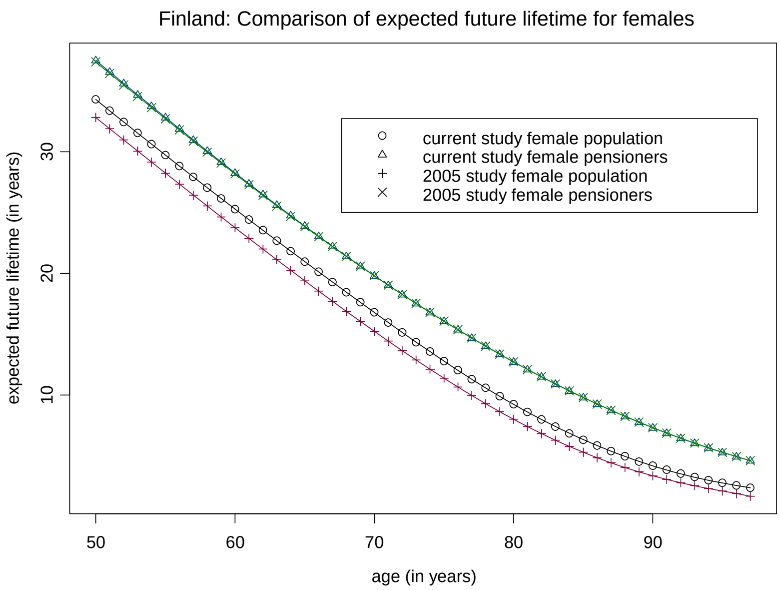


Figure 2.6.12

Table 2.6.6
Finland: Comparison of expected complete future lifetime for males

	Standard TyEL tables Male		Male population			
	2008	2003	2007 population	2002 population	difference	Annualised percentage difference
50	31.20	31.03	28.70	27.46	1.24	0.9%
55	26.70	26.53	24.58	23.25	1.32	1.1%
60	22.39	22.27	20.65	19.24	1.41	1.5%
65	18.38	18.29	16.92	15.49	1.43	1.9%
70	14.71	14.71	13.42	12.06	1.36	2.3%
75	11.52	11.52	10.21	9.04	1.17	2.6%
80	8.77	8.77	7.49	6.49	1.00	3.1%
85	6.48	6.48	5.38	4.45	0.93	4.2%
90	4.65	4.65	3.72	2.94	0.79	5.4%
95	3.24	3.24	2.63	1.87	0.77	8.2%

Table 2.6.7
Finland: Comparison of expected complete future lifetime for females

	Standard TyEL tables Female		Female population			
	updated in 2008	updated in 2003	2007 population	2002 population	difference	Annualised percentage difference
50	37.50	37.38	34.29	32.80	1.49	0.9%
55	32.81	32.70	29.71	28.24	1.48	1.0%
60	28.25	28.17	25.28	23.76	1.52	1.3%
65	23.91	23.84	20.96	19.40	1.56	1.6%
70	19.81	19.81	16.80	15.24	1.56	2.0%
75	16.09	16.09	12.80	11.39	1.41	2.5%
80	12.73	12.73	9.26	8.02	1.24	3.1%
85	9.80	9.80	6.32	5.31	1.01	3.8%
90	7.32	7.32	4.21	3.37	0.83	4.9%
95	5.30	5.30	2.79	2.12	0.67	6.3%

Table 2.6.8

Finland: Distribution of age at death given survival to age 65

Summary Statistics for the population experience

	Male			female		
	2007 population	2002 population	difference	2006 population	2002 population	difference
Lower Quartile age	75.88	74.39	1.50	80.98	79.47	1.52
Median age	82.23	80.25	1.98	86.88	85.72	1.15
Upper Quartile age	88.01	86.70	1.31	91.74	89.07	2.67
Inter quartile range	12.12	12.31	-0.19	10.75	9.60	1.15
e_{65}	16.92	15.49	1.43	20.96	19.40	1.56

Summary Statistics based on the Standard TyEL Mortality Tables

	Male			female		
	2008	2003	difference	2008	2003	difference
Lower Quartile age	76.74	76.40	0.34	81.84	81.25	0.58
Median age	83.66	83.42	0.24	89.71	89.33	0.38
Upper Quartile age	89.98	89.06	0.93	96.48	96.54	-0.06
Inter quartile range	13.24	12.65	0.59	14.64	15.29	-0.65
e_{65}	18.38	18.29	0.10	23.91	23.84	0.07

2.7 France

2.7.1 France: population mortality

The most recent population mortality experience for France available from the Human Mortality Database pertains to 2007. In the previous study, the 2002 population mortality experience from the Human Mortality Database was used.

2.7.2 France: mortality assumptions used to assess retirement liabilities within pension funding valuations

In France, the TPG05 mortality tables are the current tables most commonly used in valuing company pension liabilities. These are projected mortality tables of the generation born in 1950, for males and females separately. However, insurance companies use the projected mortality tables for females for both male and female benefits and hence the TPG05 mortality tables for females have been assumed for both male and female retirement benefits in this study.

In the previous study, the TPG93 projected mortality table of the generation born in 1950 was assumed for retirement benefits. The TPG93 table was constructed from national female mortality data published by INSEE for the period 1961 to 1987.

The normal retirement age has been 60 but this is being raised to 62 years.

2.7.3 France: projected mortality

The TPG05 are projected mortality tables. Previously, functions of the form:

$$q_x(t) = \frac{\exp(a_x t + b_x)}{1 + \exp(a_x t + b_x)}$$, where x is age and t is time,

have been used to derive projected mortality tables.

2.7.4 France: results

Table 2.7.1 gives summary results from a comparative analysis of the 2007 population mortality experience available from the Human Mortality Database and the TPG05 mortality tables. Noting that the TPG05 mortality table used in retirement liability calculations for both male and female pensioners is based on female mortality experience, there are large differences between rates based on the 2007 male population experience and those derived from this table. Expressed as a percentage of the male population value, the difference in the present value of an annuity of 1 per annum payable to a male aged 50 is 22.4% increasing to 45% at age 70, assuming a discount rate of 3% per annum. The corresponding proportional differences for females are, 8.2% at age 50 and 19.4% at age 70. When a reversionary widow's pension of 60% of a company pension scheme member's pension is included for a male aged 65, the percentage difference between male annuity rates at this age is 22.8% assuming a discount rate of 3%.

A comparison of the TPG05 mortality tables with population mortality rates shows that the TPG05 table exhibits lighter mortality at all ages x, $\left(50 \le x \le 109\right)$ as can be seen from Table 2.7.2 and Figures 2.7.1 and 2.7.2. As would be expected, there are wide differences between initial rates of mortality (q_x rates) based on the TPG05 mortality tables and initial rates of mortality derived from the male population mortality experience. The ratio of probability of death based on the TPG05 mortality table to probability of death derived from the male population experience is 29% at age 60 and 25% at age 65. In other words, a 65-year old from the 2007 male population is 4 times as likely to die as a similarly aged individual whose mortality follows that of the TPG05 mortality tables. The corresponding ratios for females are, 65% at age 60 and 59% at age 65. On the other hand, from Figure 2.7.2, it can be observed that the difference between male and female population mortality rates is decreasing as age increases, from a ratio of female to male probability of death of less than 0.5 at age 50 to about 0.9 at age 100.

Table 2.7.3 and Figure 2.7.3 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the TPG05 mortality table with expected future lifetime values derived from the 2007 population mortality experience in France. Expressed as a percentage of the population value, the differences increase with age for both males and females, with the proportional difference for an individual aged 65 being 51.6% for males and about 22% for females (Tables 2.7.1 and 2.7.3). Based on the TPG05 mortality tables, the life expectancy at age 65 is more than 9 years longer for males and 5 years longer for females compared to the observed male and female population mortality experiences respectively.

Figures 2.7.4, 2.7.5, 2.7.6 and 2.7.7 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \le k \le 100-x$. Considering the distribution of age at death given survival to age 65 (Figure 2.7.6 and the associated table), it is noted that whereas a 65-year old male from the general population would be expected to live to about age 83 years, one quarter of those alive at age 65 would be expected to live to at least age 89 years. On the other hand, while a 65-year old female from the general population would be expected to live to at least age 87 years, one quarter of those alive at age 65 would be expected to live to at least age 93 years. On the basis of the TPG05 mortality tables, a 65-year old would be expected to live to at least age 93 years, with one quarter of those who live to age 65 expected to live to nearly 99 years.

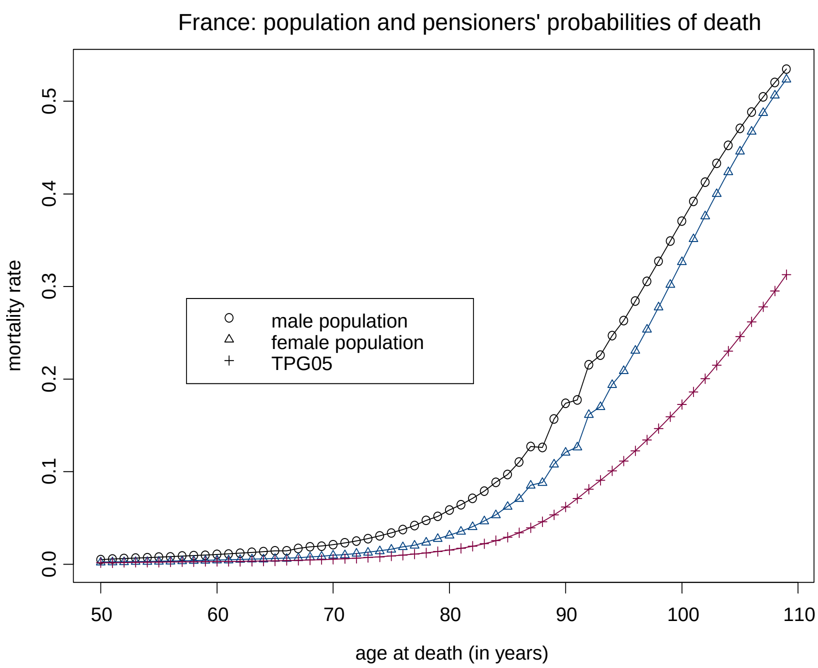


Figure 2.7.1

Table 2.7.1

France: Summary Statistics

age x = 50

	male				Female			
	population	TPG05	difference	percentage difference	population	TPG05	difference	Percentage difference
e_x	30.03	41.20	11.17	37.2	35.87	41.20	5.34	14.9
a_x : 3%	18.53	22.68	4.15	22.4	20.97	22.68	1.72	8.2
a_x : 6%	12.85	14.62	1.78	13.8	14.00	14.62	0.63	4.5

age x = 60

	male				Female			
	population	TPG05	difference	percentage difference	population	TPG05	difference	Percentage difference
e_x	21.95	32.04	10.09	46.0	26.87	32.04	5.17	19.2
a_x : 3%	14.92	19.59	4.68	31.4	17.45	19.59	2.15	12.3
a_x : 6%	11.06	13.45	2.39	21.6	12.47	13.45	0.98	7.9
$a_x + .6a_{x\|y}$: 3%	17.90	21.30	3.40	19.0				

age x = 65

	male				Female			
	population	TPG05	difference	percentage difference	population	TPG05	difference	Percentage difference
e_x	18.15	27.51	9.36	51.6	22.51	27.51	5.00	22.2
a_x : 3%	12.92	17.73	4.81	37.3	15.39	17.73	2.34	15.2
a_x : 6%	9.93	12.62	2.69	27.0	11.43	12.62	1.19	10.4
$a_x + .6a_{x\|y}$: 3%	15.93	19.56	3.63	22.8				

age x = 70

	male				female			
	population	TPG05	difference	percentage difference	population	TPG05	difference	Percentage difference
e_x	14.53	23.05	8.52	58.7	18.24	23.05	4.81	26.4
a_x : 3%	10.79	15.64	4.86	45.0	13.10	15.64	2.54	19.4
a_x : 6%	8.61	11.56	2.95	34.3	10.12	11.56	1.44	14.2

Table 2.7.2

France: One year probabilities of death (initial rates of mortality, q_x rates)

age	male			Female		
	population	TPG05	ratio	population	TPG05	Ratio
50	0.005090	0.001739	0.34	0.002440	0.001739	0.71
55	0.007810	0.002223	0.28	0.003220	0.002223	0.69
60	0.010640	0.003034	0.29	0.004670	0.003034	0.65
65	0.014530	0.003668	0.25	0.006220	0.003668	0.59
70	0.021140	0.005574	0.26	0.009830	0.005574	0.57
75	0.033790	0.008935	0.26	0.016300	0.008935	0.55
80	0.058500	0.015291	0.26	0.031580	0.015291	0.48
85	0.097050	0.029295	0.30	0.062420	0.029295	0.47
90	0.173820	0.061927	0.36	0.120850	0.061927	0.51
95	0.263140	0.111435	0.42	0.209130	0.111435	0.53

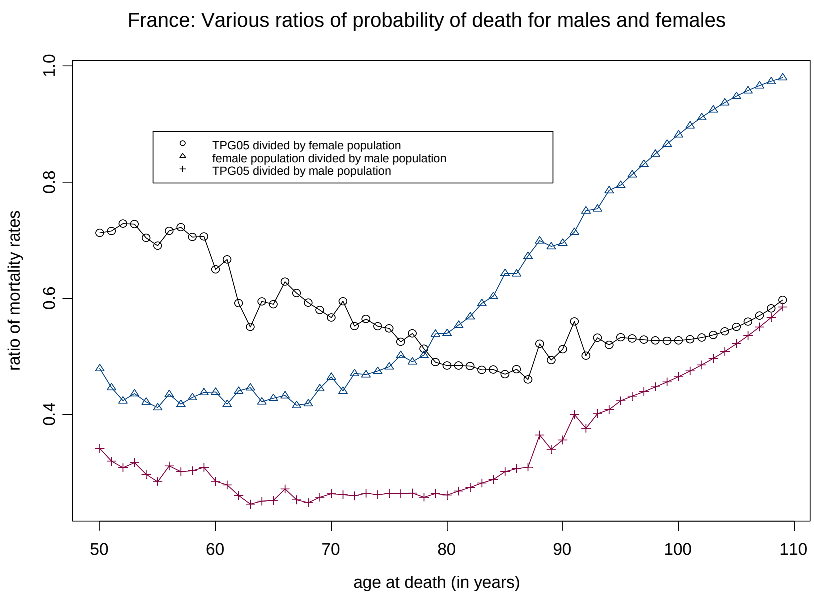


Figure 2.7.2

Table 2.7.3
France: Expected complete future lifetime

age	male				female			
	population	TPG05	difference	percentage difference	population	TPG05	difference	percentage difference
50	30.03	41.20	11.17	37.2	35.87	41.20	5.34	14.9
55	25.90	36.58	10.69	41.3	31.33	36.58	5.26	16.8
60	21.95	32.04	10.09	46.0	26.87	32.04	5.17	19.2
65	18.15	27.51	9.36	51.6	22.51	27.51	5.00	22.2
70	14.53	23.05	8.52	58.7	18.24	23.05	4.81	26.4
75	11.18	18.75	7.58	67.8	14.20	18.75	4.55	32.0
80	8.24	14.68	6.43	78.1	10.52	14.68	4.16	39.6
85	5.83	10.95	5.12	87.8	7.37	10.95	3.58	48.5
90	3.97	7.83	3.86	97.2	4.96	7.83	2.87	57.8
95	2.78	5.60	2.82	101.5	3.31	5.60	2.29	69.2

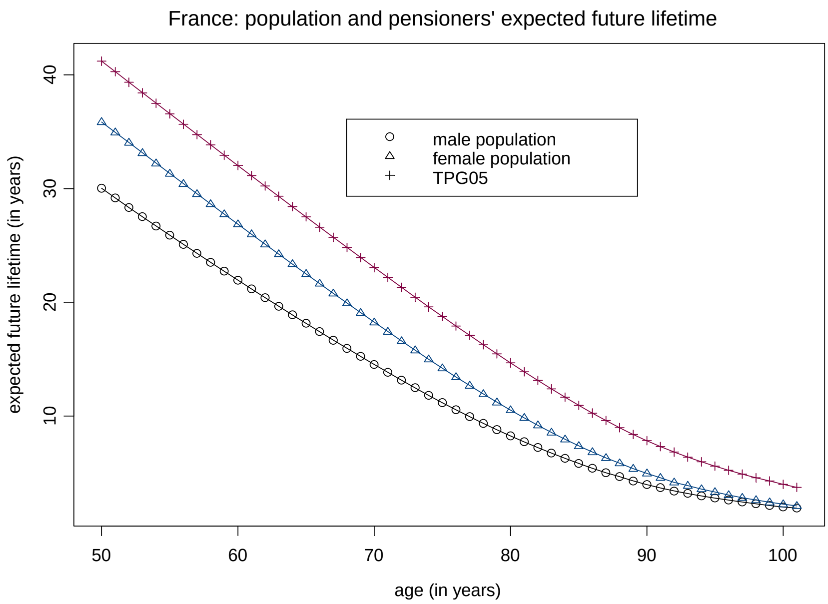


Figure 2.7.3

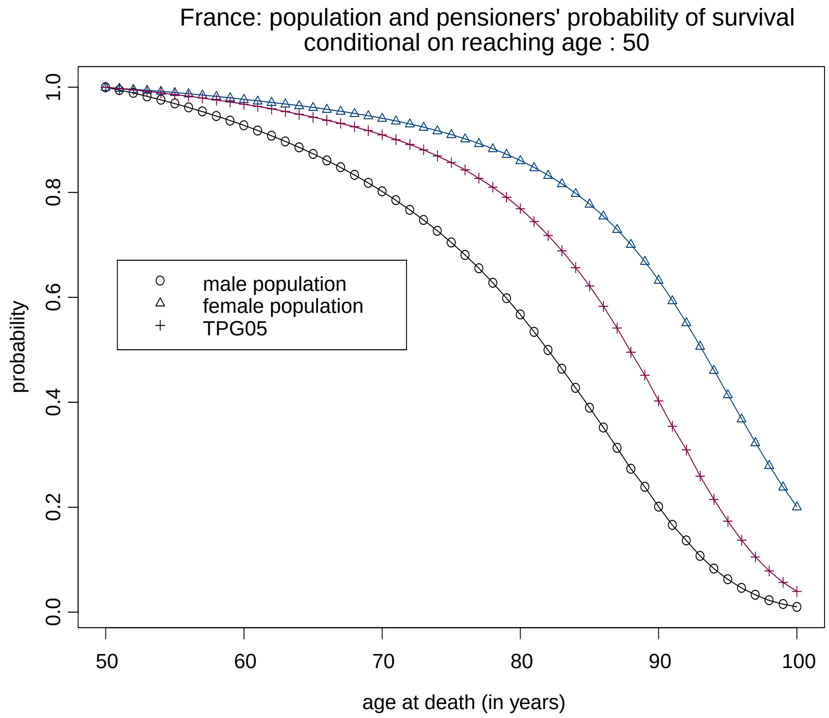


Figure 2.7.4

France: Distribution of age at death given survival to age 50

Summary Statistics

	male			female		
	population	TPG05	difference	population	TPG05	difference
Lower Quartile age	72.86	86.20	13.33	80.77	86.20	5.43
Median age	81.99	93.15	11.16	87.90	93.15	5.25
Upper Quartile age	88.67	98.72	10.05	93.21	98.72	5.52
Inter-quartile range	15.81	12.53	-3.28	12.44	12.53	0.09
e_{50}	30.03	41.20	11.17	35.87	41.20	5.34

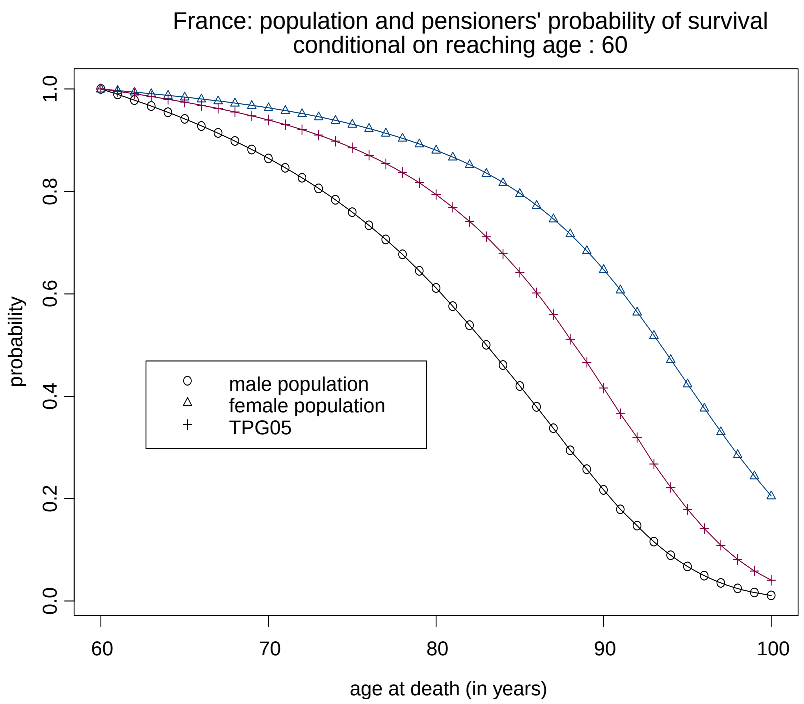


Figure 2.7.5

France: Distribution of age at death given survival to age 60

Summary Statistics

	male			female		
	population	TPG05	difference	population	TPG05	difference
Lower Quartile age	75.37	86.87	11.50	81.69	86.87	5.17
Median age	83.01	93.40	10.39	88.25	93.40	5.14
Upper Quartile age	89.18	98.86	9.68	93.39	98.86	5.47
Inter-quartile range	13.82	12.00	-1.82	11.70	12.00	0.30
e_{60}	21.95	32.04	10.09	26.87	32.04	5.17

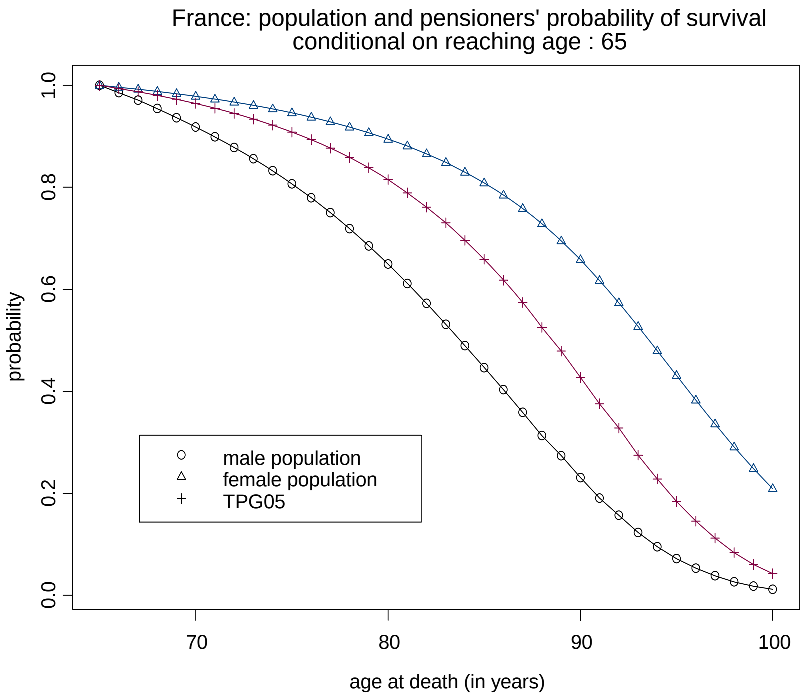


Figure 2.7.6

France: Distribution of age at death given survival to age 65

Summary Statistics

	male			female		
	population	TPG05	difference	population	TPG05	difference
Lower Quartile age	77.01	87.28	10.27	82.36	87.28	4.92
Median age	83.75	93.56	9.81	88.54	93.56	5.02
Upper Quartile age	89.55	98.96	9.41	93.53	98.96	5.43
Inter-quartile range	12.54	11.68	-0.86	11.17	11.68	0.51
e_{65}	18.15	27.51	9.36	22.51	27.51	5.00

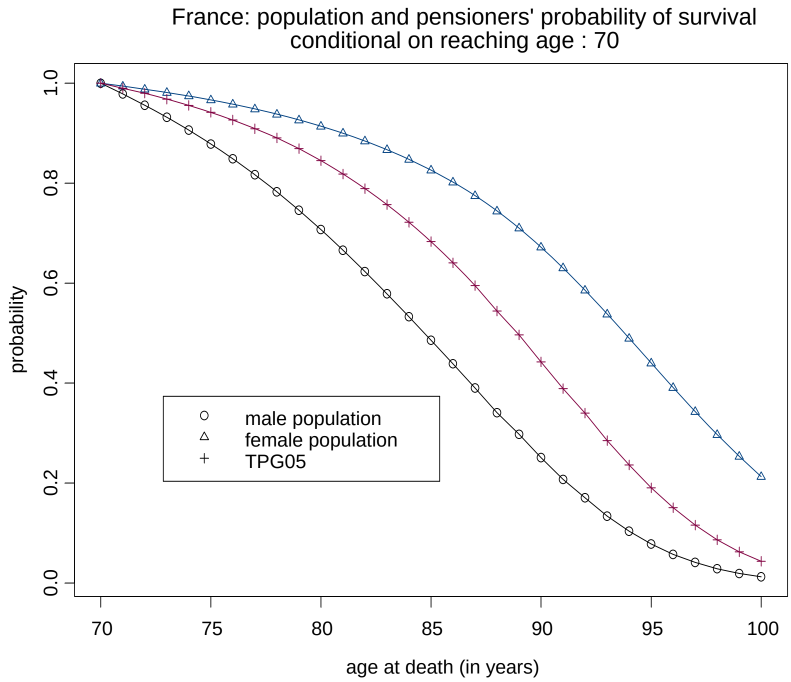


Figure 2.7.7

France: Distribution of age at death given survival to age 70

Summary Statistics

	male			female		
	population	TPG05	difference	population	TPG05	difference
Lower Quartile age	78.89	87.82	8.93	83.21	87.82	4.61
Median age	84.70	93.79	9.09	88.93	93.79	4.86
Upper Quartile age	90.02	99.09	9.06	93.72	99.09	5.37
Inter-quartile range	11.14	11.27	0.13	10.51	11.27	0.75
e_{70}	14.53	23.05	8.52	18.24	23.05	4.81

2.7.5 France results: comparison with previous study

Figures 2.7.8 and 2.7.9 compare the probabilities of death shown in Figure 2.7.1 with probabilities of death for the population in 2002 and probabilities of death derived from the TPRV93 mortality tables. The expected future lifetimes are compared in Figures 2.7.10 and 2.7.11.

Whilst it is clear that there has been an improvement in population mortality between 2002 and 2007 at all ages for both males and females, from Figures 2.7.10 and 2.7.11, it can be seen that the mortality improvements assumed for the pension-related mortality tables are considerably higher than the experienced mortality improvements between the 2007 and 2002 populations, the difference in expected future lifetimes on the basis of the TPG05 and TPRV93 mortality tables being more than three years at each age for ages below 80 years.

From the annualised percentage changes in expected future lifetime for the population shown in Tables 2.7.4 and 2.7.5, it is apparent that:

- at each age, the rate of improvement in population mortality is not very different for males and females; and
- the rate of improvement in population mortality increases with age.

Table 2.7.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of the 2007 male population in France surviving to age 65 years would be expected to live to about age 89.6 years, the same proportion of the 2002 male population in France surviving to age 65 would be expected to live to age 89 years, the actual difference being less than a year. For females, the difference from a similar comparison is considerably higher: 25% of the female population in France in 2007 alive at age 65 is expected to live to at least age 93.5 while the same proportion from the 2002 female population is expected to live to about age 91, the actual difference being about 2.5 years. On the other hand the corresponding differences in expected future lifetimes derived from the mortality tables assumed for pensioners are even higher: on the basis of the TPG05 mortality tables, 25% of 65-year olds would be expected to live about 3.7 years longer (to age 99 approximately) than on the basis of the TPRV93 mortality tables.

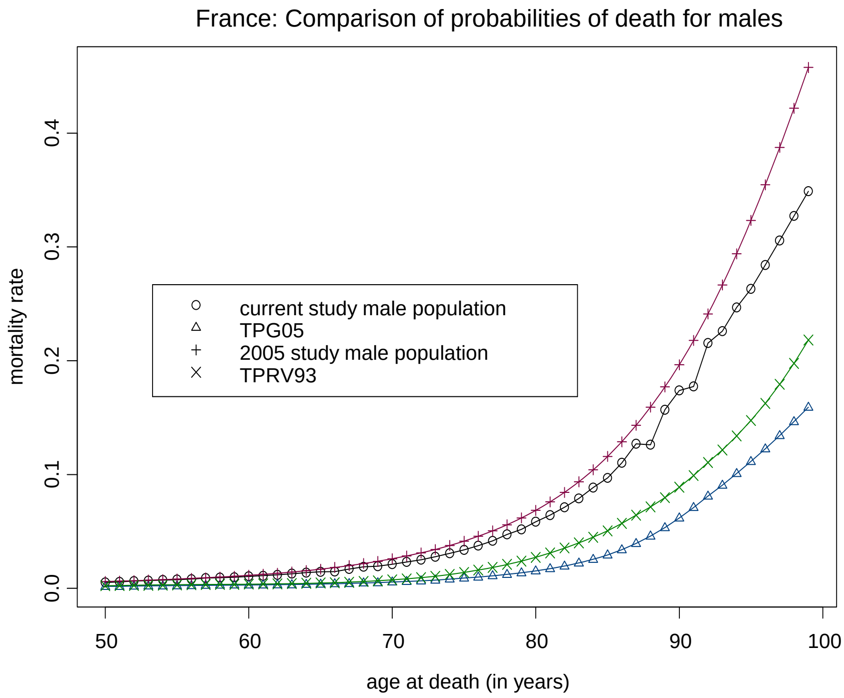


Figure 2.7.8

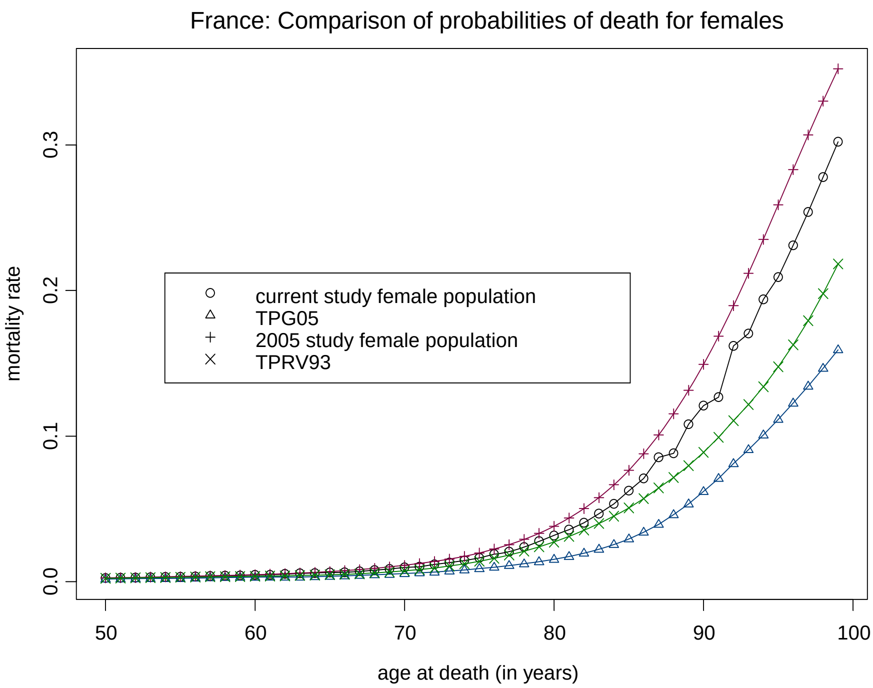


Figure 2.7.9

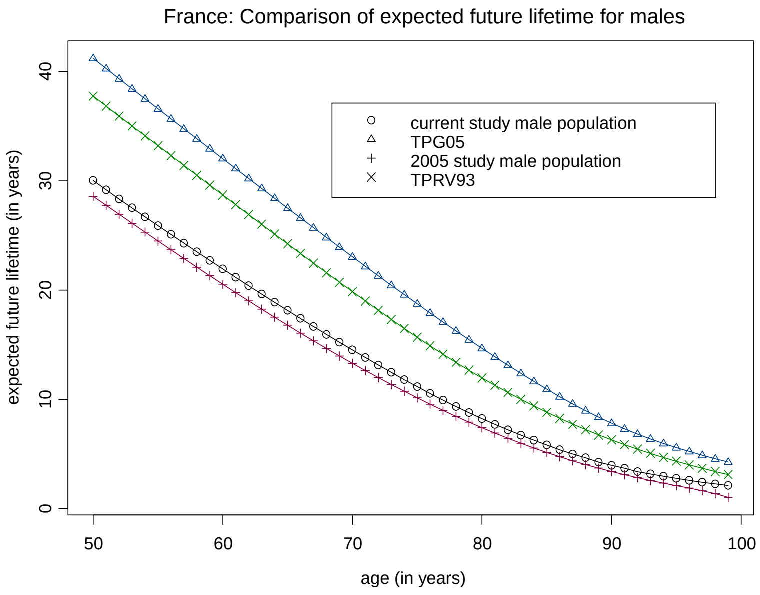


Figure 2.7.10

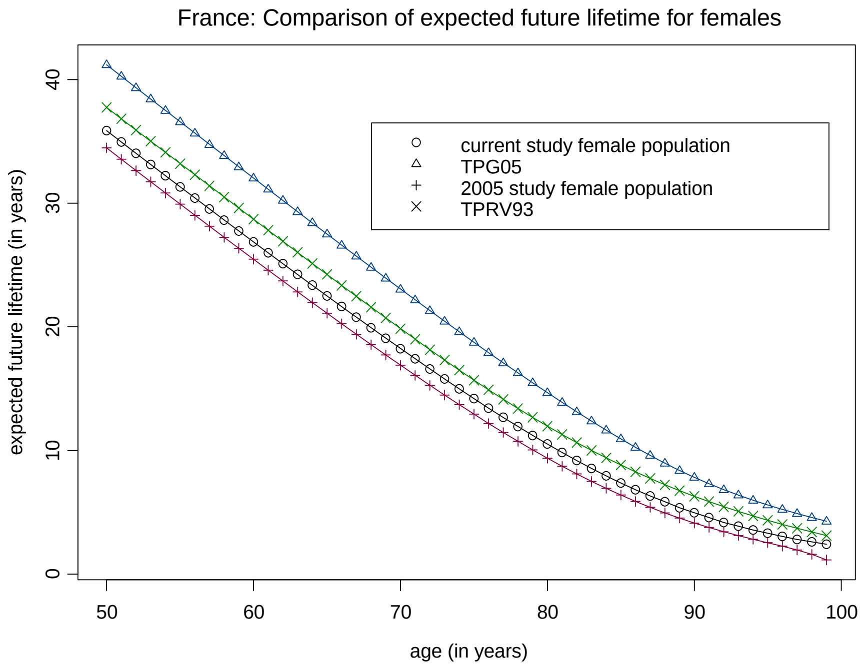


Figure 2.7.11

Table 2.7.4
France: Comparison of expected complete future lifetime for males

				Male population			
	TPG05	TPRV93	difference	2007 population	2002 population	difference	Annualised percentage difference
50	41.20	37.75	3.45	30.03	28.59	1.44	1.0%
55	36.58	33.20	3.38	25.90	24.49	1.41	1.1%
60	32.04	28.71	3.32	21.95	20.54	1.41	1.4%
65	27.51	24.25	3.26	18.15	16.79	1.36	1.6%
70	23.05	19.85	3.20	14.53	13.30	1.23	1.8%
75	18.75	15.69	3.06	11.18	10.15	1.03	2.0%
80	14.68	11.97	2.70	8.24	7.41	0.83	2.2%
85	10.95	8.83	2.12	5.83	5.15	0.68	2.6%
90	7.83	6.30	1.53	3.97	3.41	0.57	3.3%
95	5.60	4.36	1.24	2.78	2.12	0.66	6.2%

Table 2.7.5
France: Comparison of expected complete future lifetime for females

				Female population			
	TPG05	TPRV93	difference	2007 population	2002 population	difference	Annualised percentage difference
50	41.20	37.75	3.45	35.87	34.47	1.40	0.8%
55	36.58	33.20	3.38	31.33	29.93	1.40	0.9%
60	32.04	28.71	3.32	26.87	25.47	1.40	1.1%
65	27.51	24.25	3.26	22.51	21.11	1.40	1.3%
70	23.05	19.85	3.20	18.24	16.90	1.34	1.6%
75	18.75	15.69	3.06	14.20	12.94	1.26	2.0%
80	14.68	11.97	2.70	10.52	9.38	1.14	2.4%
85	10.95	8.83	2.12	7.37	6.39	0.98	3.1%
90	7.83	6.30	1.53	4.96	4.14	0.83	4.0%
95	5.60	4.36	1.24	3.31	2.55	0.76	6.0%

Table 2.7.6
France: Distribution of age at death given survival to age 65
Summary Statistics for the population experience

	Male			female		
	2007 population	2002 population	difference	2007 population	2002 population	difference
Lower Quartile age	77.01	75.37	1.64	82.36	81.89	0.47
Median age	83.75	82.77	0.98	88.54	87.86	0.68
Upper Quartile age	89.55	89.00	0.55	93.53	91.04	2.49
Inter quartile range	12.54	13.62	-1.09	11.17	9.15	2.02
e_{65}	18.15	16.79	1.36	22.51	21.11	1.40

Summary Statistics based on the TPG05 and TPRV93 Mortality Tables

	TPG05	TPRV93	difference
Lower Quartile age	87.28	83.44	3.84
Median age	93.56	90.92	2.64
Upper Quartile age	98.96	95.28	3.67
Inter quartile range	11.68	11.84	-0.17
e_{65}	27.51	24.25	3.26

2.8 Germany

2.8.1 Germany: population mortality

The last population census in Germany was in 1986. Population mortality tables are published regularly by the Statistisches Bundesamt but only within a microcensus process which means that statistics are carried forward year by year. As a result, the mortality trends resulting from these tables have become increasingly unreliable. The next full population census is scheduled for 2011.

In this study, the 2006 population mortality experience for Germany available on the Human Mortality Database has been used for comparison with pension-related mortality tables, without any adjustments.

In the previous study, the 2002 population mortality tables available from the Human Life-table Database (HLD) were the most recent population mortality experience for Germany.

2.8.2 Germany: mortality assumptions used to assess retirement liabilities within pension funding valuations

The mortality tables currently most commonly used for valuing pensions in Germany, both compulsory and voluntary (‘classical Company Pensions’) are the Richttafeln 2005 G mortality tables by Klaus Heubeck, for males and females separately. The data used to develop the Heubeck tables are principally based on the social security statistics of the years 2001 to 2003. Where such statistics were not available (for example marital status, age differences), they are based on population statistics.

The Richttafeln 2005 G mortality tables are the generally accepted tables for the valuation of pension schemes, especially according to German tax code, German GAAP, IFRS/IAS, US-GAAP/FAS, but are not applicable for pension schemes for the ‘liberal’ professions such as doctors, notaries etc. The tables are generation mortality tables constructed from lives data, with no differentiation between income or amount of pension.

In constructing the Richttafeln 2005 G mortality tables the mortality rates were smoothed using cubic splines and extrapolation was carried out using a modified Gompertz approach.

The normal retirement age is variable up to age 75 but retirement ages usually vary between ages 60 and 67. Widow(er)s' benefits usually depend on the amount of pension of the former pensioner (e.g. 60%). Mortality of widow(er)s as well as age differences between spouses are included in the reference tables Richttafeln 2005 G. In this study, only widows' benefits are considered. It is assumed that a female spouse is 3 years younger than her male spouse and is entitled to a widow's pension of 60% of a male member's pension.

In the previous study, the Richttafeln 1998 tables by Klaus Heubeck were assumed for pension-related benefits. These tables were produced from Social Security Statistics and population statistics for the period 1995-1997.

2.8.3 Germany: projected mortality

The projection parameters are based on population statistics for West Germany for the years 1981 to 1999. The derived trend is assumed as a long term trend. For the period 2005 – 2014 a stronger trend is assumed (men +0.25%, women +0.2%).

2.8.4 Germany: results

A summary of the results obtained from an analysis of mortality data for Germany is given in Table 2.8.1. From the table it can be seen that the present value of annuity rates derived on the basis of the Richttafeln 2005 G mortality tables assumed for pension liability calculations are higher than annuity rates derived on the basis of the 2006 German population mortality experience, which is consistent with lighter mortality experience for pensioners. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 9.1% for males and 9.8% for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of member's pension is included, the percentage difference between male annuity rates at age 65 is 8.2% assuming a discount rate of 3%.

Figure 2.8.1 and Table 2.8.2 show comparisons of the observed probabilities of death (q_x rates) based on the most recent (2006) population experience and the Richttafeln 2005 G mortality tables. It can be seen that for both males and females, the Richttafeln 2005 G mortality tables generally exhibit lighter mortality than the observed population except for ages below 55 years. For example, the probability from the Richttafeln 2005 G mortality tables that a 65-year male will die before his 66th birthday is 91% of the probability derived from the German male population experience. The corresponding proportion for a 65-year old female is 85%. The same trends are depicted in Figure 2.8.2 which shows the ratios of probabilities of death from the Richttafeln 2005 G mortality tables to probabilities of death derived from the male and female population mortality experiences respectively.

Figure 2.8.3 shows age-related ratios of female probabilities of death to male probabilities of death based on pension-related tables and population mortality experience. Similar trends are exhibited from both experiences with the difference between male and female mortality rates being generally decreasing as age increases.

Table 2.8.3 and Figure 2.8.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the Richttafeln 2005 G mortality tables with corresponding expected future lifetime values for the population. Expressed as a percentage of the expected future lifetime value derived from the population mortality experience, the differences tend to increase with age for both males and females, with the proportional differences at age 65 being 12.1% for males and 13.8% for females (Tables 2.8.1 and 2.8.3). Based on the Richttafeln 2005 G mortality tables, the life expectancy at age 65 is about 2 years longer for males and 2.8 years longer for females compared to the observed male and female population respectively.

Figures 2.8.5, 2.8.6, 2.8.7 and 2.8.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering age 65 (Figure 2.8.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to nearly age 84 on the basis of the Richttafeln 2005 G tables and to about age 82 on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to at least age 90 on the basis of the Richttafeln 2005 G tables and to about age 89 on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to at least age 88 on the basis of the Richttafeln 2005 G tables and to at least age 85 on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to at least age 94 on the basis of the Richttafeln 2005 G tables and to nearly age 92 on the basis of the female population experience.

Table 2.8.1

Germany: Summary Statistics

age x = 50

	male				female			
	population	Richttafeln 2005G	difference	percentage difference	population	Richttafeln 2005G	difference	percentage difference
e_x	29.08	31.11	2.03	7.0	33.57	36.34	2.78	8.3
a_x : 3%	18.21	18.96	0.75	4.1	20.16	21.08	0.92	4.5
a_x : 6%	12.74	13.05	0.31	2.4	13.69	14.02	0.33	2.4

age x = 60

	male				female			
	population	Richttafeln 2005G	difference	percentage difference	population	Richttafeln 2005G	difference	percentage difference
e_x	20.78	22.81	2.03	9.8	24.57	27.41	2.84	11.5
a_x : 3%	14.33	15.30	0.97	6.8	16.39	17.63	1.25	7.6
a_x : 6%	10.75	11.25	0.50	4.7	11.94	12.54	0.60	5.0
$a_x + .6a_{x\|y}$: 3%	17.15	18.23	1.09	6.3				

age x = 65

	male				female			
	population	Richttafeln 2005G	difference	percentage difference	population	Richttafeln 2005G	difference	percentage difference
e_x	16.94	18.99	2.05	12.1	20.26	23.06	2.80	13.8
a_x : 3%	12.22	13.33	1.11	9.1	14.21	15.61	1.40	9.8
a_x : 6%	9.50	10.15	0.64	6.8	10.77	11.52	0.75	6.9
$a_x + .6a_{x\|y}$: 3%	15.07	16.31	1.24	8.2				

age x = 70

	male				female			
	population	Richttafeln 2005G	difference	percentage difference	population	Richttafeln 2005G	difference	percentage difference
e_x	13.38	15.43	2.05	15.3	16.08	18.84	2.76	17.1
a_x : 3%	10.05	11.30	1.25	12.5	11.83	13.39	1.57	13.2
a_x : 6%	8.10	8.91	0.81	10.0	9.33	10.27	0.94	10.1

Table 2.8.2

Germany: One-year probabilities of death (initial rates of mortality, q_x rates)

age	male			female		
	population	Richttafeln 2005G	ratio	population	Richttafeln 2005G	ratio
50	0.004430	0.004472	1.01	0.002440	0.002530	1.04
55	0.007020	0.006504	0.93	0.003380	0.003444	1.02
60	0.010060	0.009589	0.95	0.004990	0.004555	0.91
65	0.015480	0.014042	0.91	0.007350	0.006271	0.85
70	0.024840	0.021136	0.85	0.012600	0.009800	0.78
75	0.041830	0.031252	0.75	0.023420	0.016266	0.69
80	0.067220	0.049674	0.74	0.045260	0.029677	0.66
85	0.113560	0.084178	0.74	0.086640	0.056697	0.65
90	0.183370	0.140359	0.77	0.156850	0.105217	0.67
95	0.286830	0.219536	0.77	0.263680	0.177710	0.67

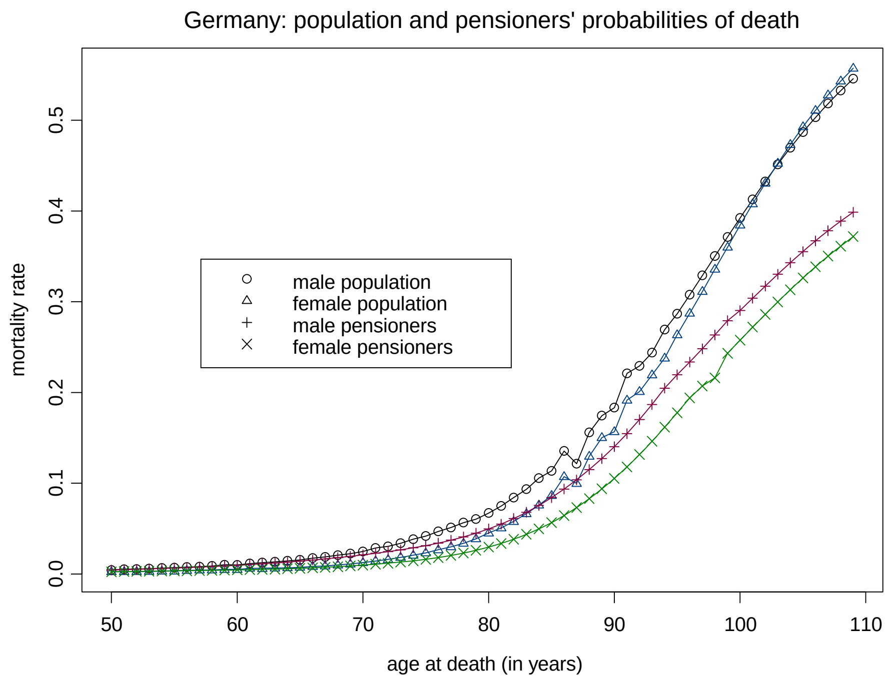


Figure 2.8.1

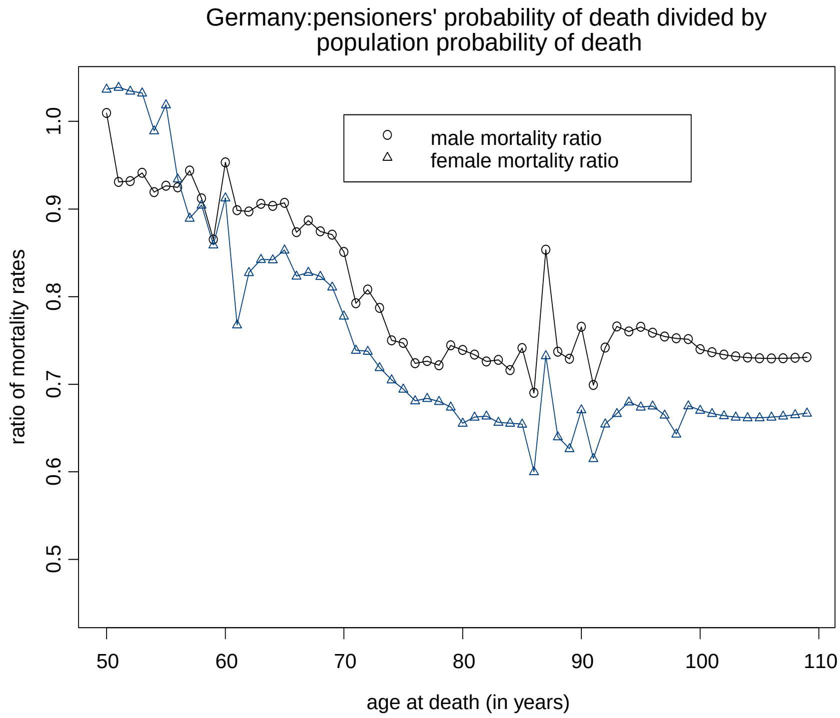


Figure 2.8.2

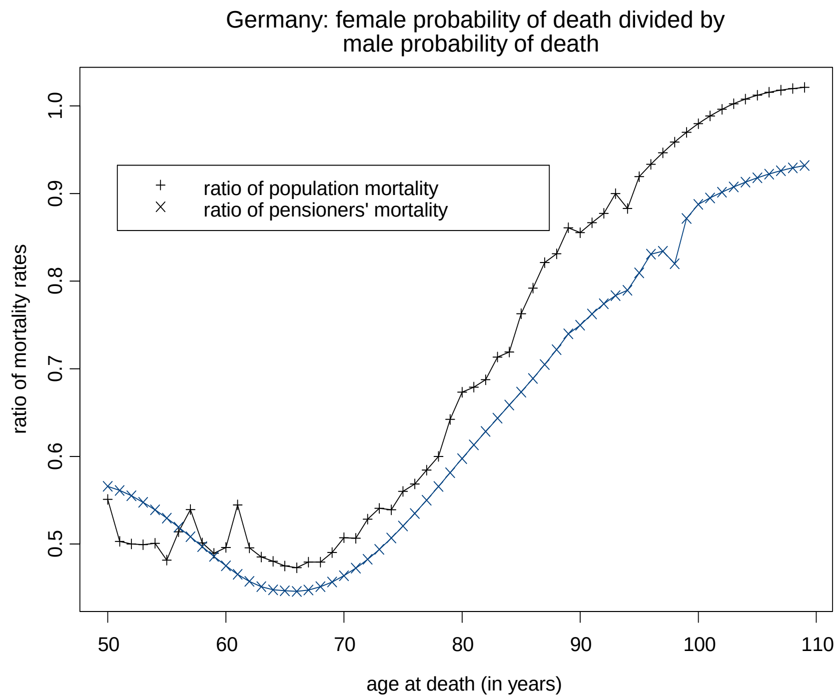


Figure 2.8.3

Table 2.8.3
Germany: Expected complete future lifetime in years

	male				female			
age	population	Richttafeln 2005G	difference	percentage difference	population	Richttafeln 2005G	difference	percentage difference
50	29.08	31.11	2.03	7.0	33.57	36.34	2.78	8.3
55	24.83	26.87	2.04	8.2	29.01	31.83	2.83	9.7
60	20.78	22.81	2.03	9.8	24.57	27.41	2.84	11.5
65	16.94	18.99	2.05	12.1	20.26	23.06	2.80	13.8
70	13.38	15.43	2.05	15.3	16.08	18.84	2.76	17.1
75	10.23	12.14	1.91	18.7	12.24	14.85	2.61	21.3
80	7.54	9.16	1.62	21.5	8.84	11.20	2.36	26.6
85	5.34	6.64	1.30	24.4	6.07	8.08	2.02	33.2
90	3.65	4.71	1.06	29.1	4.04	5.66	1.62	40.1
95	2.58	3.41	0.84	32.5	2.73	4.00	1.27	46.5

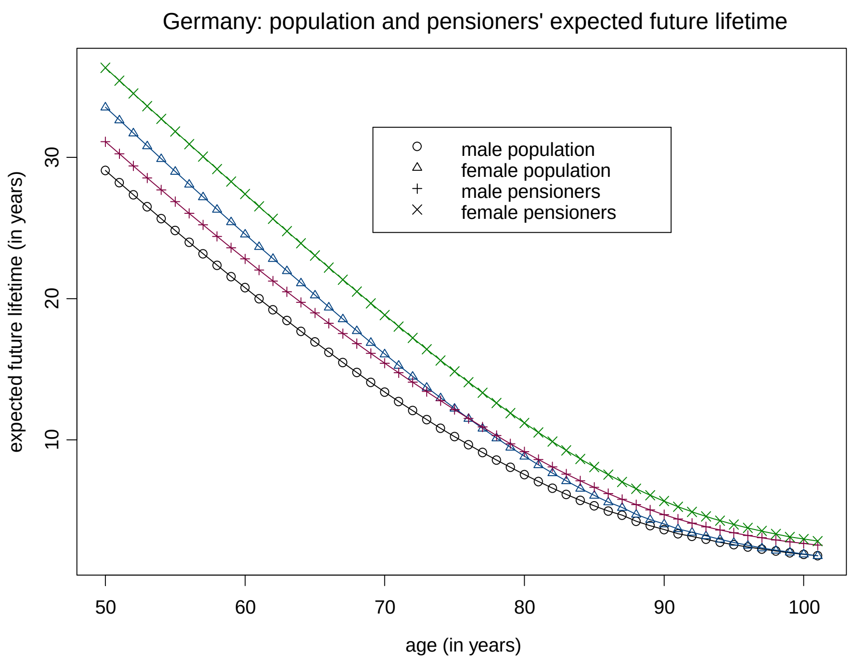


Figure 2.8.4

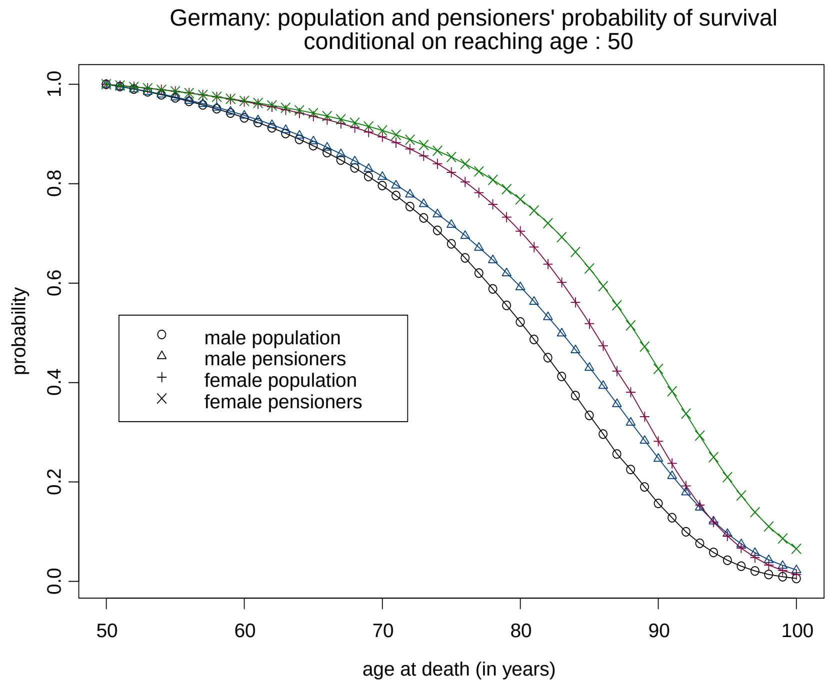


Figure 2.8.5

Germany: Distribution of age at death given survival to age 50

Summary Statistics

	male			female		
	population	Richttafeln 2005G	difference	population	Richttafeln 2005G	difference
Lower Quartile age	72.82	73.52	0.70	78.66	80.19	1.53
Median age	80.39	82.01	1.62	85.58	88.65	3.07
Upper Quartile age	87.81	89.07	1.27	90.29	95.00	4.71
Inter-quartile range	14.98	15.55	0.57	11.62	14.80	3.18
e_{50}	29.08	31.11	2.03	33.57	36.34	2.78

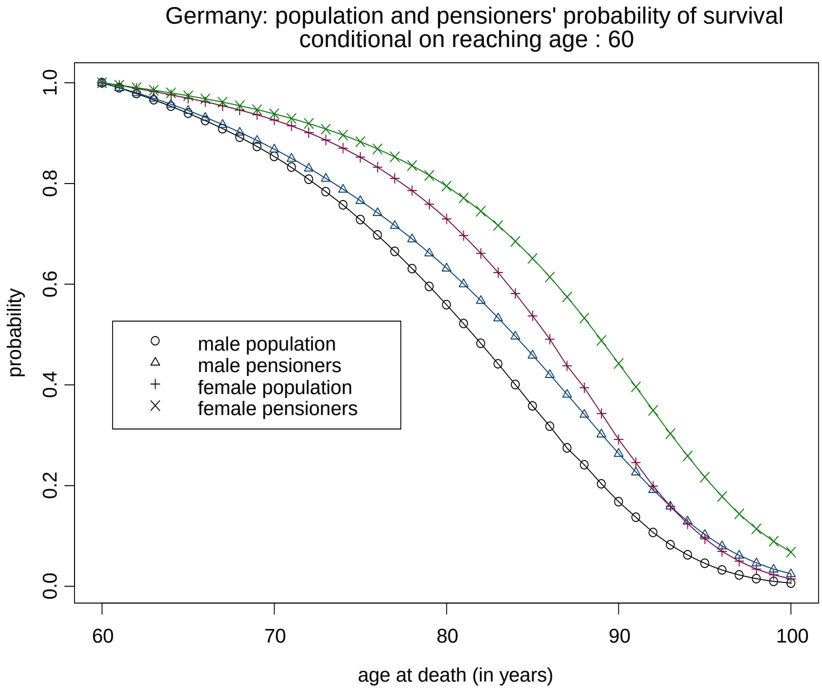


Figure 2.8.6

Germany: Distribution of age at death given survival to age 60
Summary Statistics

	male			female		
	population	Richttafeln 2005G	difference	population	Richttafeln 2005G	difference
Lower Quartile age	74.75	75.33	0.59	79.69	81.18	1.49
Median age	81.45	83.09	1.64	85.20	88.26	3.06
Upper Quartile age	87.26	90.63	3.36	90.09	94.79	4.70
Inter quartile range	12.52	15.29	2.78	10.40	13.61	3.20
e_{60}	20.78	22.81	2.03	24.57	27.41	2.84

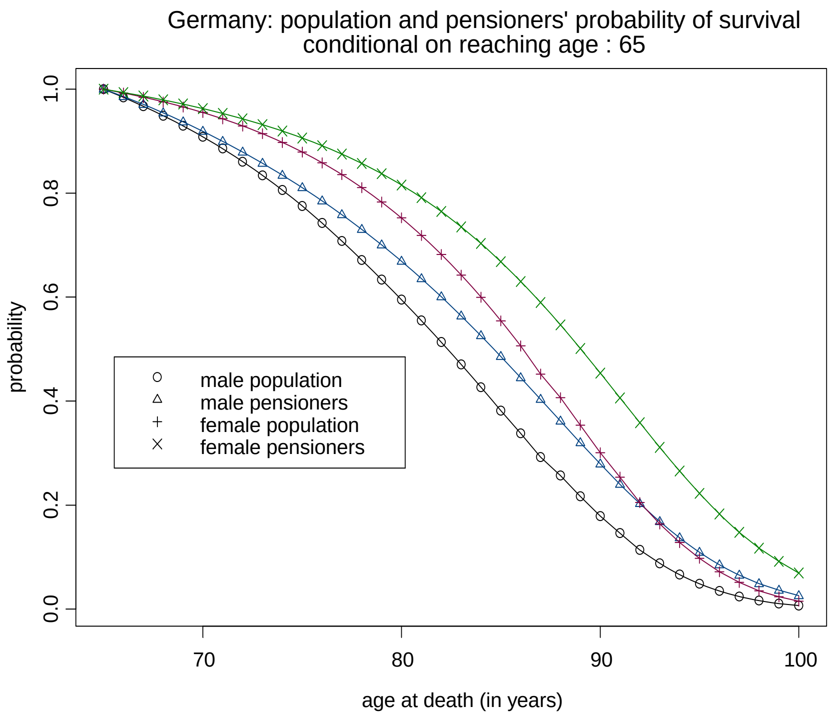


Figure 2.8.7

Germany: Distribution of age at death given survival to age 65
Summary Statistics

	male			female		
	population	Richttafeln 2005G	difference	population	Richttafeln 2005G	difference
Lower Quartile age	75.23	77.70	2.47	80.92	82.50	1.58
Median age	82.69	84.35	1.67	86.89	89.98	3.09
Upper Quartile age	88.83	90.25	1.42	91.93	94.64	2.71
Inter quartile range	13.61	12.56	-1.05	11.01	12.14	1.13
e_{65}	16.94	18.99	2.05	20.26	23.06	2.80

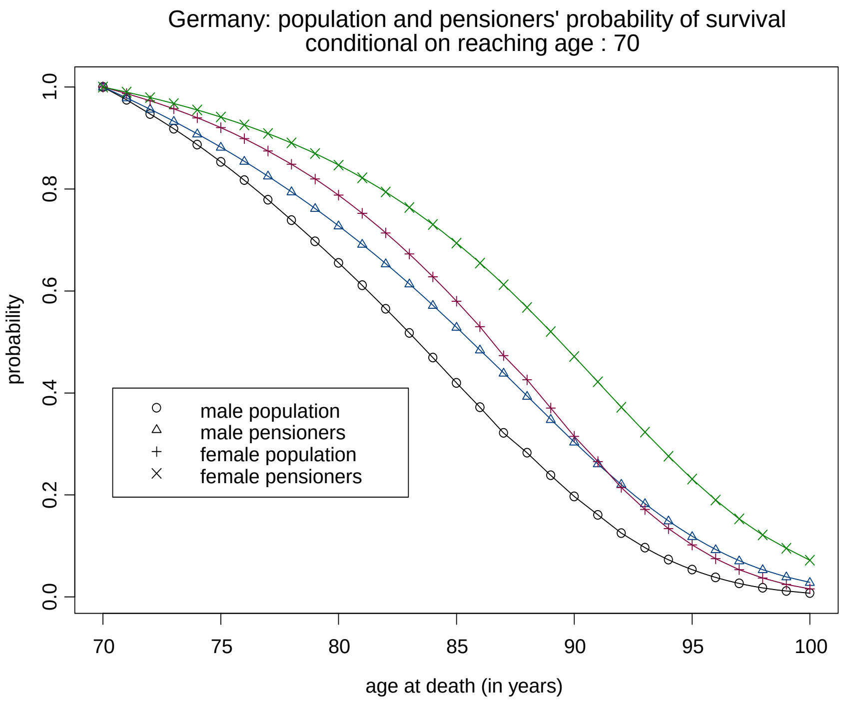


Figure 2.8.8

Germany: Distribution of age at death given survival to age 70
Summary Statistics

	male			female		
	population	Richttafeln 2005G	difference	population	Richttafeln 2005G	difference
Lower Quartile age	77.27	79.65	2.37	81.94	83.59	1.65
Median age	83.64	85.35	1.72	86.47	89.58	3.11
Upper Quartile age	88.26	91.72	3.46	91.70	94.42	2.72
Inter quartile range	10.99	12.08	1.09	9.76	10.83	1.08
e_{70}	13.38	15.43	2.05	16.08	18.84	2.76

2.8.5 Germany results: comparison with previous study

Figures 2.8.9 and 2.8.10 compare the probabilities of death shown in Figure 2.8.1 with probabilities of death assumed in the previous study, that is, probabilities based on the 2002 German population experience and the Richttafeln 1998 G mortality tables, for males and females separately. The expected future lifetimes are compared in Figures 2.8.11 and 2.8.12. Clearly, there has been an improvement in the population mortality between the 2002 experience and the 2006 experience at all ages for both males and females. From the annualised percentage changes in expected future lifetime for the population shown in Tables 2.8.4 and 2.8.5, it is apparent that the rate of improvement in population mortality at each age is higher for males, apart from extreme old age. On the other hand, the absolute differences at each age between the Richttafeln 1998 G and the Richttafeln 2005 G mortality tables assumed for pension-related benefits would appear to indicate an even greater improvement in mortality.

Table 2.8.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the 2006 German male population would be expected to live to nearly age 89 years, the same proportion of 65-year old males from the 2002 male population would be expected to live to age 88 years approximately, the actual difference being about 1 year. For females, the difference from a similar comparison is higher: 25% of the 2006 female German population alive at age 65 is expected to live to about age 92 years while the same proportion from the 2002 German female population is expected to live to about age 90.5 years, the actual difference being about 1.5 years. The corresponding differences in expected future lifetimes derived from the Richttafeln 2005 G and the Richttafeln 1998 G mortality tables assumed for pensioners are considerably greater for males: on the basis of the Richttafeln 2005 G mortality tables, the upper 25% of 65-year old males would be expected to live nearly 3 years longer than on the basis of the Richttafeln 1998 G (to at least age 90), whilst the upper 25% of females would be expected to live about 1.7 years longer to at least age 94.6.

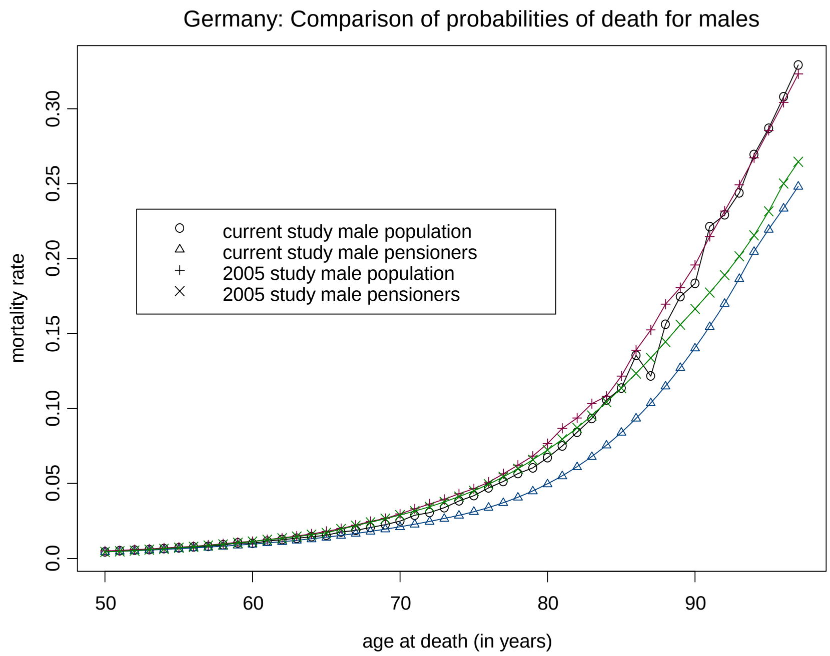


Figure 2.8.9

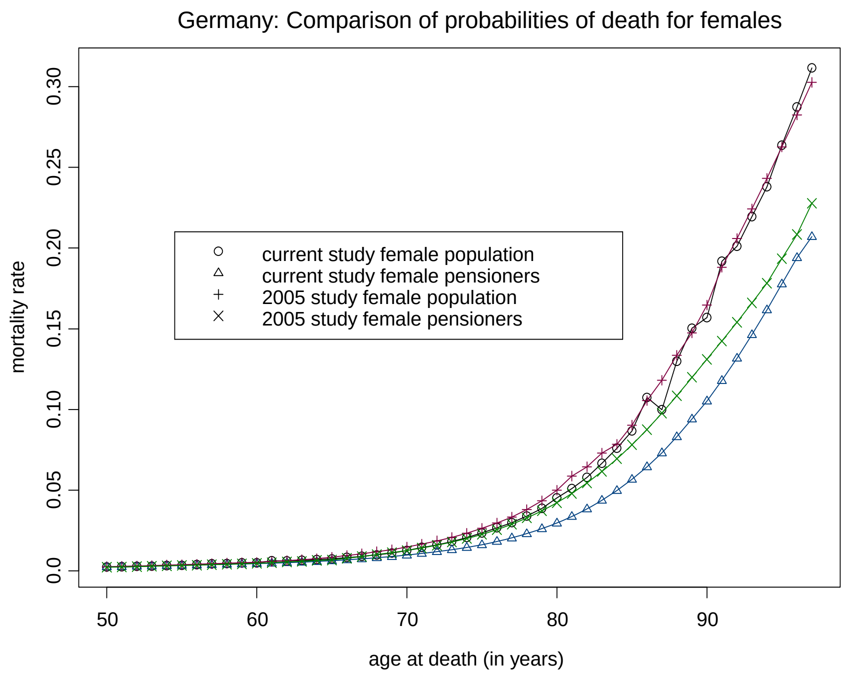


Figure 2.8.10

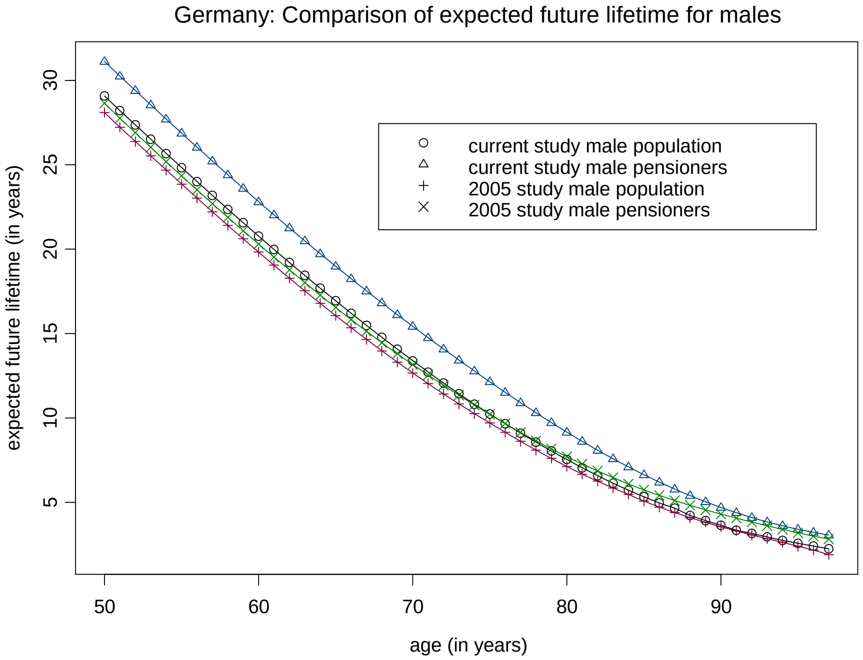


Figure 2.8.11

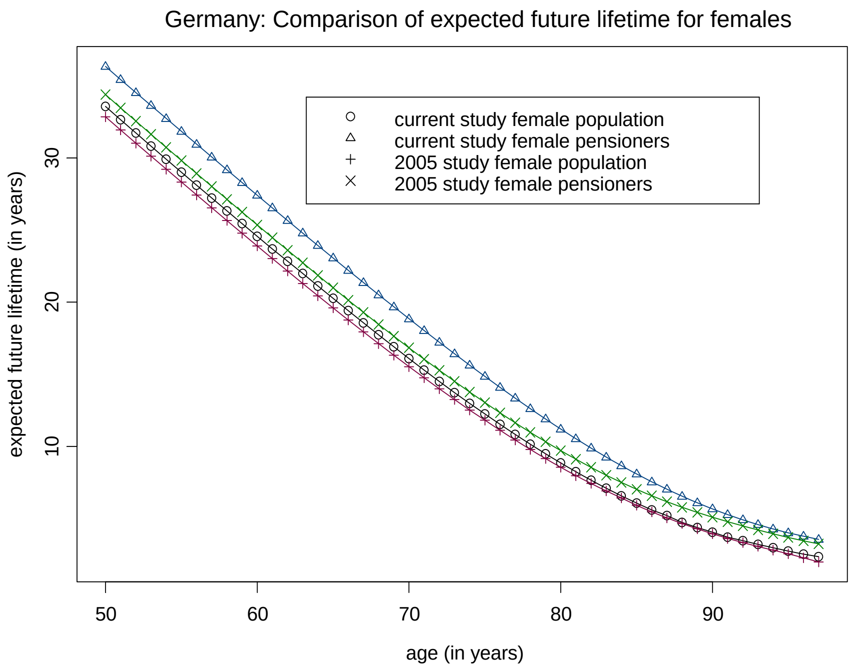


Figure 2.8.12

Table 2.8.4
Germany: Comparison of expected complete future lifetime for males

age	male pensioners			male population			
	Richttafeln 2005G	Richttafeln 1998	difference	2006	2002	difference	Annualised percentage difference
50	31.11	28.63	2.48	29.08	28.09	0.99	0.9%
55	26.87	24.34	2.53	24.83	23.85	0.98	1.0%
60	22.81	20.30	2.51	20.78	19.83	0.95	1.2%
65	18.99	16.55	2.44	16.94	16.06	0.88	1.4%
70	15.43	13.17	2.26	13.38	12.66	0.72	1.4%
75	12.14	10.21	1.93	10.23	9.70	0.53	1.4%
80	9.16	7.71	1.45	7.54	7.13	0.42	1.5%
85	6.64	5.75	0.89	5.34	5.08	0.26	1.3%
90	4.71	4.31	0.40	3.65	3.56	0.08	0.6%
95	3.41	3.19	0.22	2.58	2.41	0.17	1.7%

Table 2.8.5
Germany: Comparison of expected complete future lifetime for females

age	female pensioners			female population			
	Richttafeln 2005G	Richttafeln 1998	difference	2006	2008	difference	Annualised percentage difference
50	36.34	34.39	1.95	33.57	32.85	0.72	0.5%
55	31.83	29.82	2.01	29.01	28.32	0.69	0.6%
60	27.41	25.35	2.06	24.57	23.90	0.67	0.7%
65	23.06	20.99	2.07	20.26	19.59	0.67	0.9%
70	18.84	16.84	2.01	16.08	15.53	0.56	0.9%
75	14.85	13.03	1.82	12.24	11.81	0.43	0.9%
80	11.20	9.70	1.50	8.84	8.54	0.31	0.9%
85	8.08	7.02	1.06	6.07	5.91	0.15	0.6%
90	5.66	5.08	0.58	4.04	3.93	0.11	0.7%
95	4.00	3.69	0.32	2.73	2.55	0.18	1.8%

Table 2.8.6
Germany: Distribution of age at death given survival to age 65
Summary Statistics for the population experience

	Male			female		
	2006 population	2002 population	difference	2006 population	2002 population	difference
Lower Quartile age	75.23	74.23	1.00	80.92	79.79	1.13
Median age	82.69	81.74	0.94	86.89	85.63	1.26
Upper Quartile age	88.83	87.85	0.99	91.93	90.46	1.47
Inter quartile range	13.61	13.62	-0.01	11.01	10.67	0.33
e_{65}	16.94	16.06	0.88	20.26	19.59	0.67

Summary Statistics based on the Richttafeln Mortality Tables

	Male			female		
	Richttafeln 2005G	Richttafeln 1998	difference	Richttafeln 2005G	Richttafeln 1998	difference
Lower Quartile age	77.70	76.00	1.70	82.50	80.73	1.77
Median age	84.35	81.42	2.94	89.98	86.42	3.55
Upper Quartile age	90.25	87.26	2.99	94.64	92.91	1.72
Inter quartile range	12.56	11.27	1.29	12.14	12.18	-0.04
e_{65}	18.99	16.55	2.44	23.06	20.99	2.07

2.9 Ireland

2.9.1 Ireland: population mortality

The Irish Life Tables No 15 produced by the Central Statistics Office in Ireland, are the most recent population life tables for Ireland. The life tables are based on the mortality experience for the three years 2005, 2006 and 2007. For consistency of analysis across countries, the 2006 population mortality experience available from the Human Mortality Database has been used in this study.

In the previous study, the population mortality experience from the Irish Life Tables No 14 was assumed. The Irish Life Tables No 14 are based on the population mortality experience in Ireland over the years 2001 to 2003

2.9.2 Ireland: mortality assumptions used to assess retirement liabilities within pension funding valuations

Currently the mortality tables used in Ireland are the 1992 series of the UK PMA or PFA mortality tables (male or female as appropriate). These tables are constructed from the mortality experience of the 1991- 94 UK life office pensioners, based on amount of pension.

The Council of the Society of Actuaries in Ireland has proposed that the current basis is updated and approval for this is currently awaited from the Minister for Social and Family Affairs (equivalent to the Pensions Secretary in the UK). The proposed New Basis for Transfer Values (Proxy) differentiates between pre-retirement and post-retirement mortality. For pre-retirement mortality, the AM92 and AF92 mortality tables are assumed for males and females respectively. These are tables constructed from the mortality experience of the 1991- 94 UK assured lives.

For post-retirement mortality, the proposed basis is as follows:

- Males: 62% of PNML00; Females: 70% of PNFL00, with an increase to the annuity value of:
    - 0.50% (male with no spouse’s pension)
    - 0.38% (female with no spouse’s pension)
    - 0.39% (male or female with spouse’s pension)

(per annum compound) for each year between 2008 and the year in which normal pension date falls.

The PNML00 and PNFL00 mortality tables are constructed from the mortality experience of the 1999-2002 UK life office pensioners, lives data for males and females respectively. This basis would be used for all pension schemes. However, for Defined Contribution Schemes, the basis would be the PNMA and PNFA mortality tables which are tables based on amounts data.

The normal retirement age in Ireland is generally 60 to 65 years.

For widow's or widower's benefits, it is assumed that males are three years older than females. In circumstances where a spouse's pension would be payable only to a member's current spouse that spouse's age may be used.

In this study, the UK standard tables PMA92C10 and PFA92C10 for males and females respectively are assumed as in the previous study. A widow's pension of 60% of the spouse's pension is also assumed.

2.9.3 Ireland: projected mortality

The PMA92C10 and PFA92C10 mortality tables assumed are the base tables (1992 base) projected to 2010, in conjunction with the CMI's medium cohort projection basis to reflect further improvements in mortality since the tables were published.

The adjustments to the PNML00 and PNFL00 mortality tables proposed in the new basis are based on the Irish rates of improvement in mortality.

2.9.4 Ireland: results

A summary of the results obtained from a comparative analysis of the population mortality experience in 2006 and the PMA92C10/PFA92C10 tables assumed for retirement related benefits is given in Table 2.9.1. From the table it can be seen that the present value of annuity rates derived on the basis of the PMA92C10/PFA92C10 mortality tables assumed for pension liability calculations are considerably higher than annuity rates derived on the basis of the current population mortality, which is consistent with lighter mortality experience for pensioners. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 20.8% for males and 14.1% for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of male member's pension is included, the percentage difference between male annuity rates at age 65 is 14.5% assuming a discount rate of 3%.

Figure 2.9.1 and Table 2.9.2 show comparisons of the observed probabilities of death (q_x rates) based on the 2006 population mortality experience and the PMA92C10/PFA92C10 mortality tables. It can be seen that for both males and females, the PMA92C10/PFA92C10 mortality tables exhibit considerably lighter mortality than the observed population at all ages. For example, the probability from the PMA92C10 mortality tables that a 65-year male will die before his 66th birthday is 40% of the probability derived from the Irish male population experience. The corresponding proportion for a 65-year old female is 63%. The same trends are depicted in Figure 2.9.2 which shows the ratios of probabilities of death from the PMA92C10 and PFA92C10 mortality tables to probabilities of death derived from the male and female population mortality experiences respectively.

Figure 2.9.3 shows age-related ratios of female probabilities of death to male probabilities of death based on pension-related tables and population mortality experience. For the population mortality experience, the difference between male and female mortality rates is generally decreasing as age increases.

Table 2.9.3 and Figure 2.9.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the PMA92C10 and PFA92C10 mortality tables with corresponding expected future lifetime values for the population. Expressed as a percentage of the expected future lifetime value derived from the population mortality experience, the proportional differences at age 65 are: 25.9% for males and 19.1% for females (Tables 2.9.1 and 2.9.3). Based on the PMA92C10 and PFA92C10 mortality tables, the life expectancy at age 65 is about 4.3 years longer for males and about 3.8

years longer for females compared to the observed male and female population respectively.

Figures 2.9.5, 2.9.6, 2.9.7 and 2.9.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering age 65 (Figure 2.9.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to nearly age 86 on the basis of the PMA92C10 tables and to about age 82 on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to about age 92 on the basis of the PMA92C10 mortality tables and to about age 87.5 on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to about age 89 on the basis of the PFA92C10 tables and to about age 85 on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to about age 95 on the basis of the PFA92C10 tables and to about age 91 on the basis of the female population experience.

Table 2.9.1

Ireland: Summary Statistics

age x = 50

	male				female			
	population	PMA92C10	difference	percentage difference	population	PFA92C10	difference	percentage difference
e_x	29.41	35.02	5.61	19.1	33.27	37.89	4.62	13.9
a_x : 3%	18.46	20.81	2.36	12.8	20.04	21.75	1.72	8.6
a_x : 6%	12.92	14.02	1.11	8.6	13.63	14.36	0.73	5.4

age x = 60

	male				female			
	population	PMA92C10	difference	percentage difference	population	PFA92C10	difference	percentage difference
e_x	20.68	25.47	4.79	23.1	24.23	28.33	4.10	16.9
a_x : 3%	14.34	16.84	2.50	17.5	16.19	18.09	1.90	11.7
a_x : 6%	10.79	12.20	1.41	13.1	11.82	12.79	0.96	8.2
$a_x + .6a_{x\|y}$: 3%	17.07	19.13	2.07	12.1				

age x = 65

	male				female			
	population	PMA92C10	difference	percentage difference	population	PFA92C10	difference	percentage difference
e_x	16.65	20.96	4.32	25.9	19.97	23.78	3.82	19.1
a_x : 3%	12.07	14.58	2.51	20.8	14.01	15.98	1.97	14.1
a_x : 6%	9.43	10.98	1.55	16.4	10.63	11.73	1.10	10.3
$a_x + .6a_{x\|y}$: 3%	14.90	17.07	2.16	14.5				

age x = 70

	male				Female			
	population	PMA92C10	difference	percentage difference	population	PFA92C10	difference	percentage difference
e_x	12.97	16.74	3.77	29.1	15.91	19.45	3.54	22.2
a_x : 3%	9.79	12.21	2.42	24.8	11.69	13.73	2.04	17.4
a_x : 6%	7.94	9.57	1.63	20.6	9.23	10.48	1.24	13.5

Table 2.9.2

Ireland: One-year probabilities of death (Initial rates of mortality, q_x rates)

age	male			female		
	population	PMA92C10	ratio	population	PFA92C10	ratio
50	0.002910	0.000729	0.25	0.001910	0.000704	0.37
55	0.005680	0.001524	0.27	0.003600	0.001388	0.39
60	0.009290	0.003131	0.34	0.004940	0.002629	0.53
65	0.015940	0.006370	0.40	0.007890	0.004943	0.63
70	0.024890	0.011725	0.47	0.012780	0.008521	0.67
75	0.046530	0.021136	0.45	0.025830	0.014640	0.57
80	0.077590	0.040057	0.52	0.045920	0.026965	0.59
85	0.124290	0.080527	0.65	0.088200	0.053775	0.61
90	0.191630	0.150350	0.78	0.153260	0.101651	0.66
95	0.282630	0.226764	0.80	0.232640	0.158197	0.68

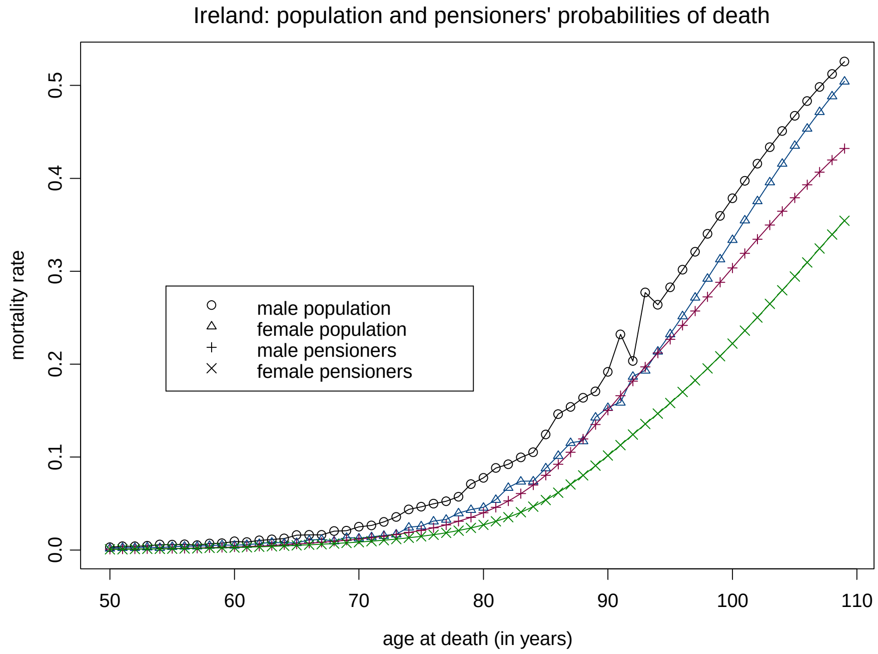


Figure 2.9.1

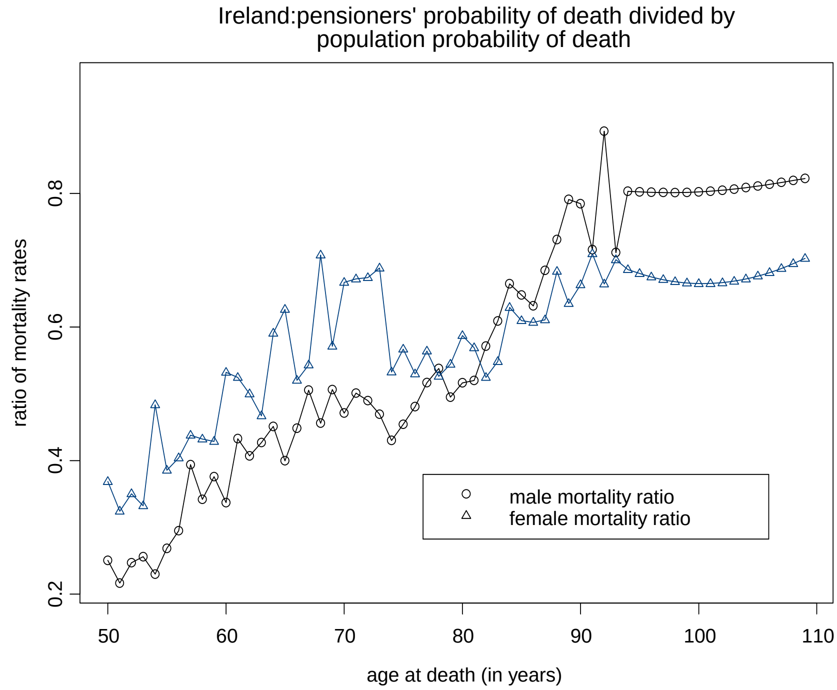


Figure 2.9.2

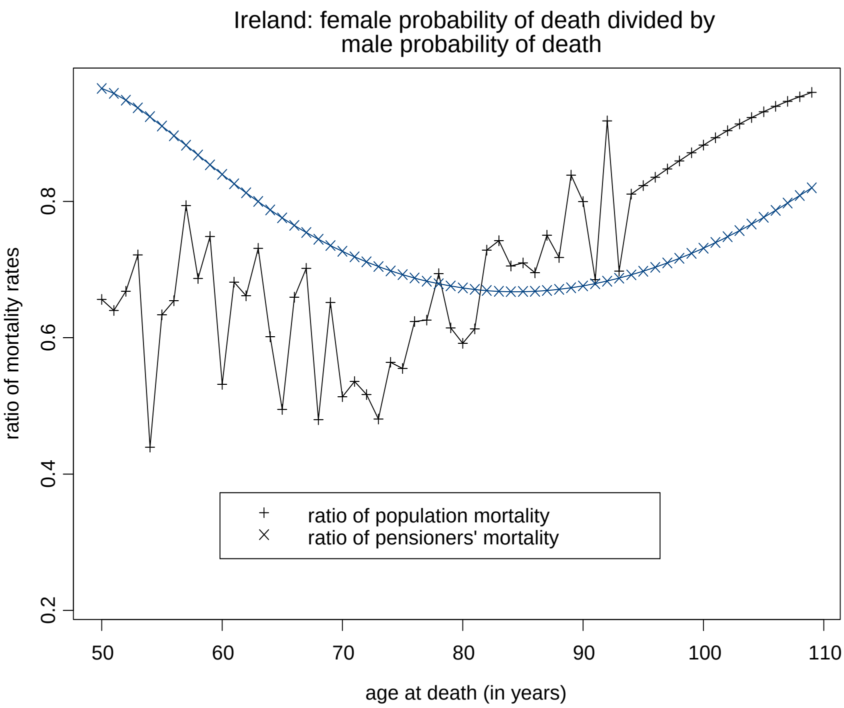


Figure 2.9.3

Table 2.9.3
Ireland: Expected complete future lifetime in years

age	Male				female			
	population	PMA92C10	difference	percentage difference	population	PFA92C10	difference	percentage difference
50	29.41	35.02	5.61	19.1	33.27	37.89	4.62	13.9
55	24.98	30.18	5.21	20.8	28.66	33.05	4.39	15.3
60	20.68	25.47	4.79	23.1	24.23	28.33	4.10	16.9
65	16.65	20.96	4.32	25.9	19.97	23.78	3.82	19.1
70	12.97	16.74	3.77	29.1	15.91	19.45	3.54	22.2
75	9.78	12.84	3.06	31.3	12.08	15.37	3.30	27.3
80	7.15	9.36	2.21	30.9	8.88	11.64	2.76	31.0
85	5.09	6.50	1.41	27.7	6.30	8.44	2.14	34.0
90	3.61	4.49	0.89	24.6	4.43	6.05	1.62	36.6
95	2.64	3.29	0.65	24.6	3.11	4.46	1.35	43.5

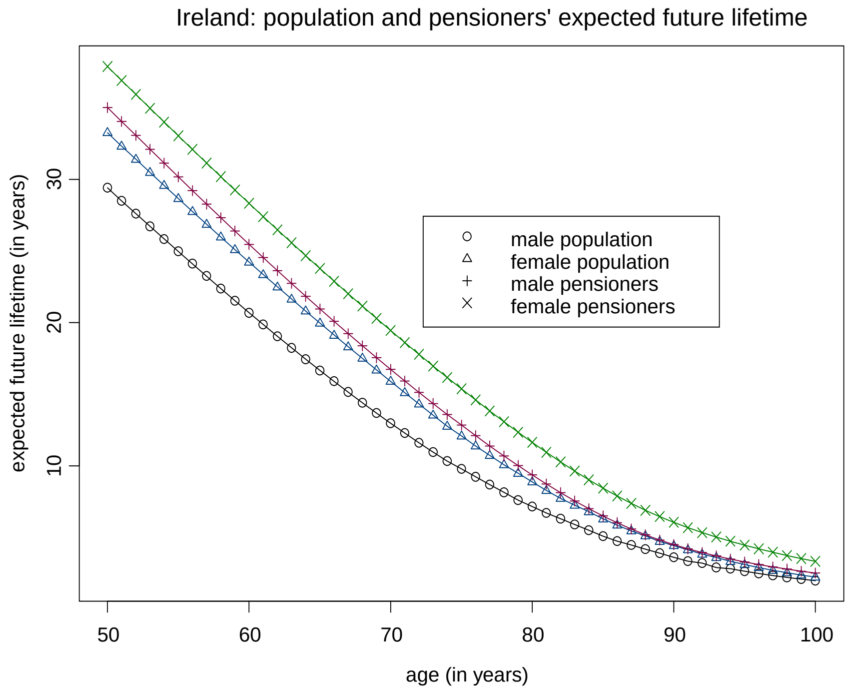


Figure 2.9.4

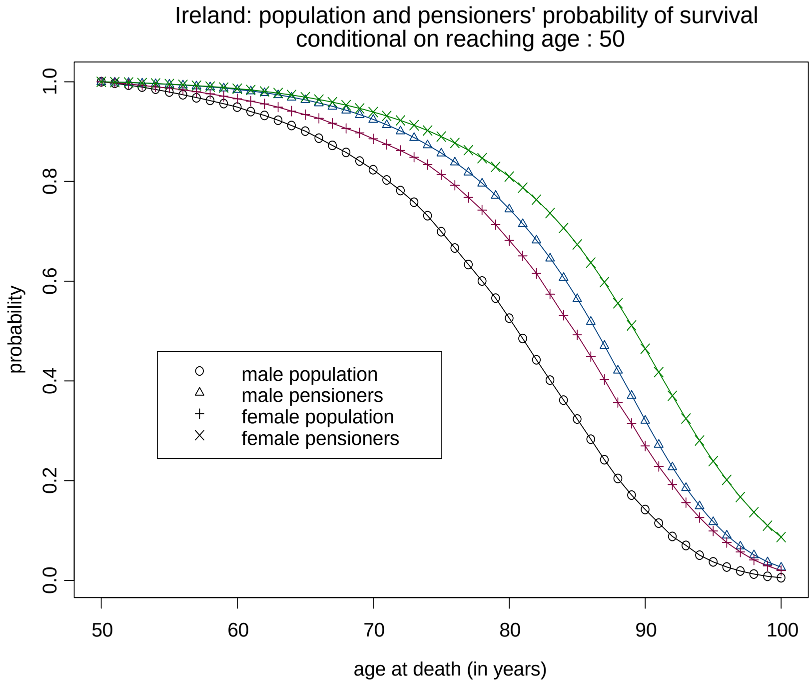


Figure 2.9.5

Ireland: Distribution of age at death given survival to age 50

Summary Statistics

	Male			female		
	population	PMA92C10	difference	population	PFA92C10	difference
Lower Quartile age	73.31	79.82	6.51	77.72	82.50	4.78
Median age	80.64	86.40	5.76	84.81	89.24	4.44
Upper Quartile age	86.81	91.51	4.70	90.48	94.74	4.26
Inter quartile range	13.50	11.69	-1.81	12.76	12.24	-0.52
e_{50}	29.41	35.02	5.61	33.27	37.89	4.62

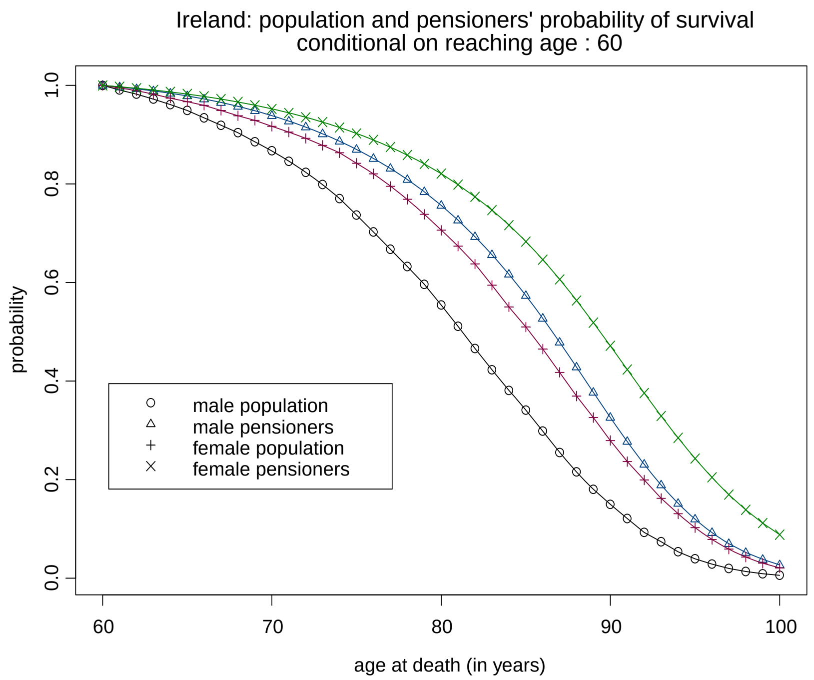


Figure 2.9.6

Ireland: Distribution of age at death given survival to age 60

Summary Statistics

	male			female		
	population	PMA92C10	difference	population	PFA92C10	difference
Lower Quartile age	74.61	80.22	5.61	78.62	82.88	4.26
Median age	81.25	86.56	5.31	85.22	89.39	4.18
Upper Quartile age	87.12	91.59	4.47	90.69	94.83	4.14
Inter quartile range	12.52	11.37	-1.15	12.06	11.94	-0.12
e_{60}	20.68	25.47	4.79	24.23	28.33	4.10

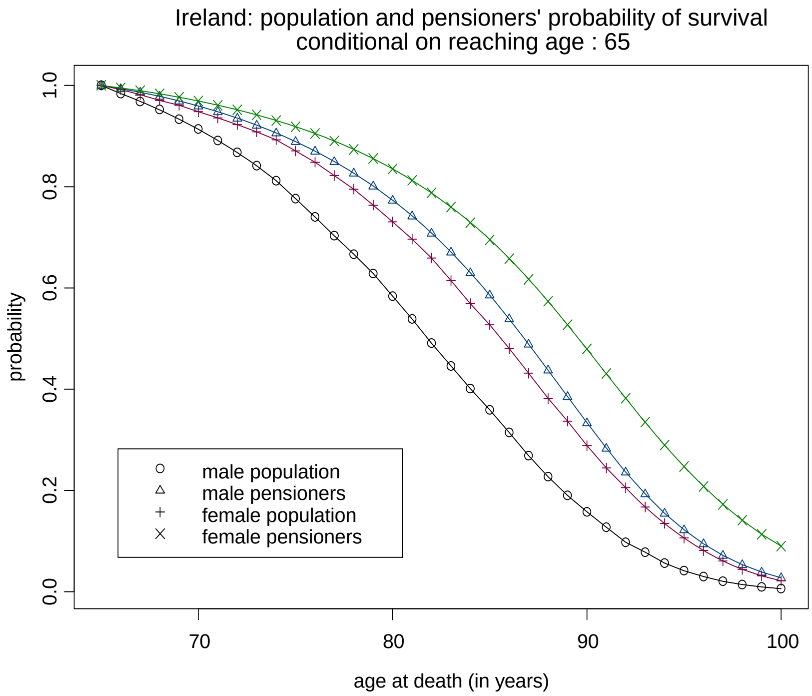


Figure 2.9.7

Ireland: Distribution of age at death given survival to age 65

Summary Statistics

	male			female		
	population	PMA92C10	difference	population	PFA92C10	difference
Lower Quartile age	75.73	80.75	5.02	79.41	83.32	3.91
Median age	81.81	86.78	4.97	85.58	89.58	3.99
Upper Quartile age	87.45	91.71	4.26	90.88	94.93	4.05
Inter quartile range	11.72	10.96	-0.76	11.47	11.61	0.14
e_{65}	16.65	20.96	4.32	19.97	23.78	3.82

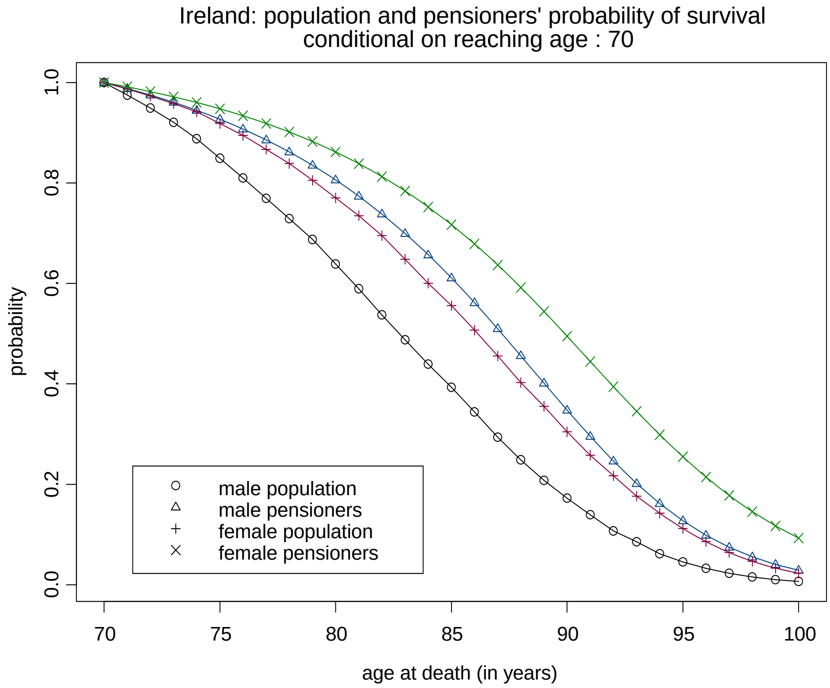


Figure 2.9.8

Ireland: Distribution of age at death given survival to age 70

Summary Statistics

	male			female		
	population	PMA92C10	Difference	population	PMA92C10	difference
Lower Quartile age	77.48	81.67	4.18	80.57	84.07	3.49
Median age	82.75	87.18	4.43	86.13	89.90	3.76
Upper Quartile age	87.97	91.92	3.95	91.19	95.12	3.93
Inter quartile range	10.48	10.25	-0.23	10.62	11.05	0.44
e_{70}	12.97	16.74	3.77	15.91	19.45	3.54

2.9.5 Ireland results: comparison with previous study

Figures 2.9.9 and 2.9.10 compare the probabilities of death shown in Figure 2.9.1 with probabilities of death from the Irish Life Tables No 14, the population mortality experience used in the previous study, for males and females separately. The expected future lifetimes are compared in Figures 2.9.11 and 2.9.12. Clearly, there has been an improvement in population mortality between 2001-2003 and 2006 at all ages for both males and females. From the annualised percentage changes in expected future lifetime shown in Tables 2.9.4 and 2.9.5, it is apparent that:

- the rate of improvement in mortality is generally higher for males; and
- the rate of improvement increases with age, particularly for the male population.

In calculating the annualised percentage changes in expected future lifetime, the Irish Life Tables No 14 has been assumed to pertain to the year 2002.

Table 2.9.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the male population in Ireland in 2006 would be expected to live to at least age 87 years, the same proportion of 65-year old males from the male population in Ireland in 2001-2003 would be expected to live to age 85 approximately, the actual difference being more than two years. For females, the difference from a similar comparison is lower: 25% of the 2006 female population in Ireland alive at age 65 is expected to live to about age 91 while the same proportion from the 2001-2003 female population in Ireland is expected to live to just over age 89, the actual difference being about one and a half years.

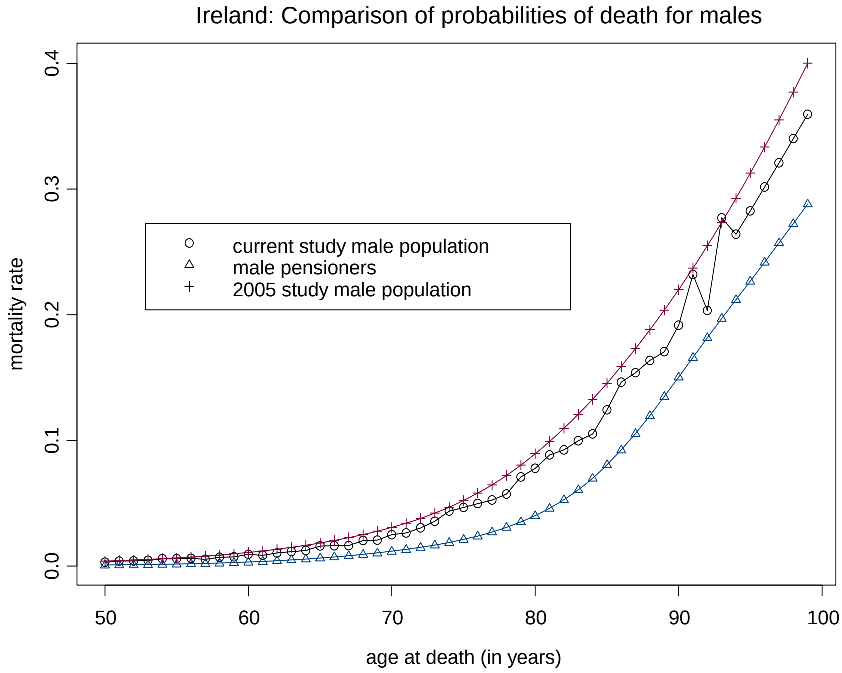


Figure 2.9.9

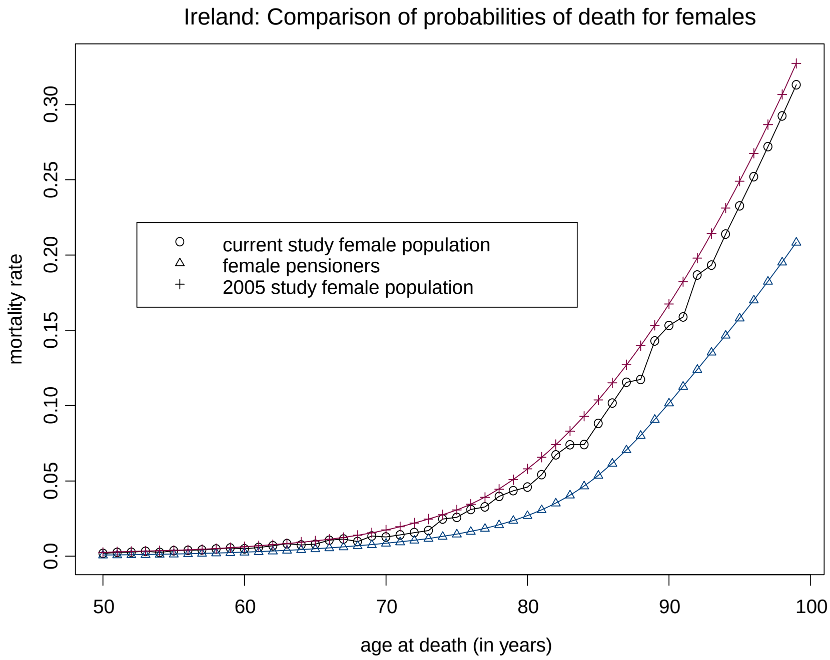


Figure 2.9.10

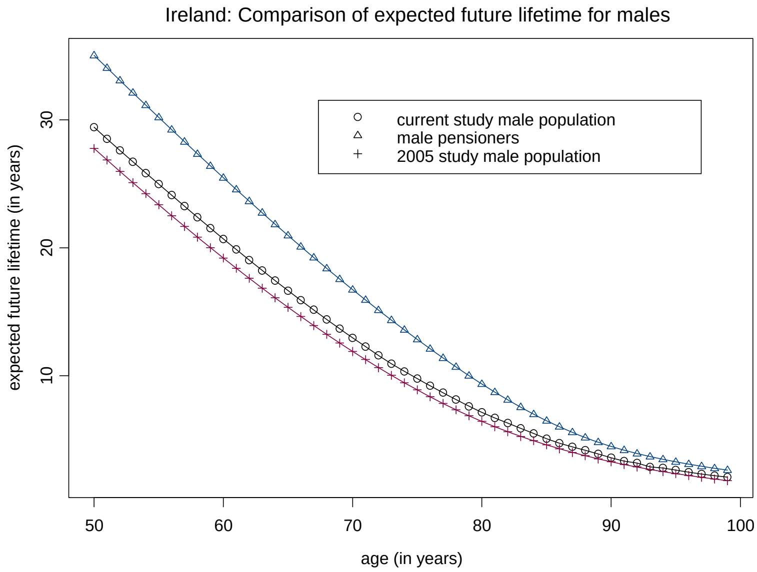


Figure 2.9.11

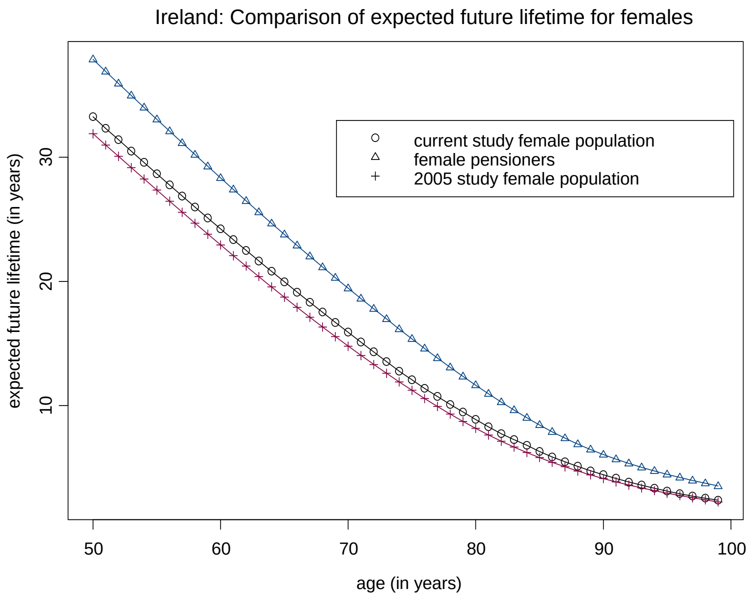


Figure 2.9.12

Table 2.9.4
Ireland: Comparison of expected complete future lifetime for males

	PMA92C10	Male population			
		2006 population	2002 population	difference	Annualised percentage difference
50	35.02	29.41	27.76	1.66	1.5%
55	30.18	24.98	23.36	1.61	1.7%
60	25.47	20.68	19.20	1.48	1.9%
65	20.96	16.65	15.36	1.28	2.1%
70	16.74	12.97	11.91	1.05	2.2%
75	12.84	9.78	8.91	0.88	2.5%
80	9.36	7.15	6.45	0.70	2.7%
85	6.50	5.09	4.61	0.48	2.6%
90	4.49	3.61	3.29	0.31	2.4%
95	3.29	2.64	2.37	0.27	2.9%

Table 2.9.5
Ireland: Comparison of expected complete future lifetime for females

	PFA92C10	Female population			
		2006 population	2002 population	difference	Annualised percentage difference
50	37.89	33.27	31.90	1.37	1.1%
55	33.06	28.66	27.35	1.31	1.2%
60	28.34	24.23	22.93	1.30	1.4%
65	23.79	19.97	18.73	1.23	1.6%
70	19.46	15.91	14.79	1.13	1.9%
75	15.38	12.08	11.22	0.85	1.9%
80	11.64	8.88	8.16	0.72	2.2%
85	8.45	6.30	5.81	0.49	2.1%
90	6.06	4.43	4.12	0.31	1.9%
95	4.48	3.11	2.94	0.17	1.5%

Table 2.9.6
Ireland: Distribution of age at death given survival to age 65
Summary Statistics

	Male			female		
	2006 population	2002 population	difference	2006 population	2002 population	difference
Lower Quartile age	75.73	74.46	1.26	79.41	78.87	0.53
Median age	81.81	80.51	1.30	85.58	84.77	0.81
Upper Quartile age	87.45	85.03	2.42	90.88	89.39	1.49
Inter quartile range	11.72	10.56	1.16	11.47	10.51	0.96
e_{65}	16.65	15.36	1.28	19.97	18.73	1.23

2.10 Italy

2.10.1 Italy: population mortality

In this study, the 2006 population mortality experience for Italy available on the Human Mortality Database has been used for comparison with pension-related mortality tables, without any adjustments.

In the previous study, the Italian Population Life Tables for 2000 available from ISTAT (National Institute of Statistics) website (*http:/www.demo.istat.it/tav/query.php*) were used for comparison with pension-related mortality tables, without any adjustments.

2.10.2 Italy: mortality assumptions used to assess retirement liabilities within pension funding valuations

As in the previous study, the mortality table commonly used for valuing retirement benefits for pension fund retirees in Italy is the projected generation table RG48, a table pertaining to the generation born in 1948. The RG48 was obtained by modifying a projected mortality table, '**generation 1948**' constructed by a government office. Modification consisted of the introduction of adverse selection coefficients resulting in increases in survival probabilities.

The table **generation 1948** was constructed from period tables of the Italian general population using the projection method proposed by Petrioli and Berti (1979), which is based on the so-called "resistance function". The method is described in Pitacco (2004) and the description in Pitacco is largely reproduced here.

The resistance function $r(x)$ is defined as:

$$r(x) = \frac{l_x/(\omega - x)}{(1 - l_x)/x},$$

where ω denotes the maximum age. The resistance function is then graduated using a model of the general form:

$$r(x) = x^{\alpha}(\omega - x)^{\beta} e^{Ax^2 + Bx + C}.$$

In particular, a three-parameter curve:

$$r(x) = kx^{\alpha}(\omega - x)^{\beta}$$

was fitted to the Italian mortality data. Assuming that (some of) the parameters of the resistance function depend on the calendar year, *t*, the projection model thus fitted was of the form:

$$r(x,t) = k(t)\,x^{\alpha(t)}(\omega - x)^{\beta(t)}.$$

2.10.3 Italy: projected mortality

The RG48 mortality table is a projected generation mortality table which includes age adjustments as detailed in Table 2.10.1.

Table 2.10.1
Italy: RG48 - age adjustments for year of birth

Males		Females	
Year of birth	Age-shift	Year of birth	Age-shift
up to 1941	1	up to 1943	1
from 1942 to 1951	0	from 1944 to 1950	0
from 1951 to 1965	-1	from 1951 to 1964	-1
from 1966	-2	from 1965	-2

2.10.4 Italy: results

A summary of the results obtained from a comparative analysis of the population mortality experience in Italy in 2006 and the RG48 mortality tables assumed for retirement related benefits is given in Table 2.10.2. From the table it can be seen that the present value of annuity rates derived on the basis of the RG48 mortality tables assumed for pension liability calculations are higher than annuity rates derived on the basis of the current population mortality, which is consistent with lighter mortality experience for pensioners. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age

65 is 8.8% for males and 8.9% for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of male member's pension is included, the percentage difference between male annuity rates at age 65 is 6.3% assuming a discount rate of 3%.

Figure 2.10.1 and Table 2.10.3 show comparisons of the observed probabilities of death (q_x rates) based on the 2006 population mortality experience and the RG48 mortality tables. It can be seen that for both males and females, the RG48 mortality tables exhibit considerably lighter mortality at all ages x, up to 90 years. For example, the probability from the RG48 mortality tables that a 65-year male will die before his 66th birthday is 56% of the probability derived from the Italian male population experience. The corresponding proportion for a 65-year old female is 38%. The same trends are depicted in Figure 2.10.2 which shows the ratios of probabilities of death from the RG48 mortality tables to probabilities of death derived from the male and female population mortality experiences.

Figure 2.10.3 shows age-related ratios of female probabilities of death to male probabilities of death based on pension-related tables and population mortality experience. From the graph, it can be seen that in both cases, the difference between male and female mortality rates is generally decreasing as age increases.

Table 2.10.4 and Figure 2.10.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the RG48 mortality tables with corresponding expected future lifetime values for the population. Expressed as a percentage of the expected future lifetime value derived from the population mortality experience, the proportional differences at age 65 are: 10.1% for males and 10.4% for females (Tables 2.10.2 and 2.10.4). Based on the RG48 mortality tables, the life expectancy at age 65 is 1.8 years longer for males and about 2.2 years longer for females compared to the observed male and female population respectively.

Figures 2.10.5, 2.10.6, 2.10.7 and 2.10.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering age 65 (Figure 2.10.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to nearly age 85 on the basis of the RG48 tables and to about age 83 on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to at least age 90 on the basis of the RG48 mortality tables and to about age 89 on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to about age 89 on the basis of the RG48 mortality tables and to about age 86.6 years on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to about age 93.6 years on the basis of the RG48 tables and to about age 92.6 years on the basis of the female population experience.

Table 2.10.2

Italy: Summary Statistics

age x = 50

	male				female			
	population	male pens	difference	percentage difference	population	fem pens	Difference	percentage difference
e_x	30.58	33.26	2.68	8.8	35.23	38.21	2.98	8.5
a_x : 3%	18.91	20.12	1.21	6.4	20.80	22.04	1.23	5.9
a_x : 6%	13.11	13.71	0.60	4.6	13.97	14.53	0.56	4.0

age x = 60

	male				female			
	population	male pens	difference	percentage difference	population	fem pens	difference	percentage difference
e_x	21.83	24.04	2.21	10.1	26.02	28.61	2.59	9.9
a_x : 3%	14.91	16.17	1.25	8.4	17.07	18.44	1.37	8.0
a_x : 6%	11.10	11.85	0.76	6.8	12.30	13.07	0.77	6.3
$a_x + .6a_{x\|y}$: 3%	17.72	18.74	1.02	5.8				

age x = 65

	male				female			
	population	male pens	difference	percentage difference	population	fem pens	difference	percentage difference
e_x	17.82	19.63	1.80	10.1	21.61	23.85	2.24	10.4
a_x : 3%	12.75	13.88	1.13	8.8	14.92	16.24	1.32	8.9
a_x : 6%	9.85	10.59	0.74	7.5	11.17	11.99	0.82	7.3
$a_x + .6a_{x\|y}$: 3%	15.65	16.63	0.99	6.3				

age x = 70

	male				female			
	population	male pens	difference	percentage difference	population	fem pens	difference	percentage difference
e_x	14.09	15.44	1.35	9.6	17.35	19.18	1.82	10.5
a_x : 3%	10.51	11.44	0.93	8.8	12.58	13.78	1.20	9.5
a_x : 6%	8.43	9.09	0.66	7.8	9.80	10.62	0.82	8.3

Table 2.10.3

Italy: One-year probabilities of death (Initial rates of mortality, q_x rates)

age	male			female		
	population	RG48	ratio	population	RG48	ratio
50	0.002930	0.001955	0.67	0.001670	0.001029	0.62
55	0.005070	0.002796	0.55	0.002670	0.001197	0.45
60	0.008300	0.004353	0.52	0.004290	0.001549	0.36
65	0.013180	0.007322	0.56	0.006430	0.002439	0.38
70	0.021030	0.013270	0.63	0.010530	0.004362	0.41
75	0.036830	0.025912	0.70	0.019050	0.009380	0.49
80	0.063510	0.050602	0.80	0.037280	0.022725	0.61
85	0.104090	0.097180	0.93	0.070610	0.057518	0.81
90	0.172840	0.175734	1.02	0.133020	0.134496	1.01
95	0.261950	0.276965	1.06	0.221480	0.251936	1.14

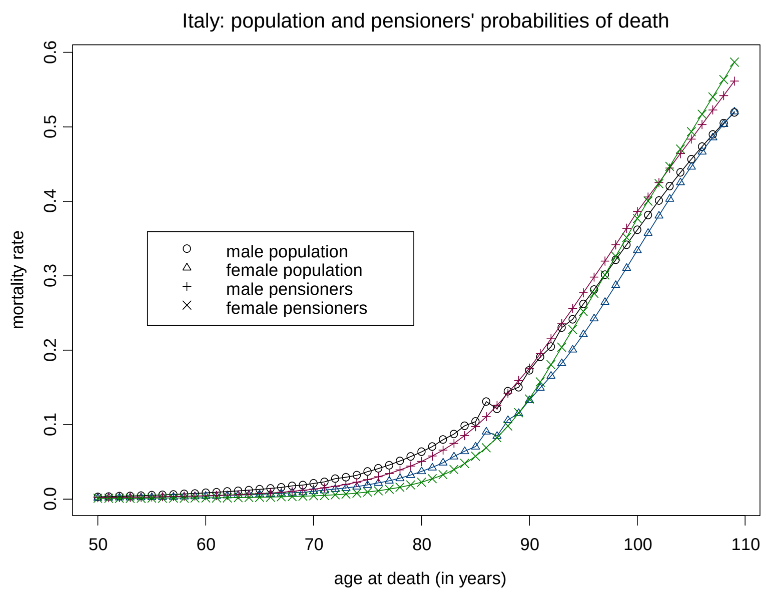


Figure 2.10.1

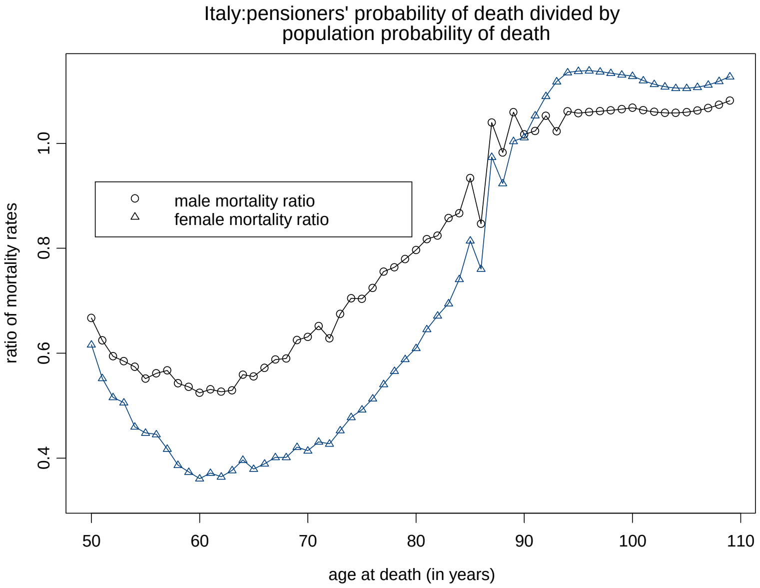


Figure 2.10.2

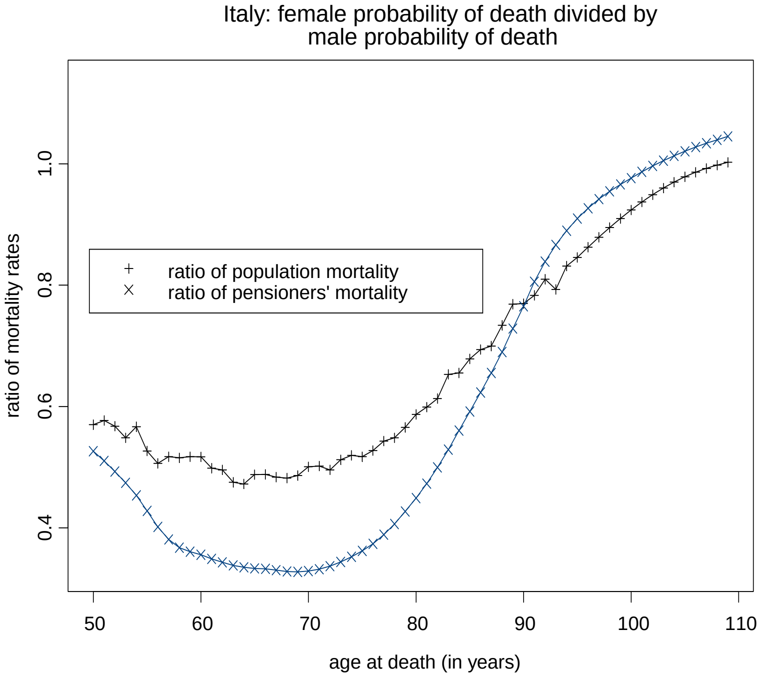


Figure 2.10.3

Table 2.10.4
Italy: Expected complete future lifetime in years

age	male				female			
	population	RG48	difference	percentage difference	population	RG48	difference	percentage difference
50	30.58	33.26	2.68	8.8	35.23	38.21	2.98	8.5
55	26.09	28.60	2.50	9.6	30.57	33.41	2.83	9.3
60	21.83	24.04	2.21	10.1	26.02	28.61	2.59	9.9
65	17.82	19.63	1.80	10.1	21.61	23.85	2.24	10.4
70	14.09	15.44	1.35	9.6	17.35	19.18	1.82	10.5
75	10.73	11.62	0.88	8.2	13.38	14.68	1.30	9.7
80	7.90	8.34	0.44	5.5	9.83	10.53	0.70	7.1
85	5.67	5.71	0.04	0.7	6.92	6.99	0.07	1.0
90	3.97	3.84	-0.13	-3.3	4.70	4.39	-0.31	-6.7
95	2.82	2.65	-0.16	-5.7	3.19	2.83	-0.36	-11.3

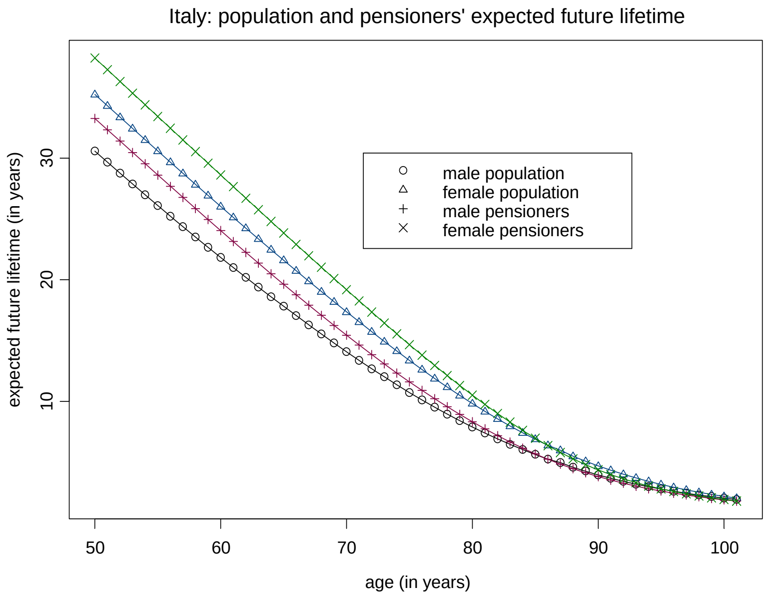


Figure 2.10.4

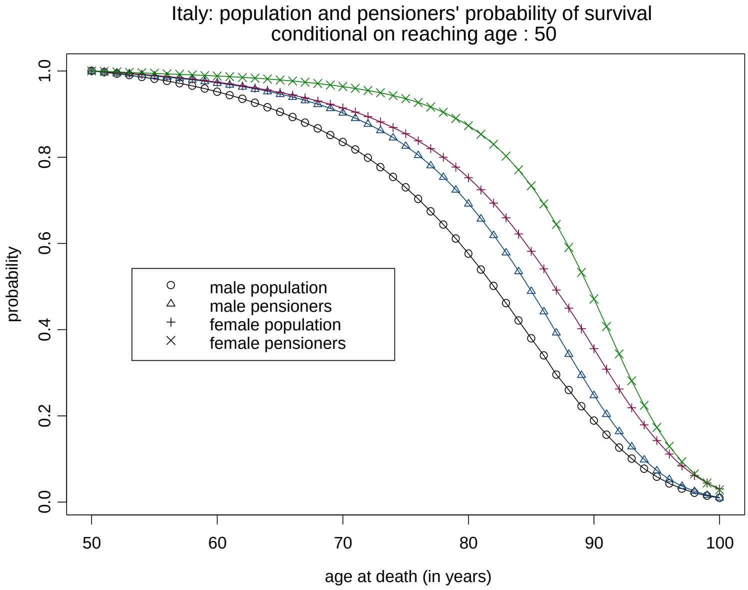


Figure 2.10.5

Italy: Distribution of age at death given survival to age 50

Summary Statistics

	male			female		
	population	RG48	difference	population	RG48	difference
Lower Quartile age	74.18	78.14	3.97	80.08	84.56	4.49
Median age	82.03	84.78	2.74	86.83	89.53	2.70
Upper Quartile age	88.26	89.96	1.69	92.28	93.55	1.26
Inter quartile range	14.08	11.81	-2.27	12.21	8.99	-3.22
e_{50}	30.58	33.26	2.68	35.23	38.21	2.98

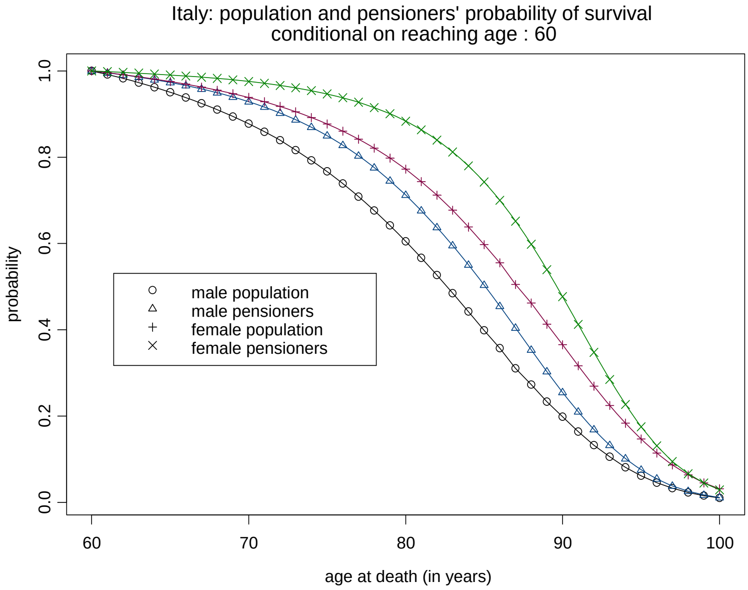


Figure 2.10.6

Italy: Distribution of age at death given survival to age 60

Summary Statistics

	male			female		
	population	RG48	difference	population	RG48	difference
Lower Quartile age	75.61	78.85	3.24	80.77	84.81	4.03
Median age	82.64	85.08	2.44	87.11	89.63	2.52
Upper Quartile age	88.58	90.11	1.53	92.43	93.60	1.17
Inter quartile range	12.98	11.26	-1.71	11.66	8.79	-2.87
e_{60}	21.83	24.04	2.21	26.02	28.61	2.59

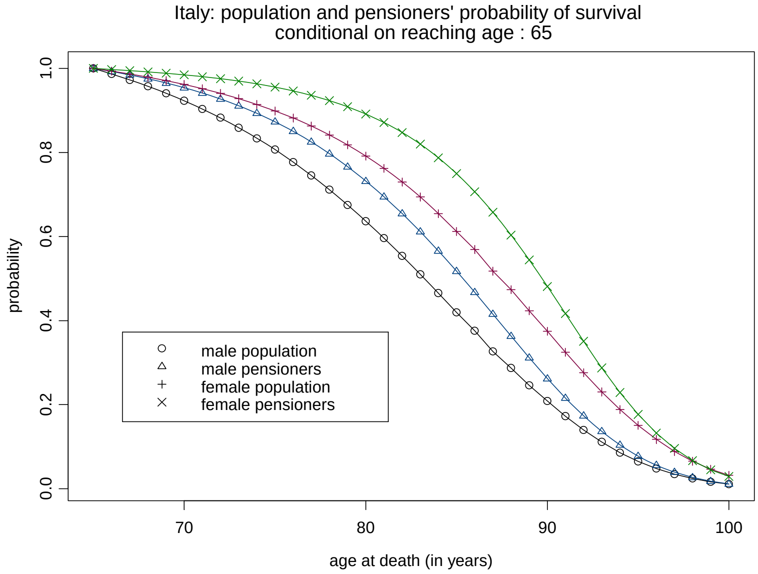


Figure 2.10.7

Italy: Distribution of age at death given survival to age 65

Summary Statistics

	male			female		
	population	RG48	difference	population	RG48	difference
Lower Quartile age	76.85	79.47	2.62	81.37	84.99	3.62
Median age	83.22	85.35	2.13	87.40	89.70	2.30
Upper Quartile age	88.89	90.26	1.37	92.57	93.64	1.07
Inter quartile range	12.04	10.79	-1.25	11.20	8.65	-2.55
e_{65}	17.82	19.63	1.80	21.61	23.85	2.24

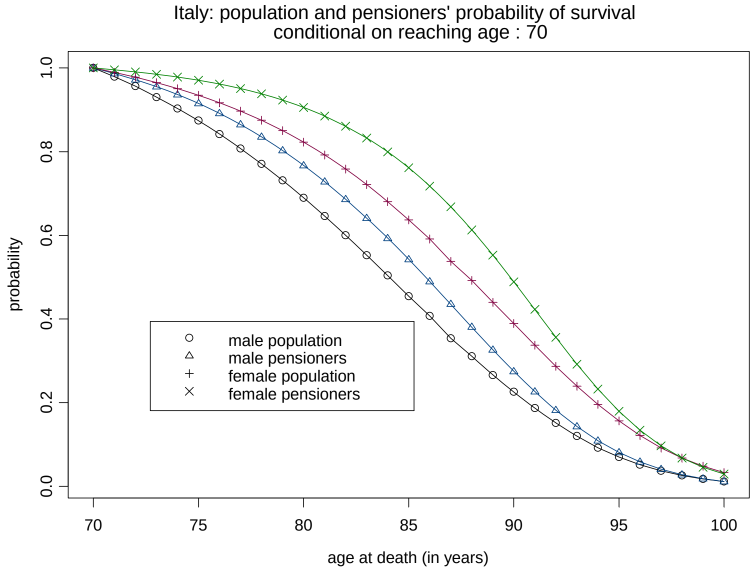


Figure 2.10.8

Italy: Distribution of age at death given survival to age 70

Summary Statistics

	male			female		
	population	RG48	difference	population	RG48	difference
Lower Quartile age	78.53	80.44	1.91	82.23	85.26	3.03
Median age	84.08	85.81	1.72	87.83	89.82	1.99
Upper Quartile age	89.40	90.51	1.11	92.78	93.71	0.93
Inter quartile range	10.88	10.07	-0.80	10.55	8.45	-2.10
e_{70}	14.09	15.44	1.35	17.35	19.18	1.82

2.10.5 Italy results: comparison with previous study

Figures 2.10.9 and 2.10.10 compare the probabilities of death shown in Figure 2.10.1 with probabilities of death for the population in 2000, the population experience used in the previous study, for males and females separately. The expected future lifetimes are compared in Figures 2.10.11 and 2.10.12. Clearly, there has been an improvement in the population mortality between 2000 and 2006 at all ages for both males and females. From the annualised percentage changes in expected future lifetime shown in Tables 2.10.5 and 2.10.6, it is apparent that:

- the rate of improvement in mortality is higher for males; and
- the rate of improvement is generally increasing with age.

It is worth noting that although the basis assumed for pension benefits is the same as that assumed in the previous study, the RG48 tables assumed still exhibit lighter mortality than that of the general Italian population.

Table 2.10.7 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the Italian male population in 2006 would be expected to live to about age 89, the same proportion of 65-year old males from the Italian male population in 2000 would be expected to live to age 87.6 years approximately, the actual difference being more than a year. For females, the difference from a similar comparison is lower: 25% of the female Italian population in 2006 alive at age 65 is expected to live to about age 92.6 years while the same proportion from the Italian female population in 2000 is expected to live to about 91.5 years, the actual difference being approximately one year.

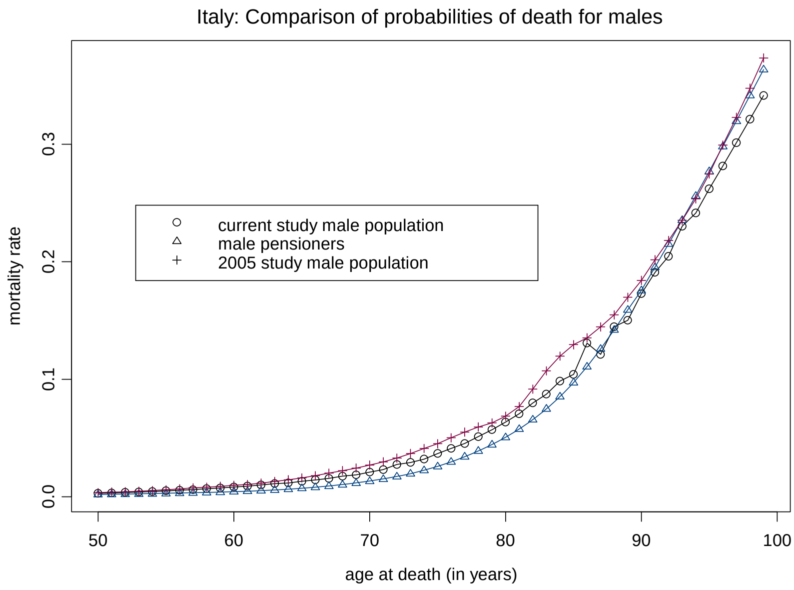


Figure 2.10.9

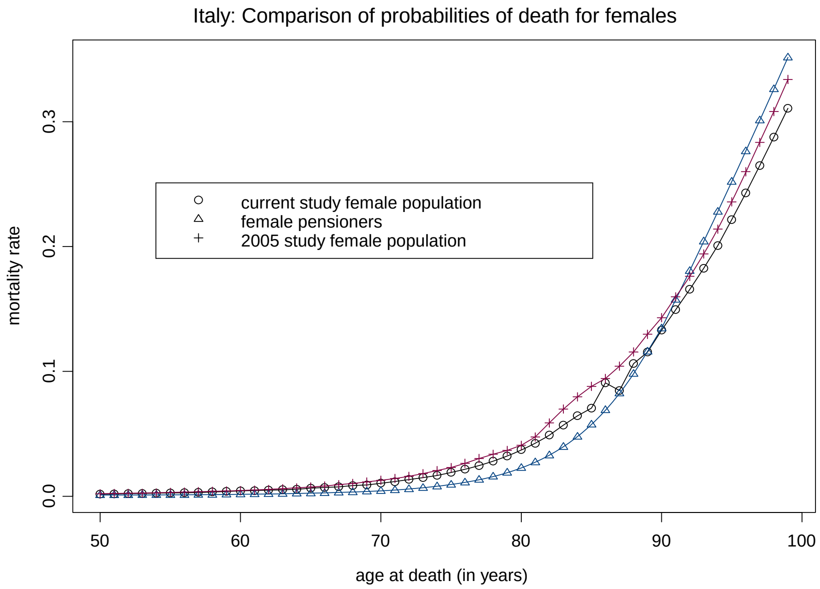


Figure 2.10.10

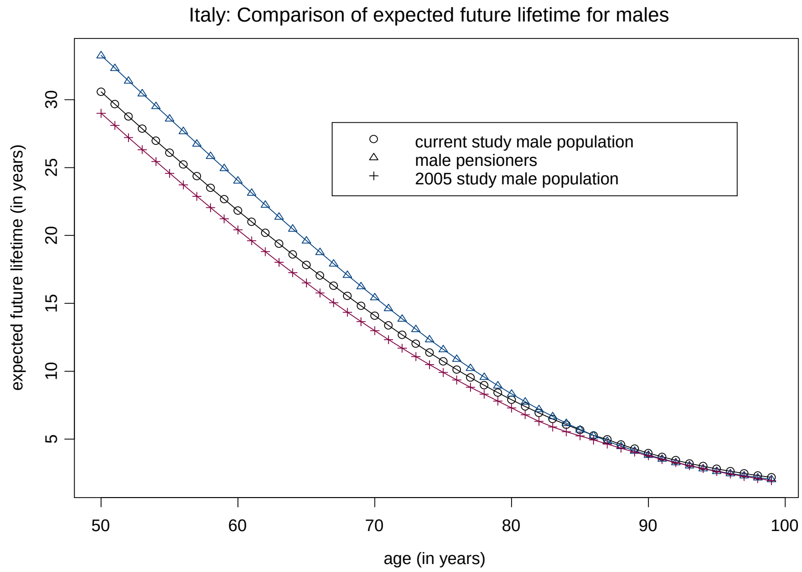


Figure 2.10.11

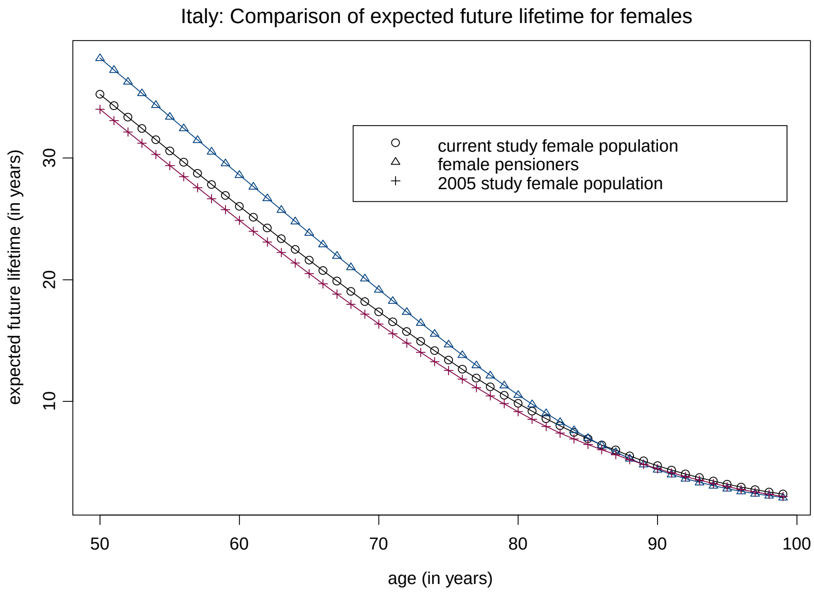


Figure 2.10.12

Table 2.10.5
Italy: Comparison of expected complete future lifetime for males

	RG48 tables	Male population			
		2006 population	2000 population	difference	Annualised percentage difference
50	33.26	30.58	29.00	1.58	0.9%
55	28.60	26.09	24.58	1.52	1.0%
60	24.04	21.83	20.41	1.42	1.2%
65	19.63	17.82	16.50	1.32	1.3%
70	15.44	14.09	12.99	1.10	1.4%
75	11.62	10.73	9.91	0.82	1.4%
80	8.34	7.90	7.30	0.61	1.4%
85	5.71	5.67	5.24	0.42	1.4%
90	3.84	3.97	3.77	0.19	0.9%
95	2.65	2.82	2.63	0.19	1.2%

Table 2.10.6
Italy: Comparison of expected complete future lifetime for females

	RG48 tables	Female population			
		2006 population	2000 population	difference	Annualised percentage difference
50	38.21	35.23	34.01	1.23	0.6%
55	33.41	30.57	29.38	1.20	0.7%
60	28.61	26.02	24.87	1.15	0.8%
65	23.85	21.61	20.50	1.10	0.9%
70	19.18	17.35	16.36	1.00	1.0%
75	14.68	13.38	12.53	0.85	1.1%
80	10.53	9.83	9.15	0.68	1.2%
85	6.99	6.92	6.46	0.47	1.2%
90	4.39	4.70	4.46	0.25	0.9%
95	2.83	3.19	2.99	0.20	1.1%

Table 2.10.7
Italy: Distribution of age at death given survival to age 65
Summary Statistics

	Male			female		
	2006 population	2000 population	difference	2006 population	2000 population	difference
Lower Quartile age	76.85	75.67	1.18	81.37	80.85	0.52
Median age	83.22	81.13	2.09	87.40	86.86	0.53
Upper Quartile age	88.89	87.59	1.31	92.57	91.51	1.06
Inter quartile range	12.04	11.92	0.12	11.20	10.66	0.54
e_{65}	17.82	16.50	1.32	21.61	20.50	1.10

2.11 Japan

The comprehensive contribution received from Japan has been reproduced below as it is felt that since Japan is a new addition to the study, the information would be of interest.

2.11.1 Japan: population mortality

The Ministry of Health, Labour and Welfare (MHLW) prepares two series of life tables — the Complete and the Abridged Life Tables. The former are constructed every five years based on the Annual Vital Statistics and the Population Census. The latter are based on the Provisional Annual Vital Statistics and the Population Estimates. The Complete Life Tables for Japan were first prepared for the period 1891-98 and the life tables and the 20th Life Tables were made available for this study.

The newest complete life tables "The 20th life tables" are based on the Annual Vital Statistics and the Population Census in 2005. MHLW smoothed the mortality rates by using Greville's formula (3rd order, 9 terms). In addition, they estimated and extrapolated the mortality rates by using Gompertz-Makeham function for advanced ages (over 90 for males and over 95 for females).

In this study, the population mortality experience in Japan in 2007 available from the Human Mortality Database has been assumed.

2.11.2 Japan: mortality assumptions used to assess retirement liabilities within pension funding valuations

Types and Coverage of DB Schemes

In Japan, there are three types of occupational defined benefit pension schemes. In Tax Qualified Pension Plans (TQPPs), which are governed by the National Tax Agency, approximately 25,000 schemes covered 3.5 million active members at the end of March, 2009. Because the tax advantageous status of these schemes would be valid only until the end of March 2012, they would be forced to be transformed to the rest of two types of defined benefit schemes or defined contribution schemes, whichever is suitable for each scheme, or to be wound-up.

Employees’ Pension Funds (EPFs) are legal entities defined in Employees’ Pension Insurance (EPI) Law and regulated and supervised by the Ministry of Health, Labour and Welfare (MHLW). These schemes include a function which plays a part of EPI, the state earnings related pension scheme that covers 34 million private sector employees, by substituting a part of its old age pensions.

Defined Benefit Corporate Pension Plans (DBs), also regulated and supervised by MHLW, were introduced in 2002 aiming at the protection of pension benefits by disclosures, fiduciary standards, and funding disciplines. TQPPs and EPFs can be transformed to DBs, although, in the latter case, the transfer to the Government of the Substitutional Portion of EPF Liabilities and corresponding Assets is required. As of the same date above, approximately 600 and 5,000 schemes cover 4.7 and 5.7 million active members respectively.

Characteristics of DB Pension Schemes

Because severance allowance schemes, which provide a lump-sum benefit upon each employee’s termination of employment based on the prescribed formula, had been developed in Japan, many firms introduced pension schemes as a transformation of them. Normally, the lump-sum would be compounded at a certain interest rate until the pensionable age and distributed as if the compound value were drawn down for a specified period with a prescribed interest. As a result, although there are some life-annuity requirements in EPFs, the majority of the annuity benefits in Japanese DB pension schemes are designed as annuities for a certain period, such as 15 years, with the same guaranteed period. Even in the case of life-annuities, most schemes provide a guaranteed period, such as 15 years. Members retain the option of receiving lump-sum in lieu of annuity benefits. Sponsors rarely provide indexation or joint life-annuities.

Although the reputation on Japanese style annuity benefits in occupational pension schemes would vary, the above situations limit the effect on pension cost caused by mortality improvements, at least to some extent.

Regulations in mortality assumptions

For funding purposes, authorities prescribe standard mortality tables. MHLW prescribed current standard mortality tables for males and females in 2005. DBs and EPFs should use the standard mortality tables. Multiplying by a safety ratio, no less than 90% for male and 85% for females, is granted, although sponsors rarely adopt the alternative. These tables are almost the same as those used in the projection of EPI scheme, which were published in 2004, as present life-base mortality tables for old age pensions. The EPI tables are based on the 19th population mortality tables (the 19th Life Tables), which were developed by using the Census of 2000, taking EPI's experiences into account.

New mortality tables for DBs and EPFs, based on 20th population mortality tables (the 20th Life Tables), and the quinquennial EPI review, have been issued and applied from April 2010. For TQPPs, both the population mortality tables and those for DBs and EPFs are available.

With regard to accounting purposes, although sponsors have ultimate responsibility for setting actuarial assumptions, most sponsors apply the above standard mortality tables.

Annuity Mortality Tables

In Japan, many people purchase individual annuities by themselves. All life insurance companies are required to fund the standard reserves, which are calculated using the standard mortality tables.

The most recent tables, the Standard Mortality Tables 2007 (SMT2007) for Annuitants, were developed by the Institute of Actuaries of Japan (IAJ), and prescribed to use for the contracts issued after April 2007 by Financial Services Agency (FSA). These tables are based on the 19th Life Tables (using the Population Census in 2000). The SMT is constructed by projecting the base table mortality in the future, and the projection period is set to at least 20 years. The improvement rates were determined from the last 25-years improvement rates, and the projection assumes that all lives age *x* in the SMT 2007 were born in 1960.

Mortality rates for ages 94 and above are extrapolated by the least squares method using a 3-degree polynomial. The mortality rates for ages 16 and below are set at 60% of the rates in the 19th Tables.

In order to make a provision against the uncertainty of the future mortality improvement, a multiple factor of 85% is applied to the mortality rate for each age.

2.11.3 Japan: results

A summary of the results obtained from a comparative analysis of the population mortality experience in Japan in 2007 and the standard mortality tables assumed for retirement related benefits is given in Table 2.11.1. From the table it can be seen that the present value of annuity rates derived on the basis of the standard mortality tables assumed for pension liability calculations are marginally higher than annuity rates derived on the basis of the current population mortality. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 0.9% for males and 1.7% for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of a male member's pension is included, the percentage difference between male annuity rates at age 65 is 1.2% assuming a discount rate of 3%.

Figure 2.11.1 and Table 2.11.2 show comparisons of the observed probabilities of death (q_x rates) based on the most recent (2007) population experience and the standard mortality tables for pensions. It can be seen that while the standard mortality tables for pension benefits exhibit lighter mortality than the observed population mortality for females at all ages, the differences in male mortality rates tend to fluctuate. For example, the probability from the standard mortality tables that a 65-year old male will die before his 66th birthday is 1% higher than the probability derived from the male population experience in Japan. The corresponding probability for a 65-year old female is 6% lower than that from the female population mortality experience. The same trends are depicted in Figure 2.11.2 which shows the ratios of probabilities of death from the standard mortality tables for pensions to probabilities of death derived from the male and female population mortality experiences respectively.

Figure 2.11.3 shows age-related ratios of female probabilities of death to male probabilities of death based on the pension-related tables and population mortality experience. Similar trends are exhibited from both experiences in that the difference between male and female mortality rates are generally decreasing as age increases.

Table 2.11.3 and Figure 2.11.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the standard mortality tables for pensions with corresponding expected future lifetime values for the population. Expressed as a percentage of the expected future lifetime value derived from the population mortality experience, the differences tend to increase with age for both males and females, with the proportional differences at age 65 being 1.4% for males and 2.7% for females (Tables 2.11.1 and 2.11.3). Based on the standard mortality tables for pensions, the life expectancy at age 65 is about a quarter of a year longer for males and just over half a year longer for females compared to the observed male and female population respectively.

Figures 2.11.5, 2.11.6, 2.11.7 and 2.11.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering age 65 (Figure 2.11.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to nearly age 84 on the basis of the standard mortality tables for pensions and to about age 83.6 years on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to age 90.1 years on the basis of the standard mortality tables for pensions and to about age 89.9 years on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to about age 89.2 years on the basis of the standard mortality tables for pensions and to about age 88.6 years on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to about age 95.5 years on the basis of the standard mortality tables for pensions and to about age 94.8 years on the basis of the female population experience.

Table 2.11.1

Japan: Summary Statistics

age x = 50

	male				female			
	population	pensioners	difference	percentage difference	population	pensioners	difference	percentage difference
e_x	31.17	31.42	0.25	0.8	37.26	37.95	0.69	1.9
a_x : 3%	19.09	19.17	0.08	0.4	21.48	21.69	0.21	1.0
a_x : 6%	13.16	13.19	0.03	0.2	14.22	14.29	0.07	0.5

age x = 60

	male				female			
	population	pensioners	difference	percentage difference	population	pensioners	difference	percentage difference
e_x	22.55	22.83	0.28	1.2	28.05	28.71	0.65	2.3
a_x : 3%	15.25	15.38	0.13	0.8	17.97	18.22	0.25	1.4
a_x : 6%	11.26	11.33	0.06	0.5	12.73	12.84	0.11	0.9
$a_x + .6a_{x\|y}$: 3%	18.28	18.46	0.18	1.0				

age x = 65

	male				female			
	population	pensioners	difference	percentage difference	population	pensioners	difference	percentage difference
e_x	18.58	18.83	0.25	1.4	23.58	24.21	0.63	2.7
a_x : 3%	13.16	13.28	0.12	0.9	15.91	16.18	0.27	1.7
a_x : 6%	10.08	10.14	0.06	0.6	11.70	11.83	0.13	1.1
$a_x + .6a_{x\|y}$: 3%	16.29	16.49	0.20	1.2				

age x = 70

	male				female			
	population	pensioners	difference	percentage difference	population	pensioners	difference	percentage difference
e_x	14.82	15.14	0.32	2.2	19.24	19.87	0.63	3.3
a_x : 3%	10.95	11.14	0.19	1.7	13.64	13.95	0.31	2.3
a_x : 6%	8.71	8.83	0.12	1.4	10.44	10.60	0.16	1.6

Table 2.11.2
Japan: One year probabilities of death (initial rates of mortality, q_x rates)

age	male			female		
	population	pensioners	ratio	population	pensioners	ratio
50	0.003280	0.003490	1.06	0.001760	0.001680	0.95
55	0.005380	0.005480	1.02	0.002550	0.002340	0.92
60	0.009030	0.007910	0.88	0.003690	0.003210	0.87
65	0.012680	0.012810	1.01	0.005300	0.004960	0.94
70	0.019600	0.019880	1.01	0.008370	0.007920	0.95
75	0.033360	0.031020	0.93	0.014770	0.013500	0.91
80	0.057890	0.053930	0.93	0.027380	0.026710	0.98
85	0.095680	0.095400	1.00	0.054650	0.052560	0.96
90	0.154090	0.149590	0.97	0.100790	0.093860	0.93
95	0.231730	0.205940	0.89	0.174100	0.144370	0.83

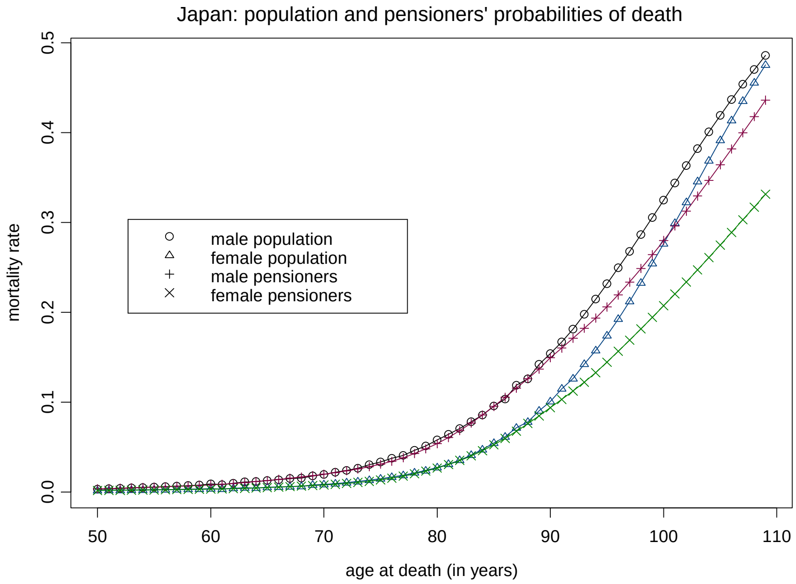


Figure 2.11.1

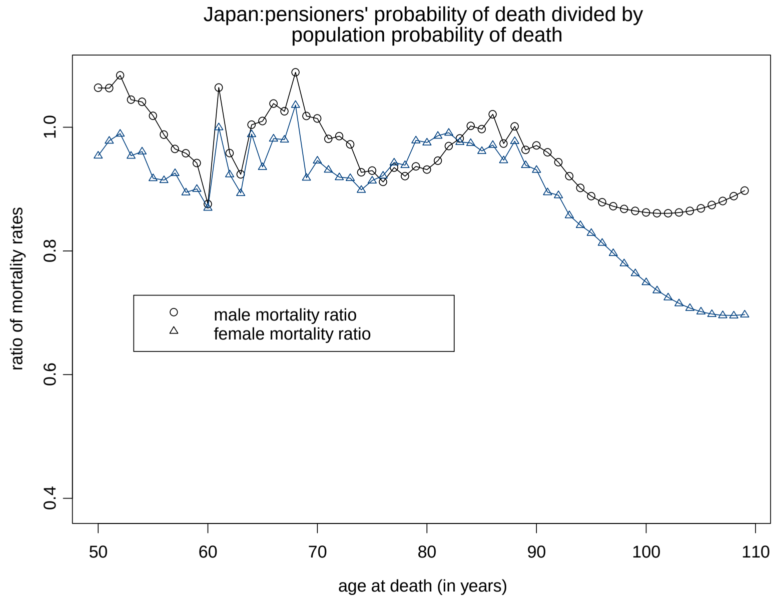


Figure 2.11.2

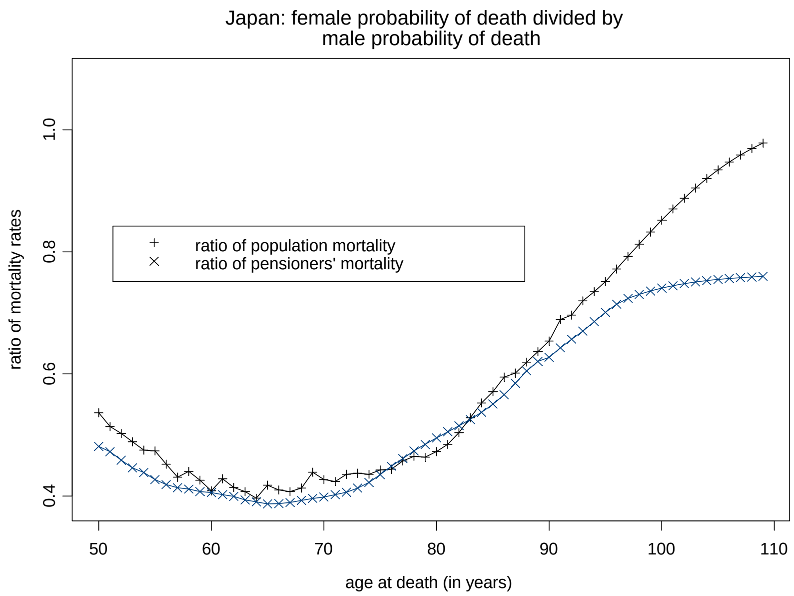


Figure 2.11.3

Table 2.11.3
Japan: Expected complete future lifetime

age	Male				female			
	population	pensioners	difference	percentage difference	population	pensioners	difference	percentage difference
50	31.17	31.42	0.25	0.8	37.26	37.95	0.69	1.9
55	26.75	27.04	0.29	1.1	32.61	33.30	0.68	2.1
60	22.55	22.83	0.28	1.2	28.05	28.71	0.65	2.3
65	18.58	18.83	0.25	1.4	23.58	24.21	0.63	2.7
70	14.82	15.14	0.32	2.2	19.24	19.87	0.63	3.3
75	11.42	11.74	0.32	2.8	15.15	15.73	0.59	3.9
80	8.52	8.74	0.21	2.5	11.41	11.97	0.57	5.0
85	6.19	6.38	0.19	3.1	8.18	8.83	0.64	7.8
90	4.42	4.73	0.32	7.1	5.68	6.46	0.79	13.8
95	3.16	3.58	0.43	13.5	3.86	4.76	0.90	23.2

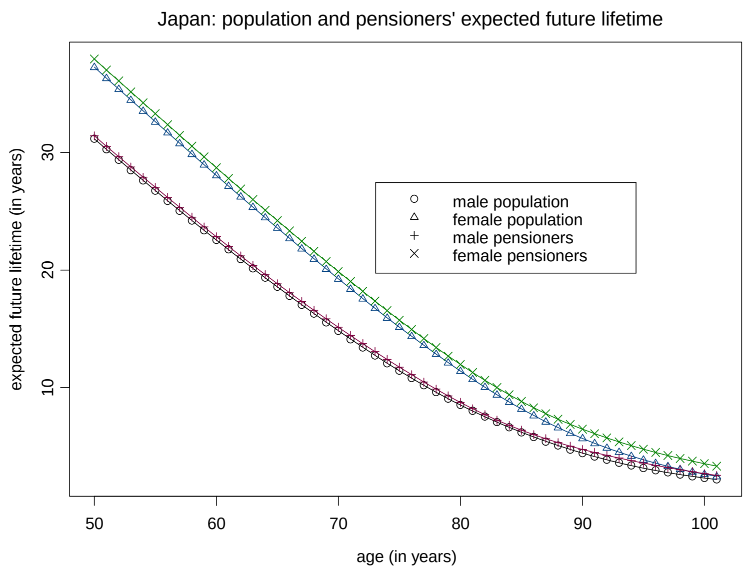


Figure 2.11.4

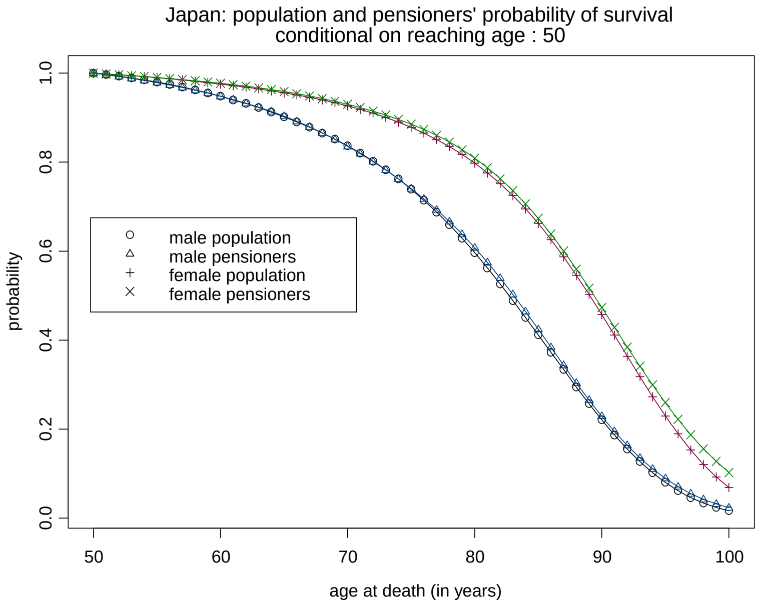


Figure 2.11.5

Japan: Distribution of age at death given survival to age 50

Summary Statistics

	male			female		
	population	pensioners	difference	population	pensioners	difference
Lower quartile age	74.53	74.57	0.04	82.06	82.48	0.42
Median age	82.70	83.08	0.38	89.07	89.39	0.32
Upper quartile age	89.20	89.43	0.22	94.53	95.26	0.73
Inter quartile range	14.68	14.86	0.18	12.47	12.78	0.31
e_{50}	31.17	31.42	0.25	37.26	37.95	0.69

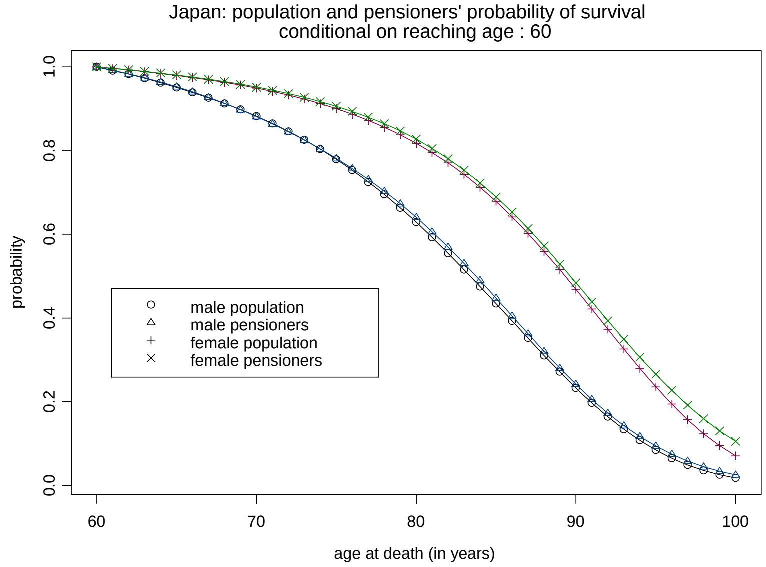


Figure 2.11.6

Japan: Distribution of age at death given survival to age 60

Summary Statistics

	male			female		
	population	pensioners	difference	population	pensioners	difference
Lower quartile age	76.12	76.27	0.16	82.75	83.11	0.36
Median age	83.39	83.75	0.36	89.33	89.65	0.31
Upper quartile age	89.56	89.79	0.23	94.67	95.41	0.74
Inter quartile range	13.44	13.51	0.07	11.93	12.31	0.38
e_{60}	22.55	22.83	0.28	28.05	28.71	0.65

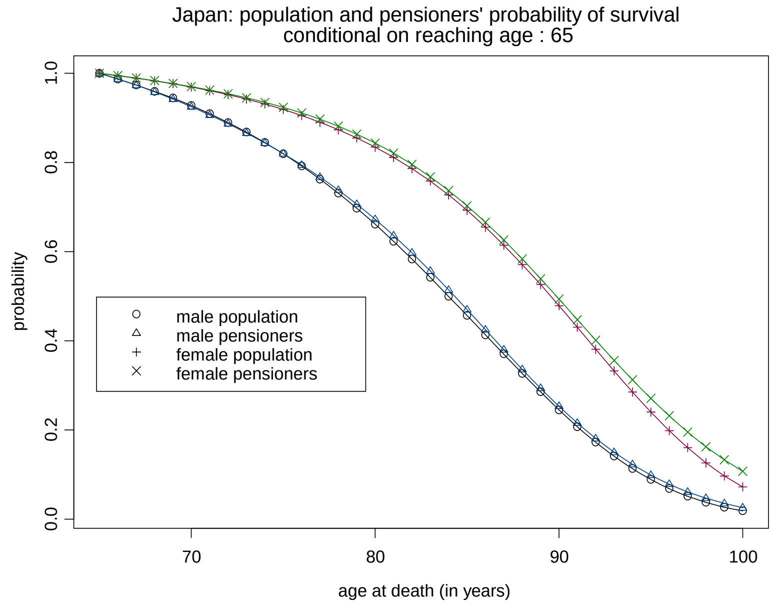


Figure 2.11.7

Japan: Distribution of age at death given survival to age 65

Summary Statistics

	male			female		
	population	pensioners	difference	population	pensioners	difference
Lower quartile age	77.40	77.59	0.20	83.27	83.57	0.30
Median age	83.99	84.32	0.33	89.55	89.86	0.31
Upper quartile age	89.88	90.10	0.22	94.79	95.54	0.75
Inter quartile range	12.48	12.51	0.03	11.52	11.96	0.45
e_{65}	18.58	18.83	0.25	23.58	24.21	0.63

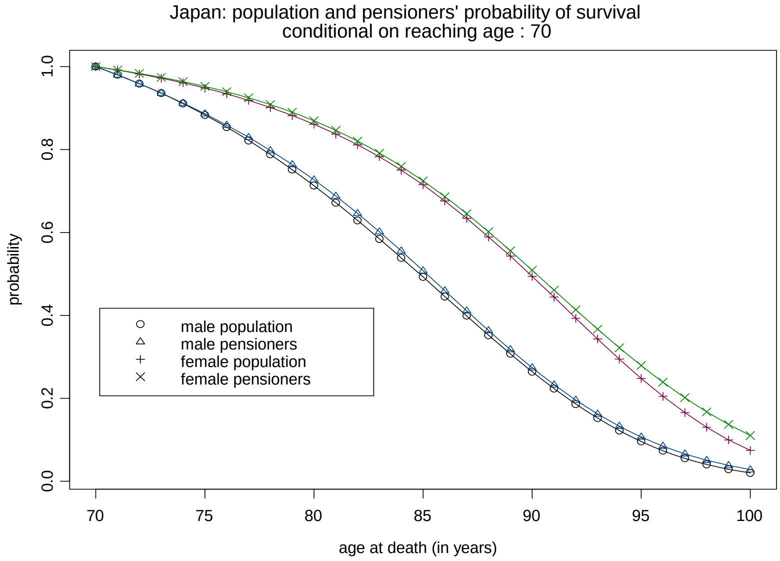


Figure 2.11.8

Japan: Distribution of age at death given survival to age 70

Summary Statistics

	male			female		
	population	pensioners	difference	population	pensioners	difference
Lower quartile age	79.04	79.38	0.33	84.01	84.27	0.26
Median age	84.84	85.17	0.33	89.87	90.18	0.31
Upper quartile age	90.34	90.59	0.25	94.96	95.73	0.77
Inter quartile range	11.30	11.22	-0.08	10.95	11.46	0.51
e_{70}	14.82	15.14	0.32	19.24	19.87	0.63

2.12 Netherlands

The mortality assumed in the previous study for the population and for pensioners is compared with the most recent population mortality experience available from the Human Mortality Database for The Netherlands. An update of the mortality experience most commonly assumed for pensions in The Netherlands has not been made available.

2.12.1 Netherlands: population mortality

The Netherlands population mortality experience in 2006 available on the Human Mortality Database has been used in this study, without any adjustments. In the previous study, the most recent population mortality experience available from the Human Mortality Database was for 2003.

2.12.2 Netherlands: mortality assumptions used to assess retirement liabilities within pension funding valuations

The mortality tables currently most commonly used for pension fund liability calculations in The Netherlands are the GEN2006 Generation Mortality Table 2005-2050. However, these tables have not been made available. Hence in this study, the most recent population mortality experience is compared with the mortality tables assumed for pension benefits in the previous study, the GB1995-2000AG. The description that follows in this section and in Section 2.12.3 is therefore reproduced from the previous report.

The GB1995-2000AG mortality tables are based on the 1995-2000 national population mortality experience. The data were graduated using 'The Van Broekhoven algorithm', essentially a two-stage algorithm consisting of transforming the raw data in the first instance and then fitting a second-degree polynomial to the 11 observations surrounding the point of interest using the method of least squares.

Firstly, the observed probabilities of death at age x in calendar year t ($q(x,t)$) were transformed to:

$$f(x,t) = \log\left[-\log\left\{1 - q(x,t)\right\}\right].$$

Defining X and Y as:

$$X = \begin{bmatrix} 1 & x-5 & (x-5)^2 \\ \vdots & \vdots & \vdots \\ 1 & x+5 & (x+5)^2 \end{bmatrix}, \quad Y = \begin{bmatrix} f(x-5,t) \\ \vdots \\ f(x+5,t) \end{bmatrix};$$

the fitted values are then given by:

$$\hat{f}(x,t) = \left[1, x, x^2\right](X'X)^{-1} X'Y \ ;$$

$$q(x,t) = 1 - \exp\left[-\left(e^{\hat{f}(x,t)}\right)\right]$$

2.12.3 Netherlands: projected mortality

The GB1995-2000AG mortality tables were constructed with both age and time as explanatory variables. In addition, an age rating of -2 years for males and -1 for females was applied to the GB1995-2000AG tables for the purposes of valuing pension-related benefits.

2.12.4 Netherlands: results

A summary of the results obtained from a comparative analysis of the population mortality experience in The Netherlands in 2006 and the GB1995-2000AG mortality tables is given in Table 2.12.1. From the table it is noted that the present value of annuity rates derived on the basis of the GB1995-2000AG mortality tables assumed for pension liability calculations are marginally lower than annuity rates derived on the basis of the current population mortality. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is -0.21% for males and -1% for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of a male member's pension is included, the percentage difference between male annuity rates at age 65 is -0.13% assuming a discount rate of 3%.

Figure 2.12.1 and Table 2.12.2 show comparisons of the observed probabilities of death (q_x rates) based on the most recent (2006) population experience and the GB1995-2000AG mortality tables assumed for pension benefits. It is observed that

that the GB1995-2000AG tables generally exhibit heavier mortality than the observed population mortality between ages 55 and 85 for males and between ages 60 and 80 for females. For example, the probability from the GB1995-2000AG mortality tables that a 65-year male will die before his 66th birthday is 13% higher than the probability derived from the male population experience in The Netherlands. The corresponding probability for a 65-year old female is 10% higher than that from the female population mortality experience. The same trends are depicted in Figure 2.12.2 which shows the ratios of probabilities of death from the GB1995-2000AG mortality tables to probabilities of death derived from the male and female population mortality experiences respectively.

Figure 2.12.3 shows age-related ratios of female probabilities of death to male probabilities of death based on the pension-related tables and the population mortality experience. Similar trends are exhibited from both experiences in that the differences between male and female mortality rates are generally increasing with age up to about age 75 and thereafter decrease as age increases.

Table 2.12.3 and Figure 2.12.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the GB1995-2000AG mortality tables with corresponding expected future lifetime values for the population. Life expectancy derived from the population mortality experience is higher for ages under 75 years for both males and females. Expressed as a percentage of the expected future lifetime value derived from the population mortality experience, the proportional differences at age 65 are -1.7% for males and -0.9% for females (Tables 2.12.1 and 2.12.3). The life expectancy at age 65 is about a quarter of a year longer (3 months) for males and just over two months longer for females on the basis of the population mortality experience.

Figures 2.12.5, 2.12.6, 2.12.7 and 2.12.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \le k \le 100-x$. Considering age 65 (Figure 2.12.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to about age 81.5 years on the basis of the GB1995-2000AG mortality tables and to about age 81.7 years on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to age 87.4 years on the basis of the GB1995-2000AG mortality tables and to about age 87.5 years on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to about age 84.9 years on the basis of the GB1995-2000AG mortality tables and to about age 85.1 years on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to about age 91.1 years on the basis of both the GB1995-2000AG mortality tables and the female population mortality experience.

These results indicate that using the GB1995-2000AG mortality tables for pension liability calculations in The Netherlands would result in losses. However, as has been stated above, the tables currently in use for pension-related benefits are the GEN2006 Generation Mortality Tables.

Table 2.12.1
Netherlands: Summary Statistics

age x = 50

	male				female			
	population	GB95-00M	difference	percentage difference	population	GB95-00F	difference	percentage difference
e_x	29.45	29.13	-0.32	-1.1	33.31	33.12	-0.19	-0.6
a_x : 3%	18.47	18.32	-0.16	-0.8	20.03	19.95	-0.08	-0.4
a_x : 6%	12.92	12.84	-0.08	-0.6	13.62	13.58	-0.04	-0.3

age x = 60

	male				female			
	population	GB95-00M	difference	percentage difference	population	GB95-00F	difference	percentage difference
e_x	20.71	20.41	-0.31	-1.5	24.39	24.18	-0.21	-0.9
a_x : 3%	14.35	14.15	-0.20	-1.4	16.27	16.14	-0.13	-0.8
a_x : 6%	10.79	10.66	-0.13	-1.2	11.87	11.78	-0.08	-0.7
$a_x + .6a_{x\|y}$: 3%	17.10	16.98	-0.13	-0.7				

age x = 65

	male				female			
	population	GB95-00M	difference	percentage difference	population	GB95-00F	difference	percentage difference
e_x	16.73	16.45	-0.28	-1.7	20.13	19.94	-0.19	-0.9
a_x : 3%	12.13	11.92	-0.21	-1.7	14.12	13.98	-0.14	-1.0
a_x : 6%	9.47	9.32	-0.16	-1.7	10.70	10.60	-0.10	-0.9
$a_x + .6a_{x\|y}$: 3%	14.97	14.84	-0.13	-0.9				

age x = 70

	male				female			
	population	GB95-00M	difference	percentage difference	population	GB95-00F	difference	percentage difference
e_x	13.04	12.92	-0.12	-0.9	16.04	15.96	-0.09	-0.5
a_x : 3%	9.84	9.73	-0.11	-1.1	11.79	11.71	-0.08	-0.6
a_x : 6%	7.98	7.89	-0.10	-1.2	9.30	9.23	-0.06	-0.7

Table 2.12.2
Netherlands: One year probabilities of death (initial rates of mortality, q_x rates)

	male			female		
age	population	GB95-00M	ratio	population	GB95-00F	ratio
50	0.003280	0.003222	0.98	0.002580	0.002555	0.99
55	0.005160	0.005349	1.04	0.003830	0.003789	0.99
60	0.008370	0.008961	1.07	0.005510	0.005781	1.05
65	0.014080	0.015931	1.13	0.008370	0.009180	1.10
70	0.025700	0.027263	1.06	0.012990	0.015190	1.17
75	0.041340	0.045606	1.10	0.024210	0.025339	1.05
80	0.075760	0.075263	0.99	0.045050	0.045793	1.02
85	0.121560	0.121288	1.00	0.087060	0.085411	0.98
90	0.195120	0.187607	0.96	0.158850	0.152662	0.96
95	0.300070	0.269203	0.90	0.257450	0.249031	0.97

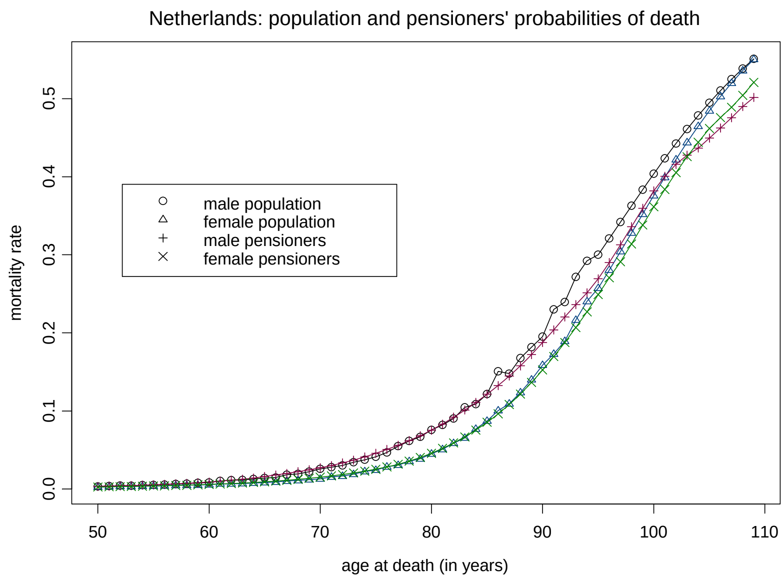
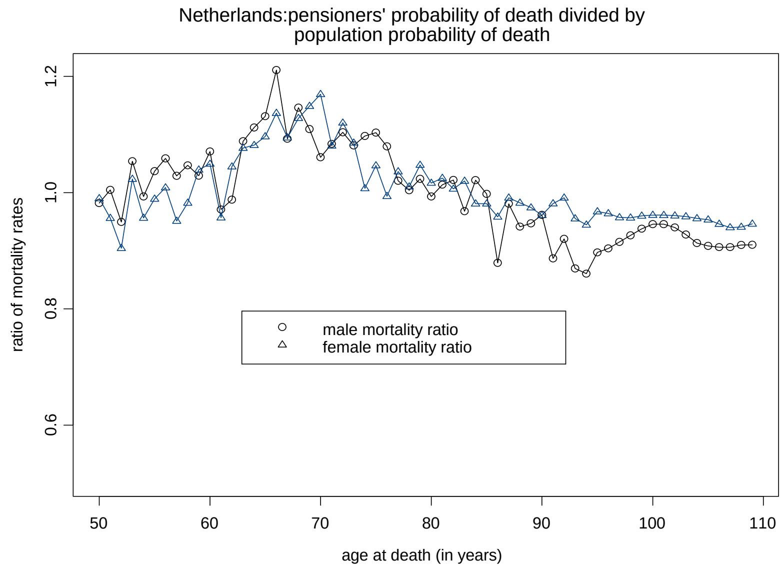


Figure 2.12.1



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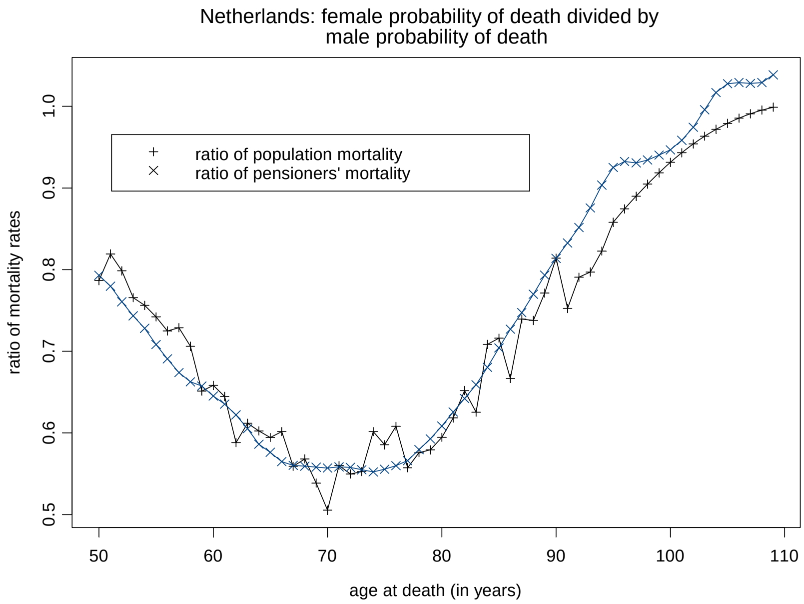


Figure 2.12.3

Table 2.12.3
Netherlands: Expected complete future lifetime

age	male				female			
	population	GB95-00M	difference	percentage difference	population	GB95-00F	difference	percentage difference
50	29.45	29.13	-0.32	-1.1	33.31	33.12	-0.19	-0.6
55	24.99	24.66	-0.33	-1.3	28.79	28.59	-0.21	-0.7
60	20.71	20.41	-0.31	-1.5	24.39	24.18	-0.21	-0.9
65	16.73	16.45	-0.28	-1.7	20.13	19.94	-0.19	-0.9
70	13.04	12.92	-0.12	-0.9	16.04	15.96	-0.09	-0.5
75	9.82	9.85	0.03	0.3	12.26	12.28	0.02	0.1
80	7.13	7.29	0.16	2.3	8.92	8.99	0.07	0.8
85	5.01	5.29	0.28	5.6	6.17	6.29	0.12	2.0
90	3.46	3.78	0.31	9.1	4.15	4.27	0.12	2.9
95	2.48	2.72	0.24	9.8	2.80	2.90	0.11	3.8

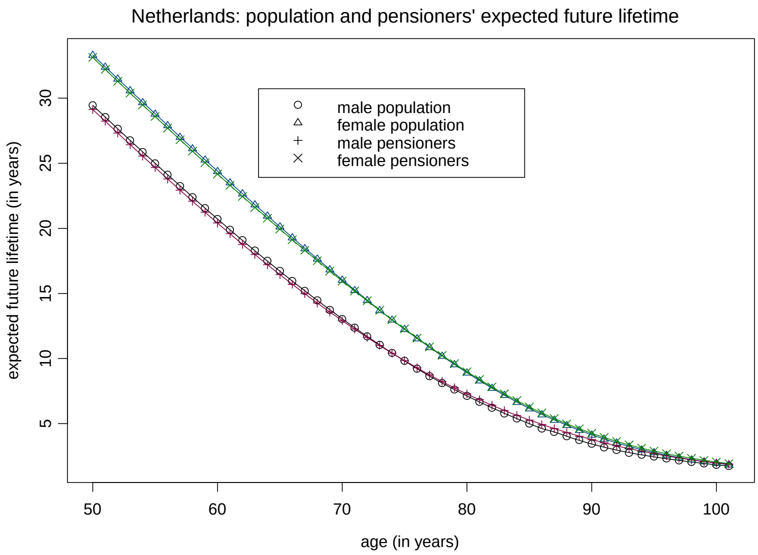


Figure 2.12.4

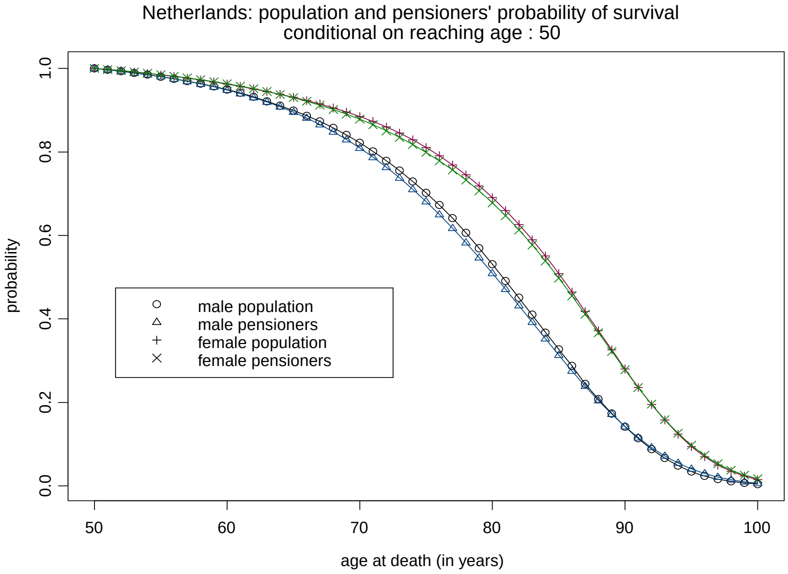


Figure 2.12.5

Netherlands: Distribution of age at death given survival to age 50

Summary Statistics

	male			female		
	population	GB95-00M	difference	population	GB95-00F	difference
Lower quartile age	73.20	72.52	-0.68	77.79	77.28	-0.50
Median age	80.77	80.25	-0.52	85.19	84.95	-0.24
Upper quartile age	86.86	86.70	-0.17	90.68	90.67	-0.01
Inter quartile range	13.67	14.18	0.51	12.89	13.39	0.49
e_{50}	29.45	29.13	-0.32	33.31	33.12	-0.19

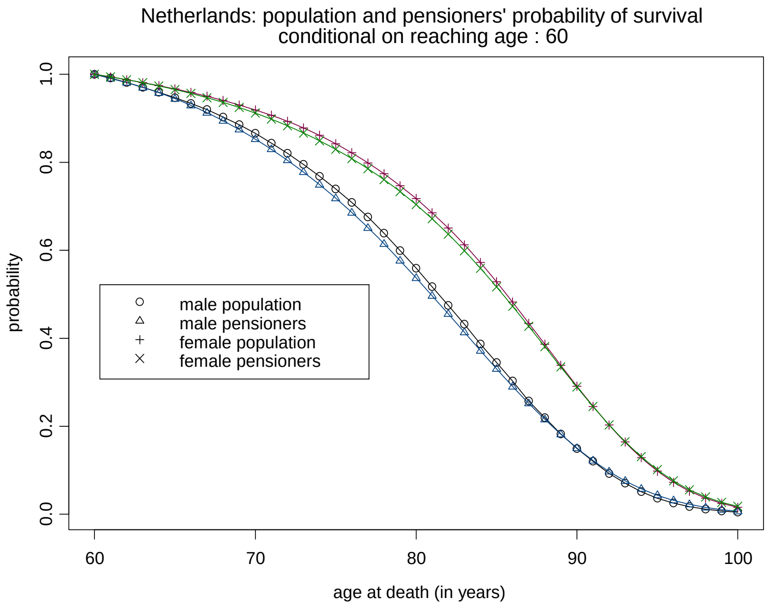


Figure 2.12.6

Netherlands: Distribution of age at death given survival to age 60
Summary Statistics

	male			female		
	population	GB95-00M	difference	population	GB95-00F	difference
Lower quartile age	74.63	73.98	-0.66	78.88	78.40	-0.48
Median age	81.40	80.92	-0.48	85.62	85.38	-0.23
Upper quartile age	87.19	87.05	-0.13	90.89	90.88	-0.01
Inter quartile range	12.56	13.08	0.52	12.02	12.49	0.47
e_{60}	20.71	20.41	-0.31	24.39	24.18	-0.21

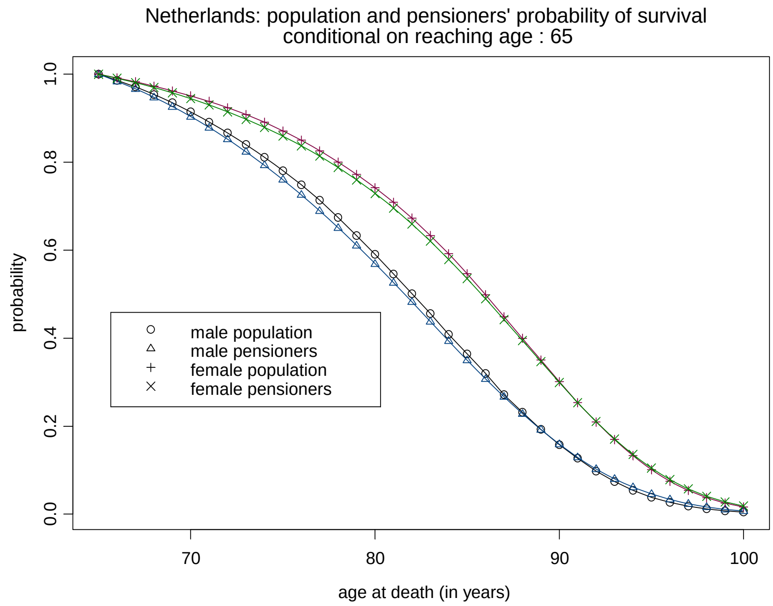


Figure 2.12.7

Netherlands: Distribution of age at death given survival to age 65
Summary Statistics

	male			female		
	population	GB95-00M	difference	population	GB95-00F	difference
Lower quartile age	75.96	75.31	-0.65	79.74	79.32	-0.42
Median age	82.03	81.60	-0.42	85.98	85.77	-0.20
Upper quartile age	87.54	87.44	-0.10	91.08	91.09	0.01
Inter quartile range	11.58	12.12	0.54	11.34	11.77	0.43
e_{65}	16.73	16.45	-0.28	20.13	19.94	-0.19

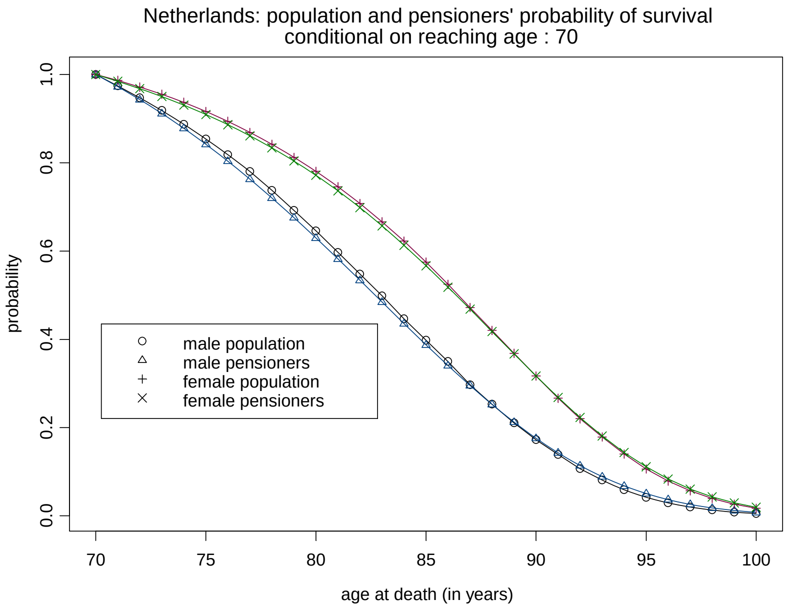


Figure 2.12.8

Netherlands: Distribution of age at death given survival to age 70

Summary Statistics

	male			female		
	population	GB95-00M	difference	population	GB95-00F	difference
Lower quartile age	77.71	77.31	-0.40	80.88	80.62	-0.26
Median age	82.97	82.69	-0.28	86.47	86.37	-0.10
Upper quartile age	88.07	88.06	-0.01	91.36	91.41	0.05
Inter quartile range	10.37	10.76	0.39	10.48	10.79	0.31
e_{70}	13.04	12.92	-0.12	16.04	15.96	-0.09

2.12.5 Netherlands results: comparison with previous study

Figures 2.12.9 and 2.12.10 compare the probabilities of death shown in Figure 2.12.1 with probabilities of death for the population in 2003, the population experience used in the previous study, for males and females separately. The expected future lifetimes are compared in Figures 2.12.11 and 2.12.12. Clearly, there has been an improvement in the population mortality between 2003 and 2006 at all ages for both males and females. From the annualised percentage changes in expected future lifetime shown in Tables 2.12.4 and 2.12.5, it is apparent that:

- the rate of improvement in mortality is generally higher for males; and
- the rate of improvement increases with age.

We reiterate that the GB1995-2000AG mortality tables have been assumed for pension benefits for comparative purposes only. The mortality tables currently in use for pension-related benefits in The Netherlands have not been made available.

Table 2.12.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the 2006 male population in The Netherlands would be expected to live to about age 87.5 years, the same proportion of 65-year old males from the 2003 male population in The Netherlands would be expected to live to age 86.9 years approximately, the actual difference being about seven months. For females, the difference from a similar comparison is greater: 25% of the 2006 female population in The Netherlands alive at age 65 is expected to live to about age 91 years while the same proportion from the 2003 female population in The Netherlands is expected to live age 89, the actual difference being more than two years.

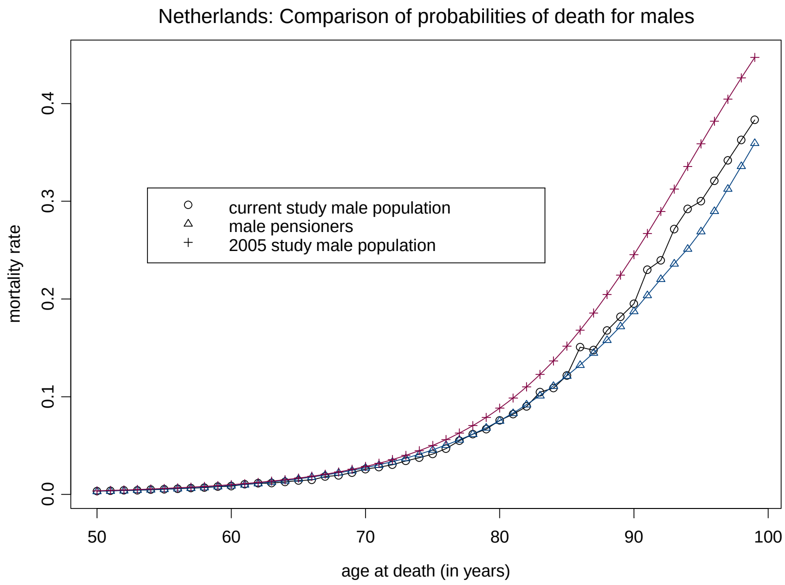


Figure 2.12.9

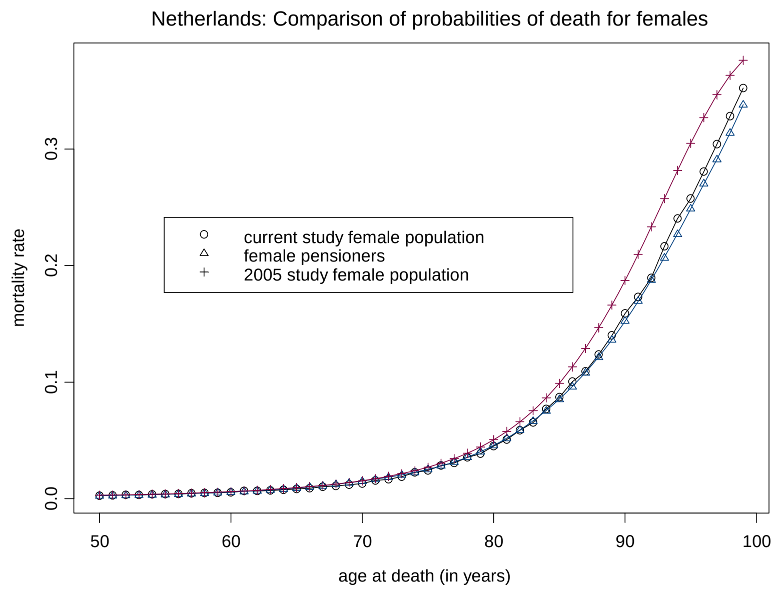


Figure 2.12.10

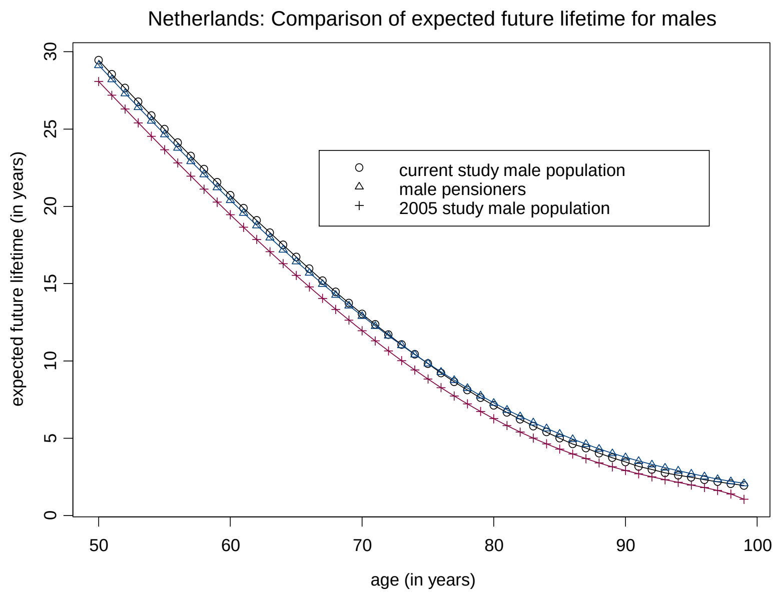


Figure 2.12.11

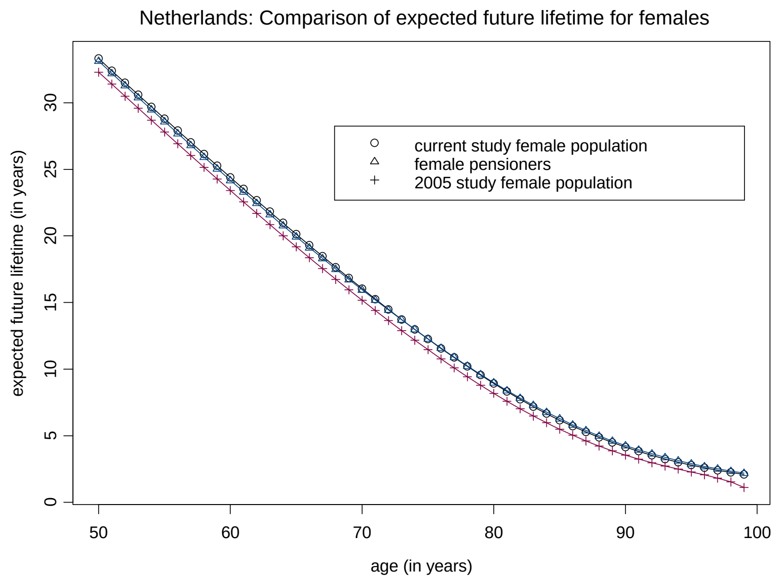


Figure 2.12.12

Table 2.12.4
Netherlands: Comparison of expected complete future lifetime for males

	GB95-00M tables	Male population			
		2006 population	2002 population	difference	Annualised percentage difference
50	29.13	29.45	28.08	1.37	1.6%
55	24.66	24.99	23.66	1.33	1.9%
60	20.41	20.71	19.46	1.26	2.2%
65	16.45	16.73	15.53	1.20	2.6%
70	12.92	13.04	11.96	1.08	3.0%
75	9.85	9.82	8.84	0.98	3.7%
80	7.29	7.13	6.26	0.87	4.6%
85	5.29	5.01	4.30	0.71	5.5%
90	3.78	3.46	2.92	0.55	6.2%
95	2.72	2.48	1.98	0.49	8.3%

Table 2.12.5
Netherlands: Comparison of expected complete future lifetime for females

	GB95-00F tables	Female population			
		2006 population	2003 population	difference	Annualised percentage difference
50	33.12	33.31	32.29	1.02	1.0%
55	28.59	28.79	27.80	1.00	1.2%
60	24.18	24.39	23.41	0.98	1.4%
65	19.94	20.13	19.18	0.95	1.7%
70	15.96	16.04	15.17	0.87	1.9%
75	12.28	12.26	11.46	0.80	2.3%
80	8.99	8.92	8.18	0.74	3.0%
85	6.29	6.17	5.49	0.68	4.1%
90	4.27	4.15	3.54	0.60	5.7%
95	2.90	2.80	2.28	0.51	7.5%

Table 2.12.6
Netherlands: Distribution of age at death given survival to age 65
Summary Statistics

	Male			female		
	2006 population	2003 population	difference	2006 population	2003 population	difference
Lower Quartile age	75.96	74.03	1.92	79.74	78.06	1.68
Median age	82.03	80.18	1.85	85.98	85.91	0.07
Upper Quartile age	87.54	86.92	0.61	91.08	89.00	2.07
Inter quartile range	11.58	12.89	-1.31	11.34	10.95	0.39
e_{65}	16.73	15.53	1.20	20.13	19.18	0.95

2.13 Norway

The mortality assumed in the previous study for the population and for pensioners is compared with the most recent population mortality experience available from the Human Mortality Database for Norway. An update of the mortality experience most commonly assumed for pensions in Norway has not been made available.

2.13.1 Norway: population mortality

The population mortality experience in Norway in 2007 available on the Human Mortality Database has been used in this study, without any adjustments. In the previous study, the 2002 population mortality experience in Norway available from the Human Mortality Database was used for comparison with the assumed pension-related mortality tables.

2.13.2 Norway: mortality assumptions used to assess retirement liabilities within pension funding valuations

The mortality tables currently most commonly used for pension fund liability calculations in Norway have not been made available. In this study, the most recent population mortality experience is compared with the mortality tables assumed for pension benefits in the previous study, the K-63 mortality tables. However, the response from Norway for the previous study indicated that plans were underway to implement new mortality assumptions based on data collected to 2001 but the methods were yet to be established.

The description that follows in this section and in Section 2.13.3 is therefore re-produced from the previous study.

For the K-63 mortality tables, the rates are derived using the Gompertz-Makeham class of formulae. In particular, the formulae used are:

Males:

$$1000\mu_x = 0.9 + 0.044 * 10^{0.042x} \quad \text{for } x < 65$$

$$1000\mu_x = 0.027 * 10^{0.042x} \quad \text{for } x \geq 65$$

Females:

$$1000\mu_x = 0.027 * 10^{0.042(x-5)}$$

A widow or widower's pension of between 50% and 60% of the spouse's pension is normally payable. Probability distributions are assumed for the age difference and being married at date of death. In this study, we assume that a male pensioner is married, the widow receives a pension benefit of 60% of the spouse's pension and that the widow is three years younger than her spouse.

2.13.3 Norway: projected mortality

The K-63 mortality tables assumed for occupational pension schemes do not incorporate projections of future improvements in mortality.

2.13.4 Norway: results

A summary of the results obtained from a comparative analysis of the population mortality experience in Norway in 2007 and the K-63 mortality tables is given in Table 2.13.1. From the table it is noted that the present value of annuity rates derived on the basis of the K-63 mortality tables assumed for pension liability calculations are lower than annuity rates derived on the basis of the current population mortality for females at all ages shown and for males at ages 50 and 60. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 0.4% for males and -3.9% for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of a male member's pension is included, the annuity rate at age 65, based on the K-63 mortality tables is marginally lower than that derived from the Norwegian male population mortality experience.

Figure 2.13.1 and Table 2.13.2 show comparisons of the observed probabilities of death (q_x rates) based on the most recent (2007) population mortality experience and the K-63 mortality tables assumed for pension benefits. It is observed that the for ages below 85 years, the K-63 tables generally exhibit heavier mortality than the observed population mortality for both males and females. For example, the probability from the K-63 mortality tables that a 65-year male will die before his 66th birthday is 8% higher than the probability derived from the male population experience in Norway. The corresponding probability for a 65-year old female is 48% higher than that from the female population mortality experience. The same trends are depicted in Figure 2.13.2 which shows the ratios of probabilities of death from the K-63 mortality tables to probabilities of death derived from the male and female population mortality experiences respectively.

Figure 2.13.3 shows age-related ratios of female probabilities of death to male probabilities of death based on the pension-related tables and the population mortality experience. While the ratio of population mortality rates is increasing with age (i.e. differences decreasing), the ratio of female to male mortality rates is generally constant on the basis of the K-63 mortality tables, with a steep change at age 65.

Table 2.13.3 and Figure 2.13.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the K-63 mortality tables with corresponding expected future lifetime values for the population. Life expectancy derived from the population mortality experience is higher for ages under 65 years for males and ages under 75 years for females. Expressed as a percentage of the expected future lifetime value derived from the population mortality experience, the proportional differences at age 65 are 1.3% for males and -3.6% for females (Tables 2.13.1 and 2.13.3). The life expectancy at age 65 is about three months lower for males and nearly nine months longer for females on the basis of the population mortality experience.

Figures 2.13.5, 2.13.6, 2.13.7 and 2.13.8 and the associated tables show conditional survival probabilities for an individual aged x ($_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering age 65 (Figure 2.13.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to about age 82.6 years on the basis of the K-63 mortality tables and to about age 82.4 years on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to just under age 90 years on the basis of the K-63 mortality tables and to about age 88.8 years on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to about age 84.9 years on the basis of the K-63 mortality tables and to about age 85.6 years on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to about age 91.2 years on the basis of both the K-63 mortality tables and to 91.4 years on the basis of the female population mortality experience.

These results indicate that using the K-63 mortality tables for pension liability calculations in Norway would result in losses. However, as has been stated above, the tables currently in use for pension-related benefits have not been made available.

Table 2.13.1

Norway: Summary Statistics

Comparison of Norwegian population mortality with the K-63 mortality tables

age x = 50

	male				female			
	population	occupational pensions	difference	percentage difference	population	occupational pensions	difference	percentage difference
e_x	30.21	28.29	-1.92	-6.4	33.99	32.77	-1.22	-3.6
a_x : 3%	18.80	17.66	-1.14	-6.1	20.31	19.70	-0.61	-3.0
a_x : 6%	13.08	12.37	-0.71	-5.4	13.75	13.43	-0.32	-2.3

age x = 60

	male				female			
	population	occupational pensions	difference	percentage difference	population	occupational pensions	difference	percentage difference
e_x	21.39	20.73	-0.65	-3.1	24.93	23.96	-0.98	-3.9
a_x : 3%	14.71	14.16	-0.55	-3.7	16.54	15.90	-0.64	-3.8
a_x : 6%	11.00	10.56	-0.43	-4.0	12.01	11.59	-0.41	-3.5
a_x+ .6$a_{x\|y}$: 3%	17.40	17.04	-0.37	-2.1				

age x = 65

	male				female			
	population	occupational pensions	difference	percentage difference	population	occupational pensions	difference	percentage difference
e_x	17.37	17.60	0.23	1.3	20.63	19.89	-0.73	-3.6
a_x : 3%	12.51	12.56	0.05	0.4	14.38	13.83	-0.56	-3.9
a_x : 6%	9.71	9.69	-0.02	-0.2	10.85	10.45	-0.41	-3.8
a_x+ .6$a_{x\|y}$: 3%	15.29	15.24	-0.05	-0.3				

age x = 70

	male				female			
	population	occupational pensions	difference	percentage difference	population	occupational pensions	difference	percentage difference
e_x	13.67	14.06	0.39	2.9	16.51	16.14	-0.37	-2.2
a_x : 3%	10.27	10.44	0.17	1.7	12.07	11.71	-0.36	-3.0
a_x : 6%	8.28	8.35	0.07	0.8	9.48	9.17	-0.31	-3.3

Table 2.13.2

Norway: One year probabilities of death (initial rates of mortality, q_x rates)

	male			female		
age	population	occupational pensions	ratio	population	occupational pensions	ratio
50	0.002790	0.006693	2.40	0.002330	0.002667	1.14
55	0.004320	0.010279	2.38	0.003620	0.004321	1.19
60	0.008250	0.016067	1.95	0.005450	0.006999	1.28
65	0.014020	0.015109	1.08	0.007650	0.011326	1.48
70	0.019500	0.024388	1.25	0.013390	0.018303	1.37
75	0.038250	0.039252	1.03	0.024090	0.029515	1.23
80	0.071780	0.062879	0.88	0.042370	0.047427	1.12
85	0.123350	0.099968	0.81	0.085470	0.075776	0.89
90	0.192650	0.157025	0.82	0.151160	0.119971	0.79
95	0.299910	0.241971	0.81	0.248200	0.187198	0.75

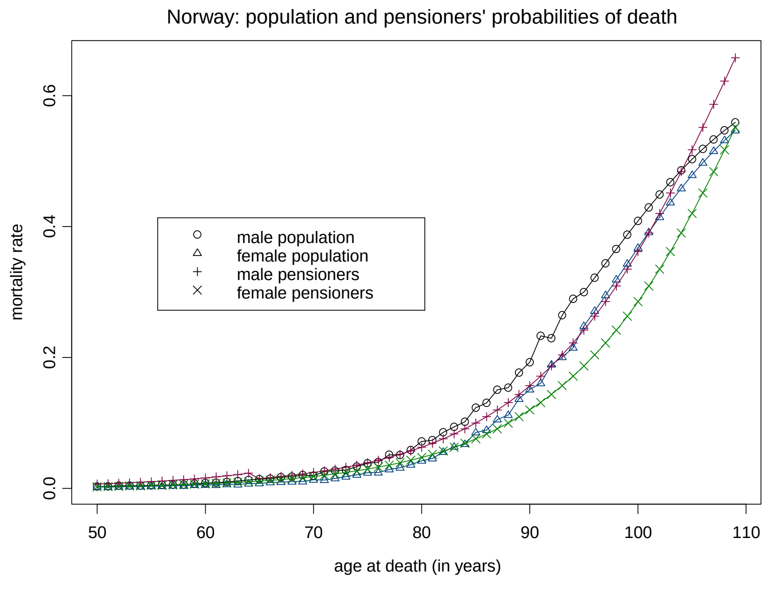


Figure 2.13.1

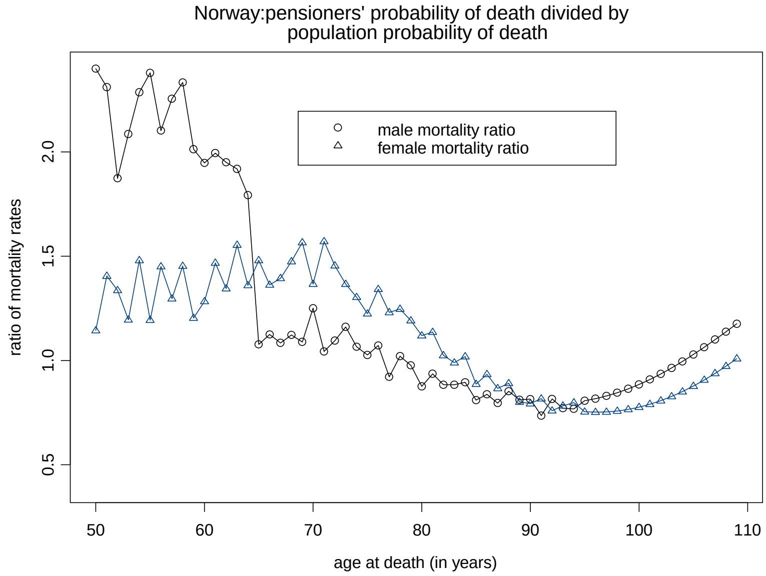


Figure 2.13.2

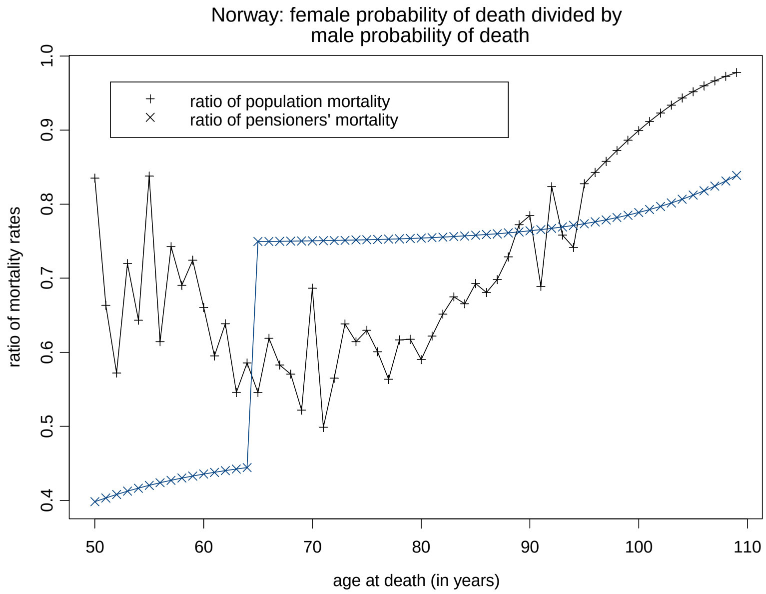


Figure 2.13.3

Table 2.13.3
Norway: Expected complete future lifetime in years

age	male				female			
	population	occupational pensions	difference	percentage difference	population	occupational pensions	difference	percentage difference
50	30.21	28.29	-1.92	-6.4	33.99	32.77	-1.22	-3.6
55	25.73	24.34	-1.39	-5.4	29.39	28.27	-1.12	-3.8
60	21.39	20.73	-0.65	-3.1	24.93	23.96	-0.98	-3.9
65	17.37	17.60	0.23	1.3	20.63	19.89	-0.73	-3.6
70	13.67	14.06	0.39	2.9	16.51	16.14	-0.37	-2.2
75	10.26	10.92	0.66	6.5	12.66	12.75	0.09	0.7
80	7.39	8.24	0.85	11.5	9.25	9.79	0.54	5.9
85	5.13	6.02	0.89	17.4	6.41	7.30	0.88	13.8
90	3.49	4.27	0.78	22.3	4.33	5.27	0.94	21.8
95	2.46	2.95	0.49	19.7	2.88	3.69	0.81	28.2

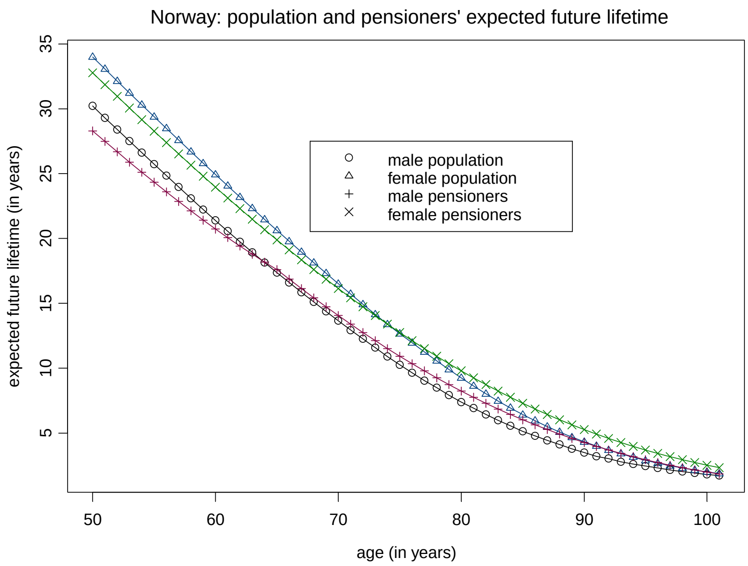


Figure 2.13.4

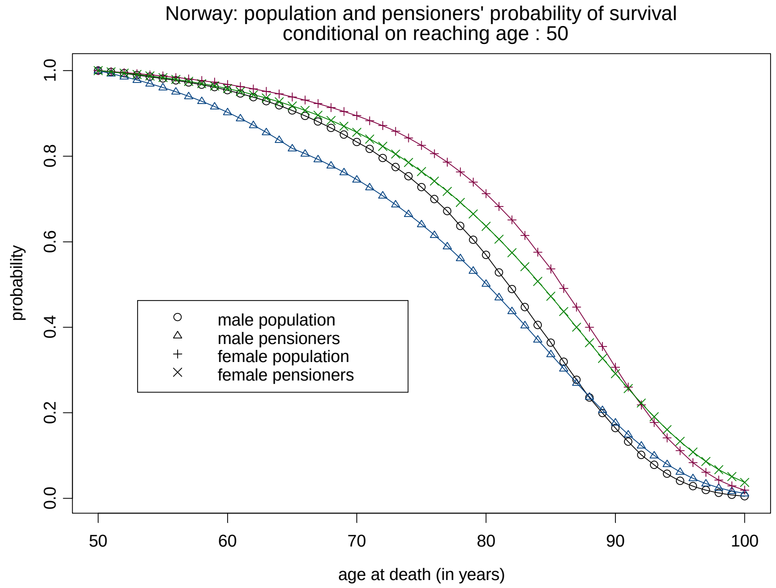


Figure 2.13.5

Norway: Distribution of age at death given survival to age 50

Summary Statistics

	male			female		
	population	occupational pensions	difference	population	occupational pensions	difference
Lower quartile age	74.89	69.27	-5.62	78.44	75.36	-3.08
Median age	81.27	80.95	-0.32	85.20	84.79	-0.41
Upper quartile age	87.34	87.38	0.04	91.75	91.80	0.05
Inter quartile range	12.46	18.11	5.66	13.31	16.44	3.13
e_{50}	30.21	28.29	-1.92	33.99	32.77	-1.22

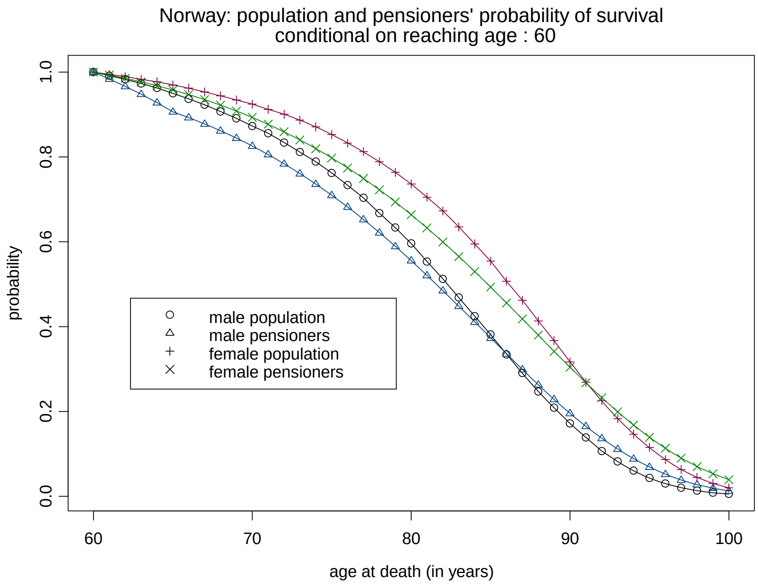


Figure 2.13.6

Norway: Distribution of age at death given survival to age 60

Summary Statistics

	male			female		
	population	occupational pensions	difference	population	occupational pensions	difference
Lower quartile age	75.58	73.56	-2.02	79.49	76.03	-3.46
Median age	82.71	81.43	-1.28	86.84	84.19	-2.65
Upper quartile age	87.07	88.62	1.54	91.56	91.49	-0.07
Inter quartile range	11.50	15.06	3.56	12.07	15.46	3.39
e_{60}	21.39	20.73	-0.65	24.93	23.96	-0.98

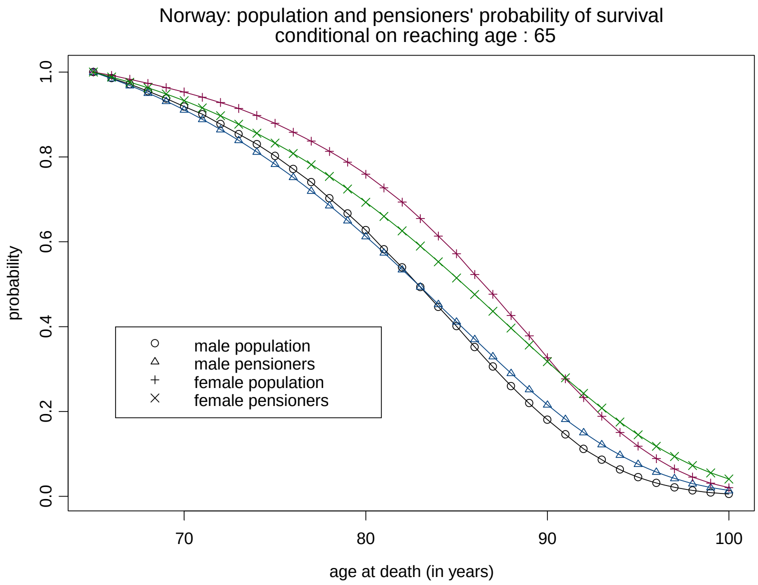


Figure 2.13.7

Norway: Distribution of age at death given survival to age 65

Summary Statistics

	male			female		
	population	occupational pensions	difference	population	occupational pensions	difference
Lower quartile age	76.30	76.93	0.62	80.71	78.86	-1.85
Median age	82.14	82.14	0.00	86.51	85.62	-0.89
Upper quartile age	88.76	89.94	1.18	91.39	91.19	-0.19
Inter quartile range	12.45	13.01	0.56	10.67	12.33	1.66
e_{65}	17.37	17.60	0.23	20.63	19.89	-0.73

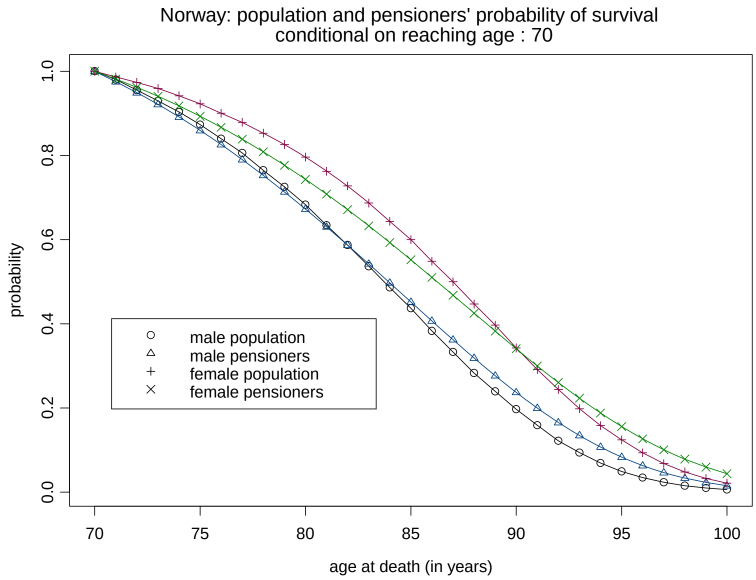


Figure 2.13.8

Norway: Distribution of age at death given survival to age 70

Summary Statistics

	male			female		
	population	occupational pensions	difference	population	occupational pensions	difference
Lower quartile age	78.63	78.93	0.30	81.64	79.20	-2.44
Median age	83.27	83.06	-0.21	86.01	86.76	0.75
Upper quartile age	88.25	89.32	1.08	91.12	92.72	1.60
Inter quartile range	9.62	10.39	0.77	9.49	13.52	4.04
e_{70}	13.67	14.06	0.39	16.51	16.14	-0.37

2.13.5 Norway results: comparison with previous study

Figures 2.13.9 and 2.13.10 compare the probabilities of death shown in Figure 2.13.1 with probabilities of death for the population in 2002, the population experience used in the previous study, for males and females separately. The expected future lifetimes are compared in Figures 2.13.11 and 2.13.12. Clearly, there has been an improvement in the population mortality between 2002 and 2007 at all ages for both males and females. From the annualised percentage changes in expected future lifetime shown in Tables 2.13.4 and 2.13.5, it is apparent that:

- the rate of improvement in mortality is higher for males at each age; and
- the rate of improvement increases with age.

We reiterate that the K-63 mortality tables have been assumed for pension benefits for comparative purposes only. The mortality tables currently in use for pension-related benefits in Norway have not been made available.

Table 2.13.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the 2007 male population in Norway would be expected to live to about age 88.8 years, the same proportion of 65-year old males from the 2002 male population in Norway would be expected to live to age 86.4 years approximately, the actual difference being more than two years. For females, the difference from a similar comparison is lower: 25% of the 2007 female population in Norway alive at age 65 is expected to live to age 91.4 years while the same proportion from the 2002 female population in Norway is expected to live age 90.7 years, the actual difference being less than one year.

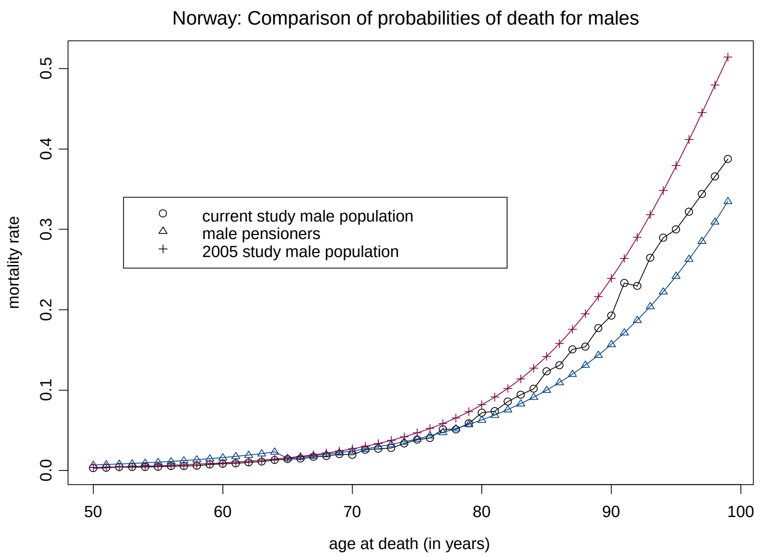


Figure 2.13.9

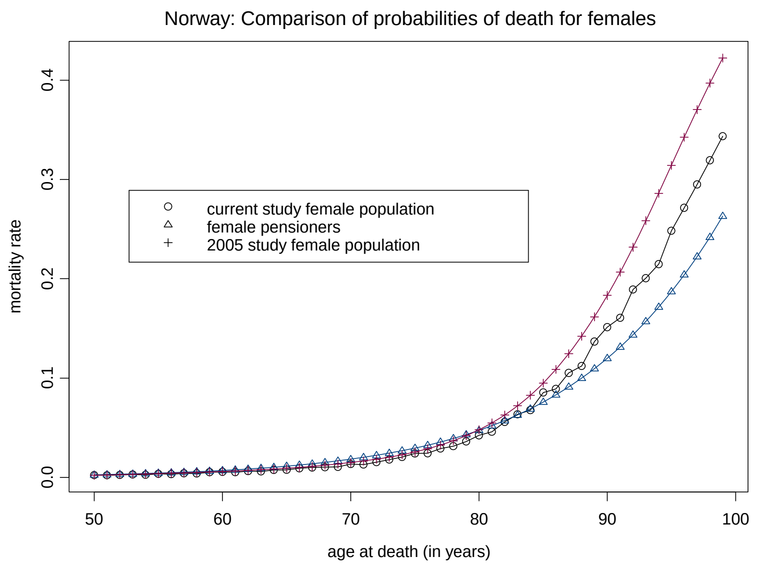


Figure 2.13.10

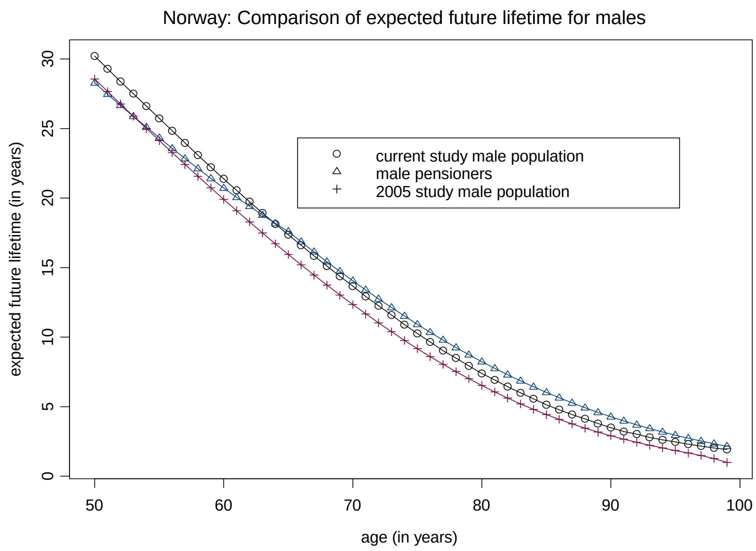


Figure 2.13.11

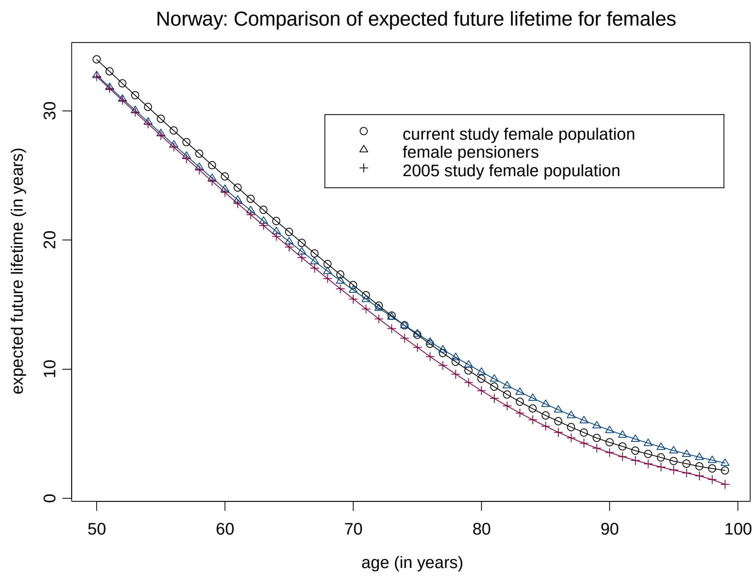


Figure 2.13.12

Table 2.13.4
Norway: Comparison of expected complete future lifetime for males

	K-63 tables	Male population			
		2007 population	2002 population	difference	Annualised percentage difference
50	28.29	30.21	28.57	1.65	1.2%
55	24.34	25.73	24.14	1.59	1.3%
60	20.73	21.39	19.91	1.48	1.5%
65	17.60	17.37	15.95	1.42	1.8%
70	14.06	13.67	12.34	1.32	2.1%
75	10.92	10.26	9.17	1.09	2.4%
80	8.24	7.39	6.52	0.87	2.7%
85	6.02	5.13	4.43	0.70	3.1%
90	4.27	3.49	2.90	0.59	4.1%
95	2.95	2.46	1.84	0.62	6.7%

Table 2.13.5
Norway: Comparison of expected complete future lifetime for females

	K-63 tables	Female population			
		2007 population	2002 population	difference	Annualised percentage difference
50	32.77	33.99	32.68	1.32	0.8%
55	28.27	29.39	28.09	1.30	0.9%
60	23.96	24.93	23.69	1.25	1.1%
65	19.89	20.63	19.46	1.17	1.2%
70	16.14	16.51	15.43	1.07	1.4%
75	12.75	12.66	11.68	0.98	1.7%
80	9.79	9.25	8.34	0.91	2.2%
85	7.30	6.41	5.58	0.84	3.0%
90	5.27	4.33	3.54	0.79	4.4%
95	3.69	2.88	2.19	0.69	6.3%

Table 2.13.6
Norway: Distribution of age at death given survival to age 65
Summary Statistics

	Male			female		
	2007 population	2002 population	difference	2007 population	2002 population	difference
Lower Quartile age	76.30	75.69	0.61	80.71	79.72	0.99
Median age	82.14	81.69	0.46	86.51	85.56	0.94
Upper Quartile age	88.76	86.35	2.40	91.39	90.69	0.70
Inter quartile range	12.45	10.66	1.79	10.67	10.97	-0.30
e_{65}	17.37	15.95	1.42	20.63	19.46	1.17

2.14 Spain

2.14.1 Spain: population mortality

The population mortality experience in Spain in 2007 available on the Human Mortality Database has been used in this study, without any adjustments. In the previous study, the 2002 population mortality experience in Spain available from the Human Mortality Database was used for comparison with the assumed pension-related mortality tables.

2.14.2 Spain: mortality assumptions used to assess retirement liabilities within pension funding valuations

In Spain, mortality tables commonly used for valuing benefits for pension fund retirees are the PERM/F 2000C (for policies existing at 3/10/2000) and PERM/F 2000 P (for policies issued after 3/10/2000). In this study, the PERM/F 2000P mortality tables for the generation born in 1955 have been assumed for comparison with population mortality rates.

2.14.3 Spain: projected mortality

The PERM/F 2000 mortality tables are projected generation tables.

2.14.4 Spain: results

A summary of the results obtained from a comparative analysis of the population mortality experience in Spain in 2007 and the PERM/F mortality tables assumed for retirement related benefits is given in Table 2.14.1. From the table it can be seen that the present value of annuity rates derived on the basis of the mortality tables assumed for pension liability calculations are higher than annuity rates derived on the basis of the current population mortality. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 22.2% for males and 19.5% for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of a male member's pension is included, the percentage difference between male annuity rates at age 65 is 17.6% assuming a discount rate of 3%.

Figure 2.14.1 and Table 2.14.2 show comparisons of the observed probabilities of death (q_x rates) based on the most recent (2007) population experience and the mortality tables assumed for pensions. It can be seen that the PERM 2000P (males) and the PERF 2000P (females) mortality tables exhibit considerably lighter mortality than the observed population mortality at all ages up to age 95. For example, the probability from the PERM 2000P mortality tables that a 65-year old male will die before his 66th birthday is 62% of the probability derived from the male population experience in Spain. The corresponding probability for a 65-year old female is half the probability derived from the female population mortality experience. The same trends are depicted in Figure 2.14.2 which shows the ratios of probabilities of death from the mortality tables assumed for pensions to probabilities of death derived from the male and female population mortality experiences respectively. Above age 95, the ratios rapidly increase to values above 1, indicating heavier mortality at extreme old age on the basis of the PERM 2000P and the PERF 2000P mortality tables.

Figure 2.14.3 shows age-related ratios of female probabilities of death to male probabilities of death based on the pension-related tables and population mortality experience. Similar trends are exhibited from both experiences in that the difference between male and female mortality rates are decreasing as age increases.

Table 2.14.3 and Figure 2.14.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the PERM 2000P and the PERF 2000P mortality tables with corresponding expected future lifetime values for the population. Expressed as a percentage of the expected future lifetime value derived from the population mortality experience, the proportional differences tend to increase with age for both males and females, with the proportional differences at age 65 being 30.9% for males and 27.8% for females (Tables 2.14.1 and 2.14.3). Based on the PERM 2000P and the PERF 2000P mortality tables for pensions, the life expectancy at age 65 is more than 5 years longer for males and six years longer for females compared to the observed male and female population respectively.

Figures 2.14.5, 2.14.6, 2.14.7 and 2.14.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \le k \le 100-x$. Considering age 65 (Figure 2.14.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to at least age 88 on the basis of the PERM 2000P mortality tables and to about age 82.7 years on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to age 96.5 years on the basis of the PERM 2000P mortality tables and to about age 89 years on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to about age 92.7 years on the basis of the PERF 2000P mortality tables and to about age 86.6 years on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to about age 98.8 years on the basis of the PERF 2000P mortality tables and to about age 92.4 years on the basis of the female population experience.

Table 2.14.1

Spain: Summary Statistics

age x = 50

	male				female			
	population	PERM 2000P	difference	percentage difference	population	PERF 2000P	difference	percentage difference
e_x	29.94	35.81	5.87	19.6	35.38	41.75	6.37	18.0
a_x : 3%	18.56	20.67	2.12	11.4	20.89	22.98	2.09	10.0
a_x : 6%	12.90	13.76	0.87	6.7	14.02	14.79	0.77	5.5

age x = 60

	male				female			
	population	PERM 2000P	difference	percentage difference	population	PERF 2000P	difference	percentage difference
e_x	21.58	27.21	5.63	26.1	26.13	32.29	6.16	23.6
a_x : 3%	14.74	17.32	2.59	17.5	17.16	19.79	2.63	15.3
a_x : 6%	10.97	12.27	1.30	11.8	12.37	13.58	1.22	9.9
$a_x + .6a_{x\|y}$: 3%	17.66	20.13	2.47	14.0				

age x = 65

	male				female			
	population	PERM 2000P	difference	percentage difference	population	PERF 2000P	difference	percentage difference
e_x	17.70	23.16	5.46	30.9	21.64	27.65	6.01	27.8
a_x : 3%	12.65	15.46	2.81	22.2	14.97	17.88	2.91	19.5
a_x : 6%	9.77	11.33	1.56	15.9	11.22	12.73	1.52	13.5
$a_x + .6a_{x\|y}$: 3%	15.61	18.36	2.75	17.6				

age x = 70

	male				female			
	population	PERM 2000P	difference	percentage difference	population	PERF 2000P	difference	percentage difference
e_x	14.08	19.35	5.27	37.4	17.31	23.09	5.78	33.4
a_x : 3%	10.49	13.52	3.03	28.9	12.57	15.75	3.18	25.3
a_x : 6%	8.40	10.25	1.85	22.0	9.81	11.66	1.85	18.8

Table 2.14.2

Spain: One year probabilities of death (initial rates of mortality, q_x rates)

age	male			female		
	population	PERM 2000P	ratio	population	PERF 2000P	ratio
50	0.004260	0.003044	0.71	0.001820	0.001077	0.59
55	0.006320	0.004687	0.74	0.002280	0.001524	0.67
60	0.010300	0.006564	0.64	0.003720	0.002106	0.57
65	0.015590	0.009653	0.62	0.005950	0.002964	0.50
70	0.023170	0.013731	0.59	0.009680	0.004480	0.46
75	0.037030	0.021329	0.58	0.018630	0.007734	0.42
80	0.062610	0.031671	0.51	0.037440	0.014023	0.37
85	0.105580	0.045719	0.43	0.075660	0.028716	0.38
90	0.168530	0.066494	0.39	0.139040	0.055666	0.40
95	0.251840	0.127576	0.51	0.228950	0.116012	0.51

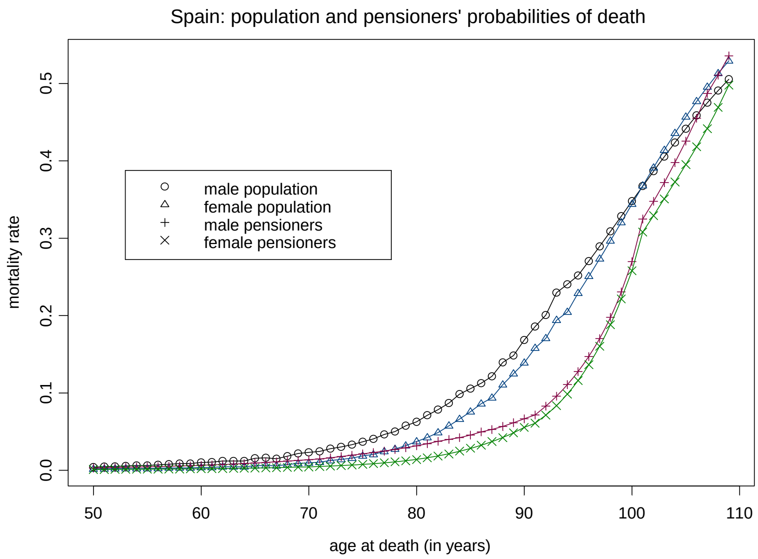


Figure 2.14.1

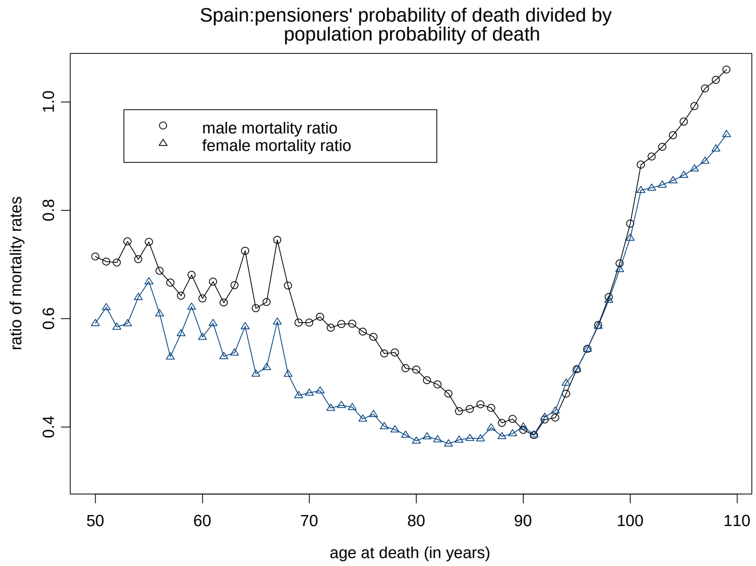


Figure 2.14.2

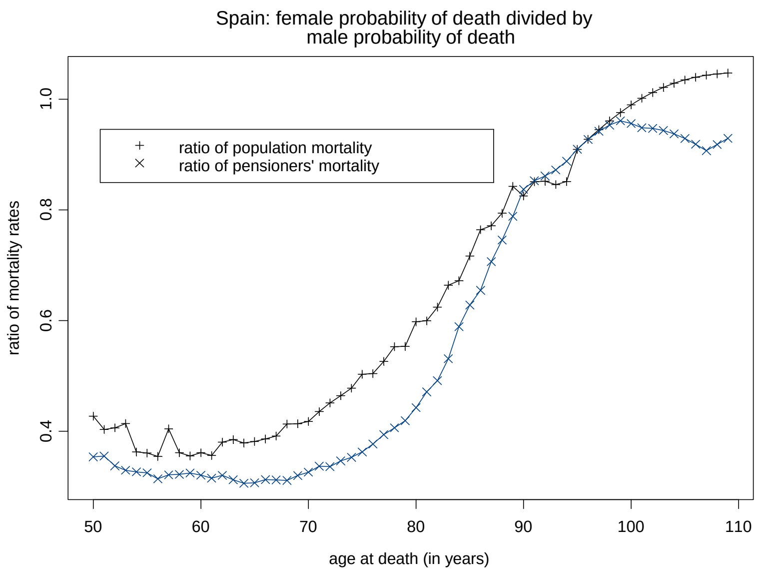


Figure 2.14.3

Table 2.14.3
Spain: Expected complete future lifetime in years

age	male				female			
	population	PERM 2000P	difference	percentage difference	population	PERF 2000P	difference	percentage difference
50	29.94	35.81	5.87	19.6	35.38	41.75	6.37	18.0
55	25.66	31.43	5.77	22.5	30.73	37.00	6.27	20.4
60	21.58	27.21	5.63	26.1	26.13	32.29	6.16	23.6
65	17.70	23.16	5.46	30.9	21.64	27.65	6.01	27.8
70	14.08	19.35	5.27	37.4	17.31	23.09	5.78	33.4
75	10.82	15.80	4.98	46.1	13.26	18.67	5.41	40.8
80	8.01	12.59	4.57	57.1	9.66	14.48	4.82	49.9
85	5.81	9.68	3.87	66.5	6.73	10.67	3.94	58.5
90	4.05	6.93	2.88	71.0	4.56	7.37	2.81	61.7
95	2.93	4.38	1.45	49.5	3.09	4.58	1.49	48.1

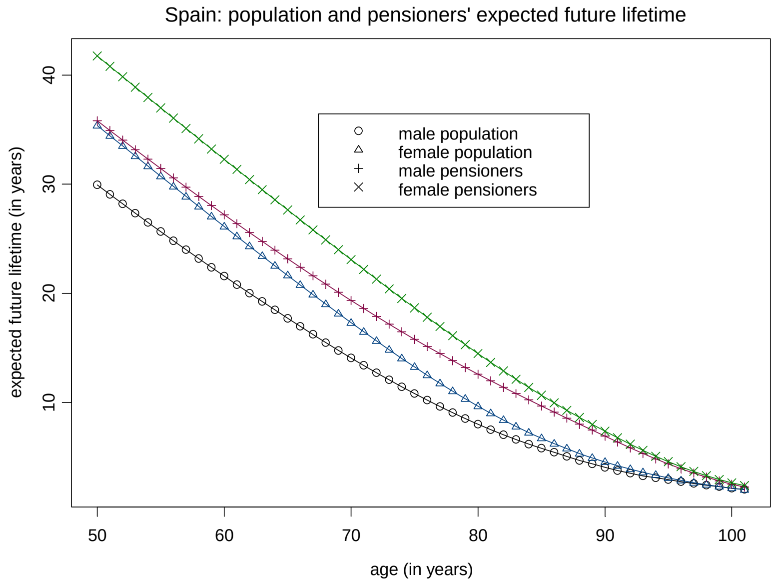


Figure 2.14.4

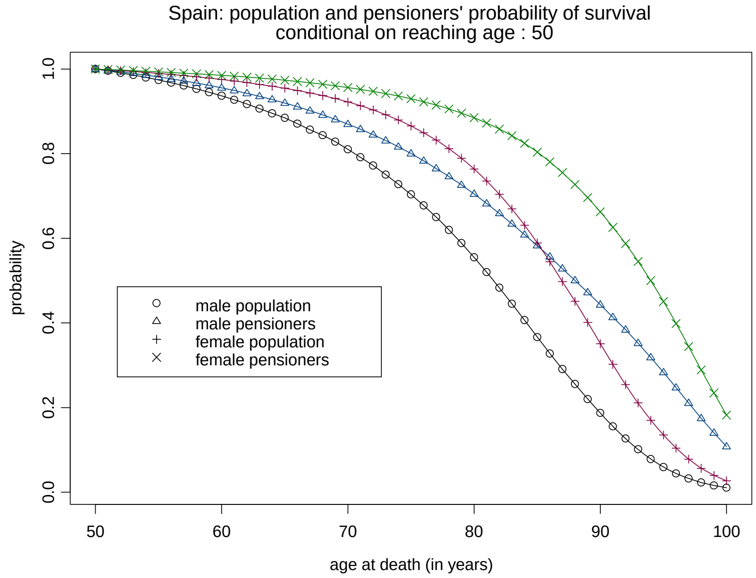


Figure 2.14.5

Spain: Distribution of age at death given survival to age 50
Summary Statistics

	male			female		
	population	PERM 2000P	difference	population	PERF 2000P	difference
Lower quartile age	73.03	77.80	4.77	80.49	87.20	6.70
Median age	81.54	88.03	6.48	86.95	94.00	7.05
Upper quartile age	88.16	95.92	7.76	92.10	98.70	6.60
Inter quartile range	15.13	18.12	2.99	11.61	11.51	-0.10
e_{50}	29.94	35.81	5.87	35.38	41.75	6.37

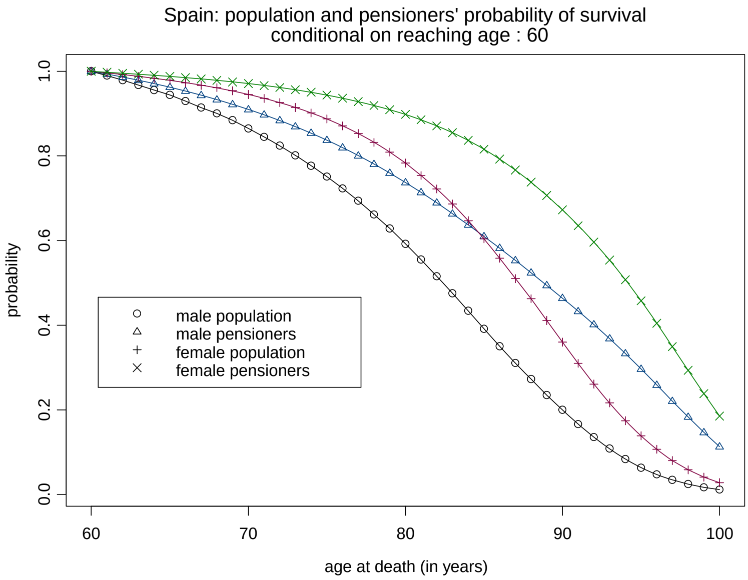


Figure 2.14.6

Spain: Distribution of age at death given survival to age 60

Summary Statistics

	male			female		
	population	PERM 2000P	difference	population	PERF 2000P	difference
Lower quartile age	75.04	79.43	4.39	81.12	87.59	6.46
Median age	82.39	88.80	6.42	87.22	94.15	6.93
Upper quartile age	88.60	96.22	7.62	92.24	98.78	6.54
Inter quartile range	13.56	16.79	3.23	11.12	11.20	0.08
e_{60}	21.58	27.21	5.63	26.13	32.29	6.16

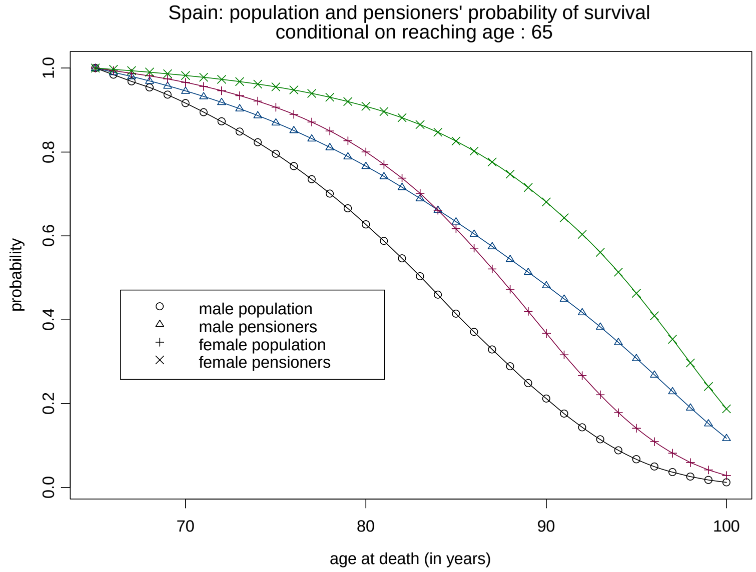


Figure 2.14.7

Spain: Distribution of age at death given survival to age 65

Summary Statistics

	male			female		
	population	PERM 2000P	difference	population	PERF 2000P	difference
Lower quartile age	76.52	80.66	4.15	81.62	87.90	6.28
Median age	83.08	89.42	6.35	87.44	94.27	6.83
Upper quartile age	88.97	96.47	7.50	92.36	98.84	6.47
Inter quartile range	12.45	15.81	3.36	10.75	10.94	0.19
e_{65}	17.70	23.16	5.46	21.64	27.65	6.01

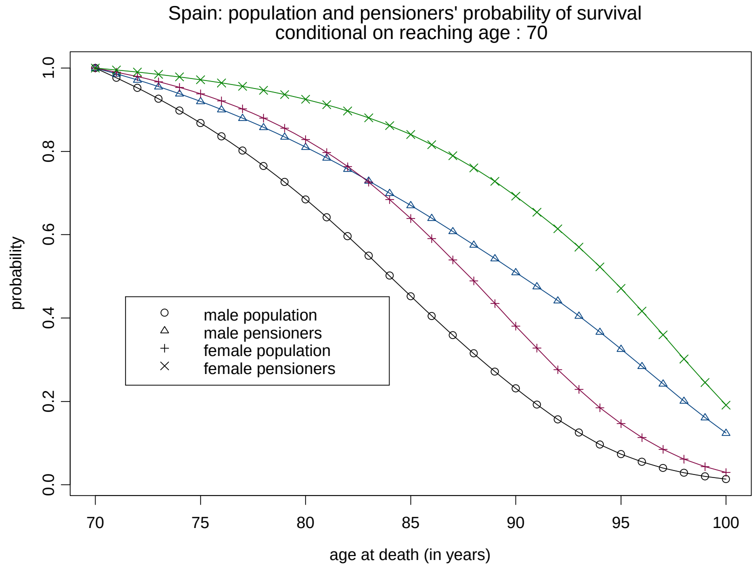


Figure 2.14.8

Spain: Distribution of age at death given survival to age 70

Summary Statistics

	male			female		
	population	PERM 2000P	difference	population	PERF 2000P	difference
Lower quartile age	78.39	82.27	3.88	82.36	88.32	5.96
Median age	84.04	90.29	6.25	87.79	94.44	6.66
Upper quartile age	89.53	96.82	7.28	92.55	98.91	6.36
Inter quartile range	11.14	14.55	3.40	10.19	10.60	0.41
e_{70}	14.08	19.35	5.27	17.31	23.09	5.78

2.14.5 Spain results: comparison with previous study

Figures 2.14.9 and 2.14.10 compare the probabilities of death shown in Figure 2.14.1 with probabilities of death assumed in the previous study, that is, probabilities based on the 2002 population experience in Spain and the PERM/F 2000P mortality tables, for males and females separately. The expected future lifetimes are compared in Figures 2.14.11 and 2.14.12. Clearly, there has been an improvement in the population mortality between the 2002 experience and the 2007 experience at all ages for both males and females. From the annualised percentage changes in expected future lifetime for the population shown in Tables 2.14.4 and 2.14.5, it is apparent that the rate of improvement in population mortality at each age is generally higher for males, apart from extreme old age.

In this study, for pension-related benefits, the projected mortality of the generation born in 1955 is assumed while in the previous study, the projected mortality of the generation born in 1950 was assumed from the PERM 2000P and PERF 2000P mortality tables. The absolute differences at each age between the two sets of mortality tables are relatively small and are essentially the same for males and females.

Table 2.14.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the male population in Spain in 2007 would be expected to live to nearly age 89 years, the same proportion of 65-year old males from the 2002 male population would be expected to live to about age 87.5 years approximately, the actual difference being 1.5 years. For females, the difference from a similar comparison is lower: 25% of the 2007 female population in Spain alive at age 65 is expected to live to just under age 92 while the same proportion from the 2002 female population in Spain is expected to live to about age 92.4 years, the actual difference being half a year.

On the basis of PERM 2000P mortality tables, 25% of males born in 1955 who survive to age 65 would be expected to live to age 96.5 years approximately, which is 1.3 years longer than on the basis of the mortality table pertaining to the 1950 generation. For females, while 25% of those born in 1955 who survive to age 65 would be expected to live to age 98.8 years approximately, the corresponding proportion from the 1950 would be expected to live to age 98.6 years, a difference of about three months.

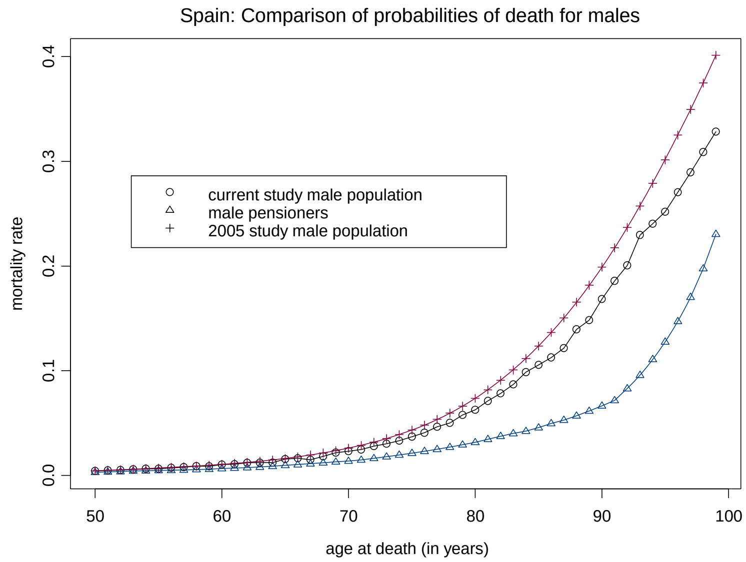


Figure 2.14.9

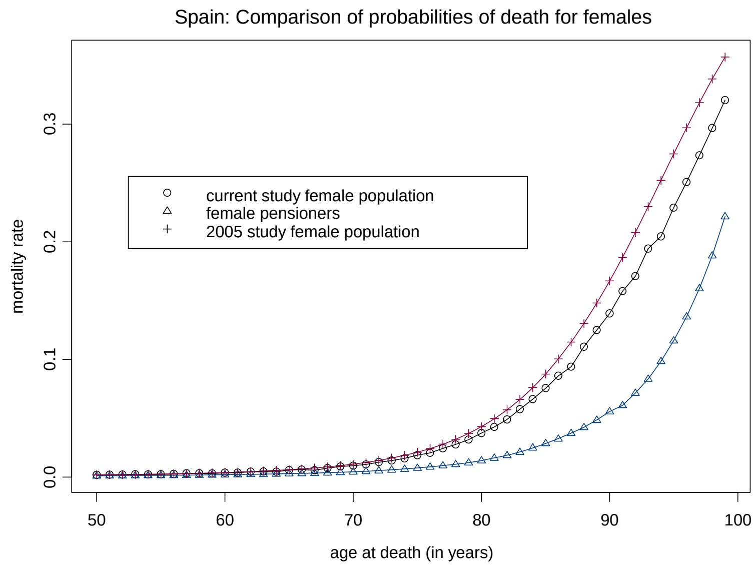


Figure 2.14.10

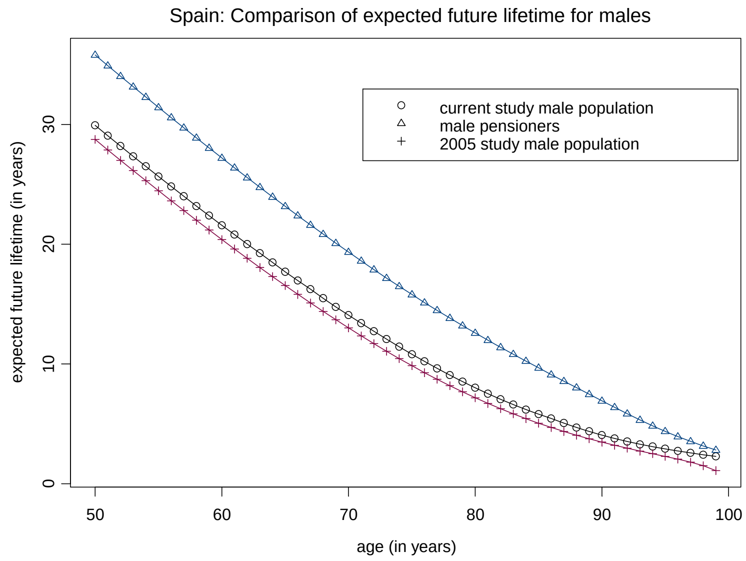


Figure 2.14.11

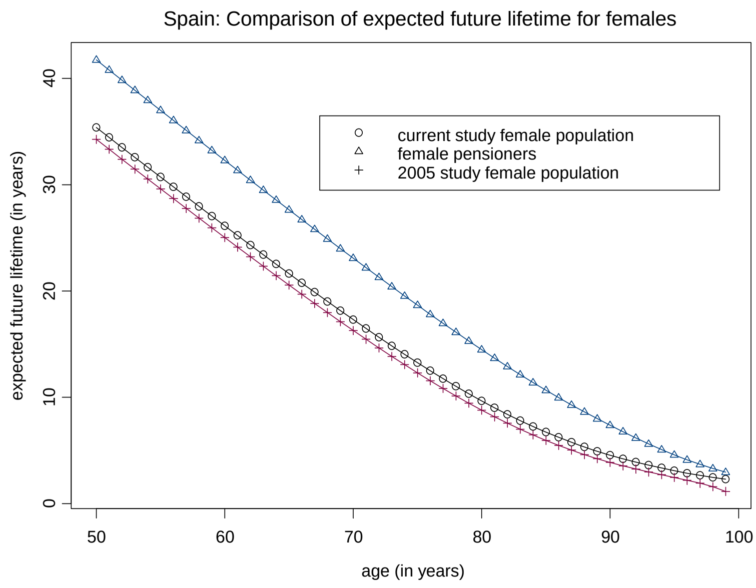


Figure 2.14.12

Table 2.14.4
Spain: Comparison of expected complete future lifetime for males

age	male pensioners			male population			
	PERM 2005P 1955 gen	PERM 2005P 1950 gen	difference	2007	2002	difference	Annualised percentage difference
50	35.81	35.08	0.73	29.94	28.75	1.19	0.8%
55	31.43	30.74	0.69	25.66	24.46	1.20	1.0%
60	27.21	26.56	0.65	21.58	20.39	1.19	1.2%
65	23.16	22.56	0.60	17.70	16.55	1.15	1.4%
70	19.35	18.81	0.54	14.08	13.01	1.07	1.6%
75	15.80	15.32	0.48	10.82	9.85	0.96	2.0%
80	12.59	12.19	0.39	8.01	7.18	0.83	2.3%
85	9.68	9.38	0.30	5.81	5.06	0.75	3.0%
90	6.93	6.74	0.19	4.05	3.47	0.58	3.3%
95	4.38	4.30	0.07	2.93	2.28	0.64	5.6%

Table 2.14.5
Spain: Comparison of expected complete future lifetime for females

age	female pensioners			female population			
	PERF 2005P 1955 gen	PERF 2005P 1950 gen	difference	2007	2002	difference	Annualised percentage difference
50	41.75	41.05	0.69	35.38	34.26	1.12	0.7%
55	37.00	36.33	0.67	30.73	29.61	1.12	0.8%
60	32.29	31.66	0.63	26.13	25.03	1.10	0.9%
65	27.65	27.05	0.59	21.64	20.56	1.08	1.0%
70	23.09	22.54	0.55	17.31	16.28	1.03	1.3%
75	18.67	18.19	0.49	13.26	12.30	0.96	1.6%
80	14.48	14.08	0.40	9.66	8.79	0.87	2.0%
85	10.67	10.37	0.29	6.73	5.95	0.78	2.6%
90	7.37	7.19	0.18	4.56	3.87	0.68	3.5%
95	4.58	4.51	0.07	3.09	2.46	0.63	5.2%

Table 2.14.6

Spain: Distribution of age at death given survival to age 65

Summary Statistics for the population experience

	Male			female		
	2007 population	2002 population	difference	2007 population	2002 population	difference
Lower Quartile age	76.52	75.44	1.08	81.62	80.30	1.32
Median age	83.08	81.12	1.96	87.44	86.58	0.86
Upper Quartile age	88.97	87.46	1.51	92.36	91.86	0.50
Inter quartile range	12.45	12.02	0.43	10.75	11.57	-0.82
e_{65}	17.70	16.55	1.15	21.64	20.56	1.08

Summary Statistics based on the PERM/F 2000P Mortality Tables

	Male			female		
	1955 generation	1950 generation	difference	1955 generation	1950 generation	difference
Lower Quartile age	80.66	80.99	-0.33	87.90	87.92	-0.02
Median age	89.42	88.41	1.01	94.27	93.38	0.89
Upper Quartile age	96.47	95.16	1.31	98.84	98.58	0.26
Inter quartile range	15.81	14.17	1.64	10.94	10.66	0.28
e_{65}	23.16	22.56	0.60	27.65	27.05	0.59

2.15 Sweden

The mortality assumed in the previous study for the population and for pensioners is compared with the most recent population mortality experience available from the Human Mortality Database for Sweden. An update of the mortality experience most commonly assumed for pension benefits in Sweden has not been made available for this study.

2.15.1 Sweden: population mortality

The population mortality experience in Sweden in 2007 available on the Human Mortality Database has been used in this study without any adjustments. In the previous study, the 2003 population mortality experience in Sweden available from the Human Mortality Database was used for comparison with the assumed pension-related mortality tables.

2.15.2 Sweden: mortality assumptions used to assess retirement liabilities within pension funding valuations

The mortality tables currently most commonly used for pension fund liability calculations in Sweden have not been made available. In this study, the most recent population mortality experience is compared with the mortality tables assumed for pension benefits in the previous study, the FFFS 2001:13 mortality tables published by the Financial Supervisory Authority in Sweden.

The Financial Supervisory Authority in Sweden publishes assumptions pertaining to the calculation of technical provisions and these are the assumptions used by the major supplier in the Swedish market for pensions for private white-collar workers. The assumptions used in the previous study are published as FFFS 2001:13 and are as follows:

$1000\mu_x = 0.0154 * e^{0.103x}$ for males, and

$1000\mu_x = 0.0089 * e^{0.103x}$ for females.

2.15.3 Sweden: projected mortality

The Financial Supervisory Authority's FFFS 2001:13 does not incorporate allowances for future improvements in mortality.

2.15.4 Sweden: results

A summary of the results obtained from a comparative analysis of the population mortality experience in Sweden in 2007 and the FFFS 2001:13 mortality tables assumed for retirement related benefits is given in Table 2.15.1. From the table it can be seen that the present value of annuity rates derived on the basis of mortality tables assumed for pension liability calculations are higher than annuity rates derived on the basis of the current population mortality, although the differences are relatively small. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 0.8% for males and 5.6% for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of a male member's pension is included, the percentage difference between male annuity rates at age 65 is 3.1% assuming a discount rate of 3%.

Figure 2.15.1 and Table 2.15.2 show comparisons of the observed probabilities of death (q_x rates) based on the most recent (2007) population experience and the mortality tables assumed for pensions. It can be seen that the FFFS 2001:13 mortality tables exhibit lighter mortality than the observed population mortality at most ages. For example, the probability from the FFFS 2001:13 mortality tables that a 65-year old male will die before his 66th birthday is 97% of the probability derived from the male population experience in Sweden. The corresponding probability for a 65-year old female is 84% of the probability derived from the female population mortality experience.

The same trends are depicted in Figure 2.15.2 which shows the ratios of probabilities of death derived from the mortality tables assumed for pension benefits to probabilities of death derived from the male and female population mortality experiences respectively. It is clear that for females, the FFFS 2001:13 mortality tables generally exhibit lighter mortality than the observed population mortality at most ages. For males, the FFFS 2001:13 mortality tables exhibit heavier mortality at ages between 65 and 80 years, and at ages above 100 years.

Figure 2.15.3 shows age-related ratios of female probabilities of death to male probabilities of death based on the pension-related tables and population mortality experience. The ratio of population mortality rates is higher at all ages increasing from about 61% at age 50 to about 98% at age 109, while the ratio of pension related mortality rates increases from about 58% at age 50 to about 70% at age 109.

Table 2.15.3 and Figure 2.15.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the FFFS 2001:13 mortality tables with corresponding expected future lifetime values for the population. Expressed as a percentage of the expected future lifetime value derived from the population mortality experience, the proportional differences increase with age for both males and females, with the proportional differences at age 65 being 1.6% for males and 8.7% for females (Tables 2.15.1 and 2.15.3). Based on the FFFS 2001:13 mortality tables assumed for pension benefits, the life expectancy at age 65 is just over 3 months longer for males and nearly two years longer for females compared to the observed male and female population respectively.

Figures 2.15.5, 2.15.6, 2.15.7 and 2.15.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \le k \le 100-x$. Considering age 65 (Figure 2.15.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to at least age 83 on the basis of the FFFS 2001:13 mortality tables and to about age 82.8 years on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to age 89.5 years on the basis of the FFFS 2001:13 mortality tables and to about age 88.2 years on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to about age 87.4 years on the basis of the FFFS 2001:13 mortality tables and to about age 85.6 years on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to age 94.5 years on the basis of the FFFS

2001:13 mortality tables and to about age 91.4 years on the basis of the female population experience.

Table 2.15.1

Sweden: Summary Statistics

age x = 50

	male				female			
	population	FFFS 2001:13	difference	percentage difference	population	FFFS 2001:13	difference	percentage difference
e_x	30.69	30.95	0.26	0.8	34.10	35.91	1.81	5.3
a_x : 3%	18.99	19.05	0.06	0.3	20.37	20.92	0.55	2.7
a_x : 6%	13.16	13.17	0.01	0.1	13.78	13.97	0.19	1.4

age x = 60

	male				female			
	population	FFFS 2001:13	difference	percentage difference	population	FFFS 2001:13	difference	percentage difference
e_x	21.89	22.14	0.26	1.2	24.95	26.73	1.78	7.1
a_x : 3%	14.98	15.05	0.07	0.5	16.55	17.25	0.70	4.2
a_x : 6%	11.15	11.16	0.01	0.1	12.02	12.31	0.29	2.4
$a_x + .6a_{x\|y}$: 3%	17.56	17.96	0.40	2.3				

age x = 65

	male				female			
	population	FFFS 2001:13	difference	percentage difference	population	FFFS 2001:13	difference	percentage difference
e_x	17.83	18.11	0.29	1.6	20.62	22.41	1.79	8.7
a_x : 3%	12.79	12.89	0.10	0.8	14.38	15.19	0.80	5.6
a_x : 6%	9.89	9.91	0.03	0.3	10.85	11.24	0.38	3.5
$a_x + .6a_{x\|y}$: 3%	15.45	15.92	0.47	3.1				

age x = 70

	male				female			
	population	FFFS 2001:13	Difference	percentage difference	population	FFFS 2001:13	Difference	percentage difference
e_x	14.05	14.42	0.37	2.6	16.54	18.36	1.83	11.0
a_x : 3%	10.53	10.70	0.17	1.6	12.10	13.03	0.93	7.7
a_x : 6%	8.46	8.53	0.08	0.9	9.50	10.00	0.50	5.3

Table 2.15.2

Sweden: One year probabilities of death (initial rates of mortality, q_x rates)

age	male			female		
	population	FFFS 2001:13	ratio	population	FFFS 2001:13	ratio
50	0.003220	0.002793	0.87	0.001950	0.001615	0.83
55	0.004470	0.004670	1.04	0.002630	0.002702	1.03
60	0.007070	0.007804	1.10	0.004810	0.004518	0.94
65	0.013400	0.013027	0.97	0.009040	0.007549	0.84
70	0.020410	0.021706	1.06	0.012130	0.012603	1.04
75	0.035290	0.036062	1.02	0.021950	0.021003	0.96
80	0.064390	0.059619	0.93	0.043590	0.034901	0.80
85	0.110730	0.097764	0.88	0.081030	0.057723	0.71
90	0.195410	0.158174	0.81	0.145370	0.094717	0.65
95	0.299240	0.250367	0.84	0.254140	0.153411	0.60

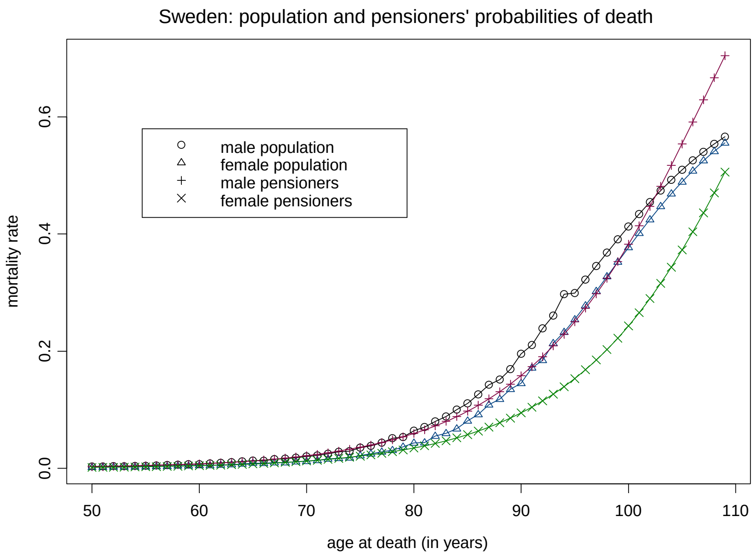


Figure 2.15.1

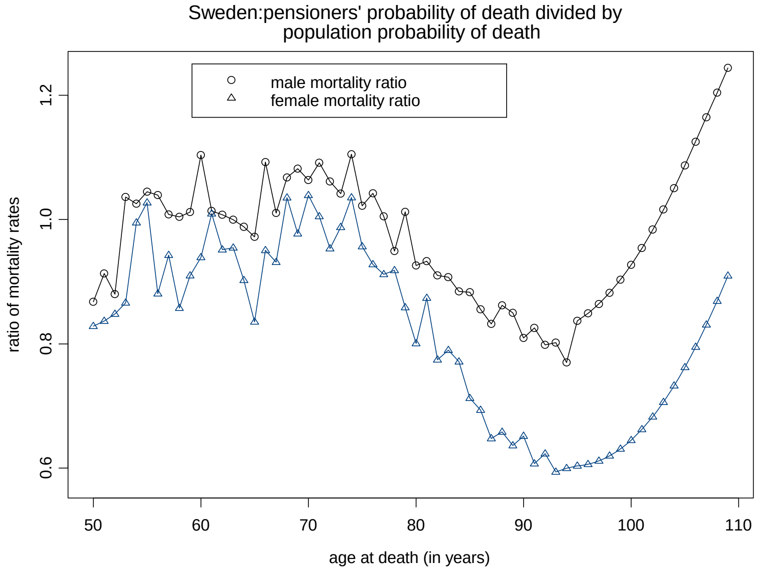


Figure 2.15.2

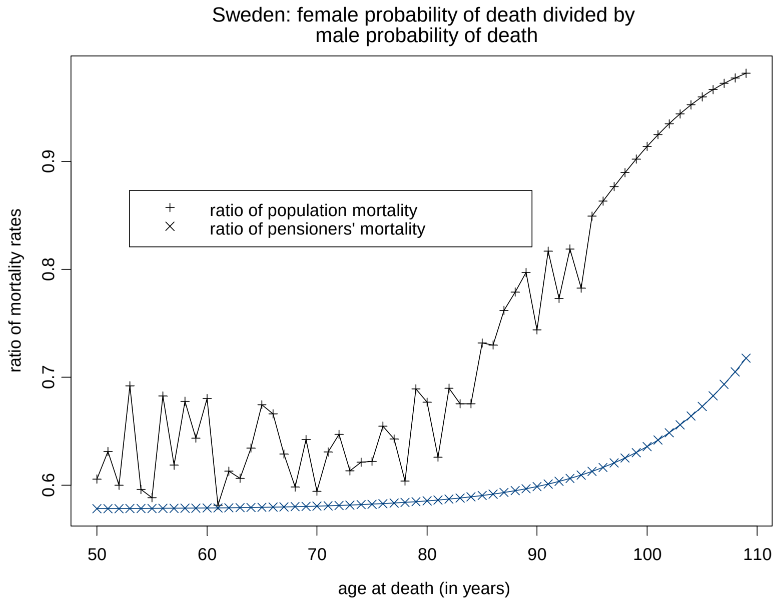
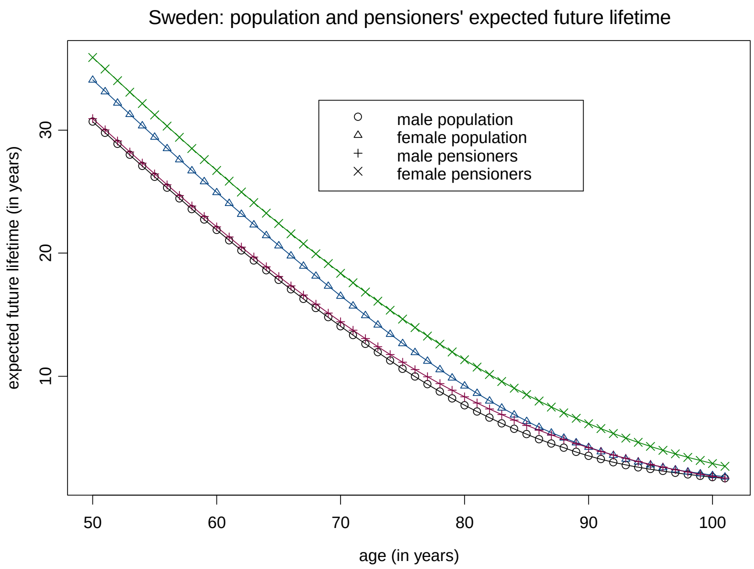


Figure 2.15.3

Table 2.15.3
Sweden: Expected complete future lifetime in years

age	male				female			
	population	FFFS 2001:13	difference	percentage difference	population	FFFS 2001:13	difference	percentage difference
50	30.69	30.95	0.26	0.8	34.10	35.91	1.81	5.3
55	26.21	26.44	0.24	0.9	29.46	31.25	1.79	6.1
60	21.89	22.14	0.26	1.2	24.95	26.73	1.78	7.1
65	17.83	18.11	0.29	1.6	20.62	22.41	1.79	8.7
70	14.05	14.42	0.37	2.6	16.54	18.36	1.83	11.0
75	10.60	11.14	0.54	5.1	12.67	14.65	1.98	15.6
80	7.63	8.33	0.69	9.1	9.23	11.34	2.11	22.9
85	5.29	6.01	0.72	13.7	6.35	8.49	2.15	33.8
90	3.52	4.19	0.67	18.9	4.25	6.14	1.90	44.7
95	2.46	2.83	0.37	15.2	2.81	4.29	1.48	52.6



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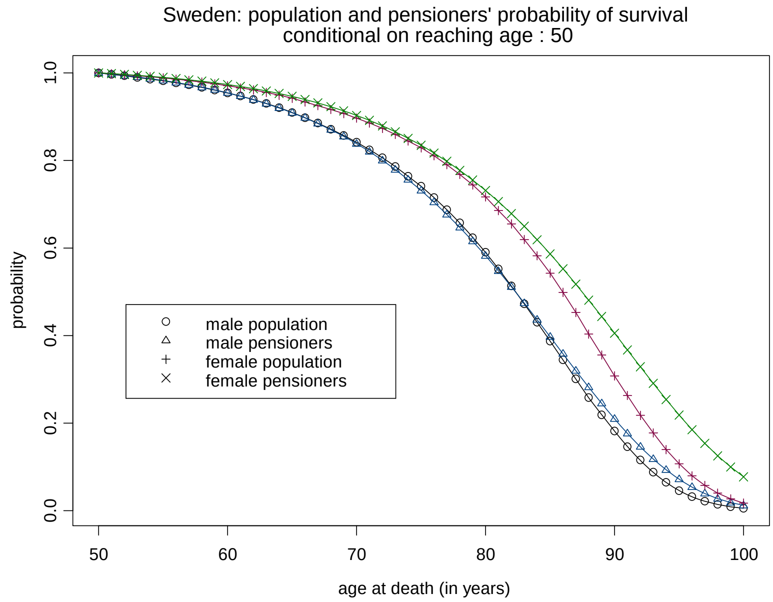


Figure 2.15.5

Sweden: Distribution of age at death given survival to age 50

Summary Statistics

	male			female		
	population	FFFS 2001:13	difference	population	FFFS 2001:13	difference
Lower quartile age	74.39	74.75	0.37	78.24	79.77	1.53
Median age	82.67	82.69	0.02	85.03	87.52	2.49
Upper quartile age	88.79	88.13	-0.66	91.71	94.88	3.17
Inter quartile range	14.41	13.38	-1.03	13.47	15.11	1.64
e_{50}	30.69	30.95	0.26	34.10	35.91	1.81

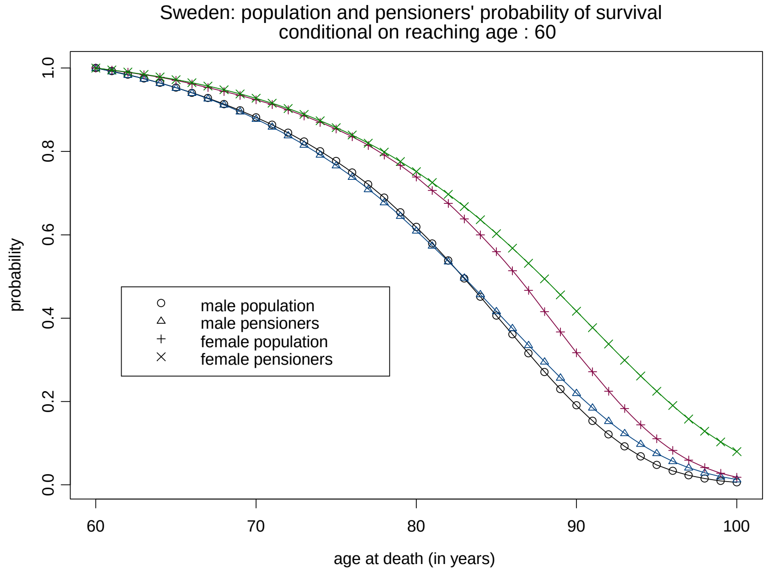


Figure 2.15.6

Sweden: Distribution of age at death given survival to age 60

Summary Statistics

	male			female		
	population	FFFS 2001:13	difference	population	FFFS 2001:13	difference
Lower quartile age	75.02	75.41	0.39	79.40	80.94	1.54
Median age	82.11	82.08	-0.03	86.71	87.15	0.45
Upper quartile age	88.50	89.82	1.32	91.55	94.70	3.15
Inter quartile range	13.48	14.40	0.92	12.14	13.75	1.61
e_{60}	21.89	22.14	0.26	24.95	26.73	1.78

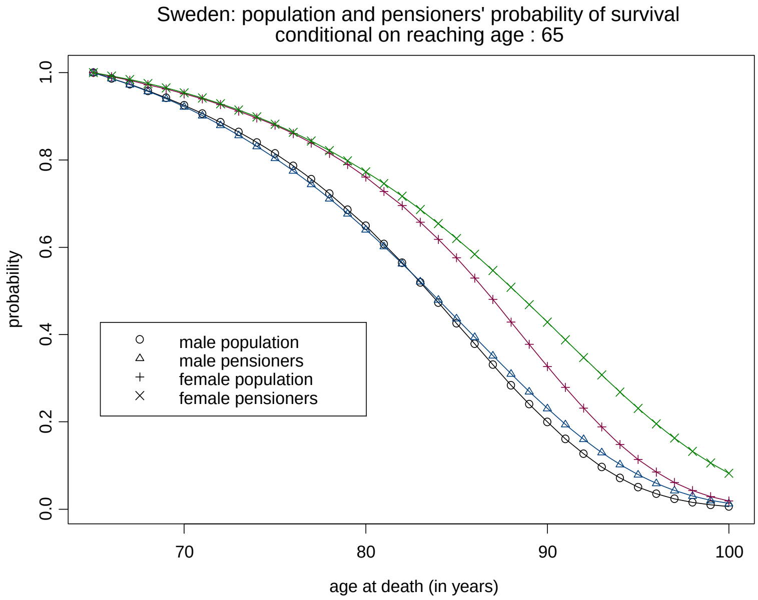


Figure 2.15.7

Sweden: Distribution of age at death given survival to age 65

Summary Statistics

	male			female		
	population	FFFS 2001:13	difference	population	FFFS 2001:13	difference
Lower quartile age	77.82	76.18	-1.64	80.67	80.15	-0.52
Median age	83.58	83.48	-0.09	86.40	88.79	2.39
Upper quartile age	88.22	89.50	1.28	91.39	94.51	3.12
Inter quartile range	10.40	13.32	2.92	10.72	14.36	3.64
e_{65}	17.83	18.11	0.29	20.62	22.41	1.79

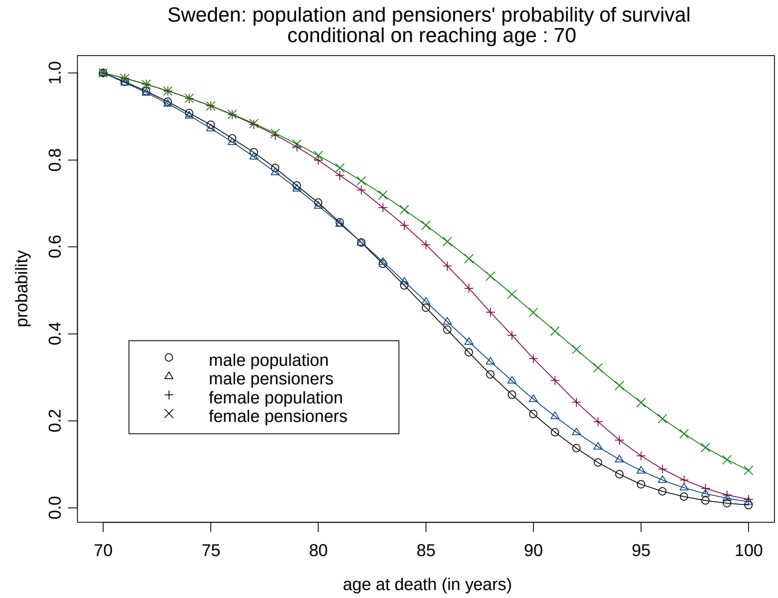


Figure 2.15.8

Sweden: Distribution of age at death given survival to age 70

Summary Statistics

	male			female		
	population	FFFS 2001:13	difference	population	FFFS 2001:13	difference
Lower quartile age	78.22	78.42	0.20	81.56	82.95	1.38
Median age	84.77	84.56	-0.21	87.91	88.21	0.30
Upper quartile age	89.77	90.99	1.22	91.14	94.20	3.06
Inter quartile range	11.55	12.57	1.02	9.57	11.25	1.68
e_{70}	14.05	14.42	0.37	16.54	18.36	1.83

2.15.5 Sweden results: comparison with previous study

Figures 2.15.9 and 2.15.10 compare the probabilities of death shown in Figure 2.15.1 with probabilities of death for the population in 2003, the population experience used in the previous study, for males and females separately. The expected future lifetimes are compared in Figures 2.15.11 and 2.15.12. Clearly, there has been an improvement in population mortality over the period 2003 to 2007 at all ages for both males and females. From the annualised percentage changes in expected future lifetime shown in Tables 2.15.4 and 2.15.5, it is apparent that:

- the rate of improvement in mortality is higher for males at each age; and
- the rate of improvement increases with age.

We reiterate that the FFFS 2001:13 mortality tables have been assumed for pension benefits for comparative purposes only. The mortality tables currently in use for pension-related benefits in Sweden have not been made available.

Table 2.15.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the 2007 male population in Sweden would be expected to live to about age 88.2 years, the same proportion of 65-year old males from the 2003 male population in Sweden would be expected to live to age 87.4 years approximately, the difference being about nine months. For females, the difference from a similar comparison is higher: 25% of the 2007 female population in Sweden alive at age 65 is expected to live to age 91.4 years while the same proportion from the 2003 female population is expected to live to age 90.1 years, the actual difference being more than a year.

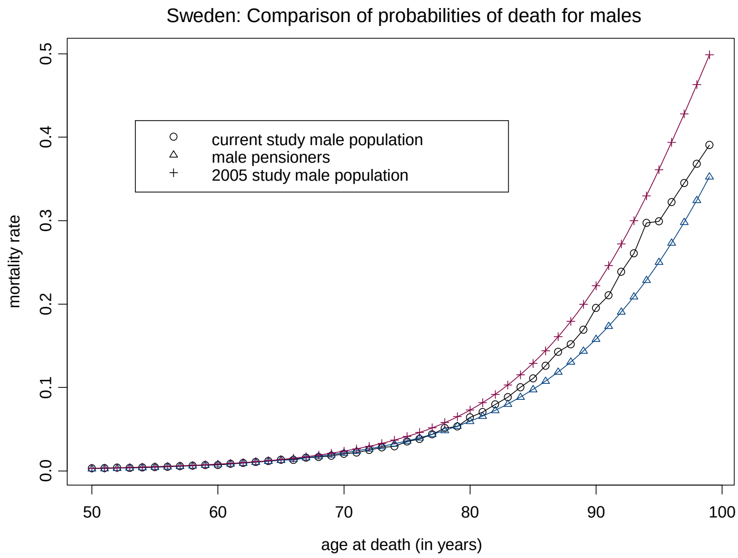
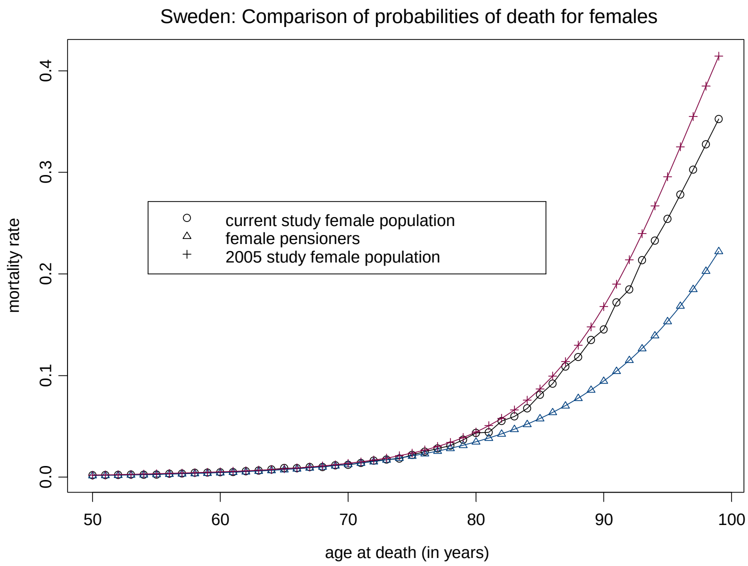


Figure 2.15.9



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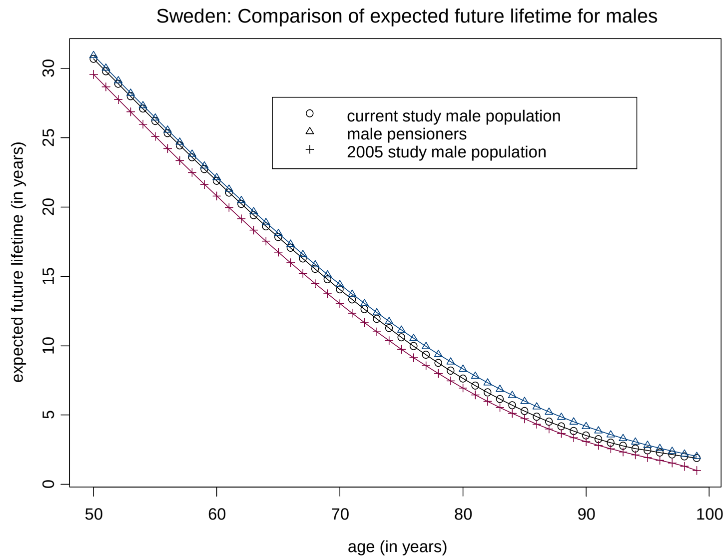


Figure 2.15.11

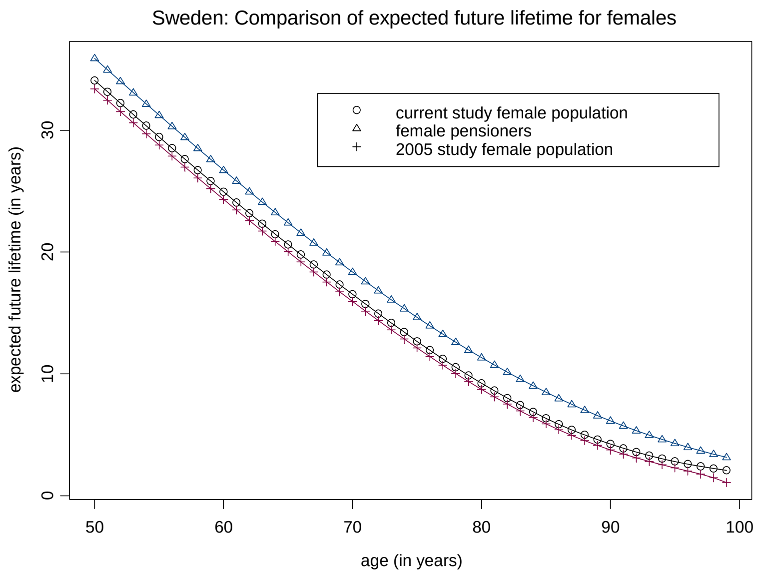


Figure 2.15.12

Table 2.15.4
Sweden: Comparison of expected complete future lifetime for males

	FFFS 2001:13	Male population			
		2007 population	2003 population	difference	Annualised percentage difference
50	30.95	30.69	29.57	1.12	0.9%
55	26.44	26.21	25.09	1.12	1.1%
60	22.14	21.89	20.80	1.09	1.3%
65	18.11	17.83	16.75	1.07	1.6%
70	14.42	14.05	13.04	1.02	2.0%
75	11.14	10.60	9.74	0.86	2.2%
80	8.33	7.63	6.95	0.68	2.5%
85	6.01	5.29	4.72	0.56	3.0%
90	4.19	3.52	3.08	0.45	3.6%
95	2.83	2.46	1.93	0.53	6.9%

Table 2.15.5
Sweden: Comparison of expected complete future lifetime for females

	FFFS 2001:13	Female population			
		2007 population	2003 population	difference	Annualised percentage difference
50	35.91	34.10	33.41	0.69	0.5%
55	31.25	29.46	28.79	0.67	0.6%
60	26.73	24.95	24.33	0.62	0.6%
65	22.41	20.62	20.03	0.59	0.7%
70	18.36	16.54	15.94	0.60	0.9%
75	14.65	12.67	12.13	0.54	1.1%
80	11.34	9.23	8.73	0.49	1.4%
85	8.49	6.35	5.90	0.45	1.9%
90	6.14	4.25	3.76	0.49	3.2%
95	4.29	2.81	2.29	0.53	5.8%

Table 2.15.6
Sweden: Distribution of age at death given survival to age 65
Summary Statistics

	Male			female		
	2007 population	2003 population	difference	2007 population	2003 population	difference
Lower Quartile age	77.82	76.87	0.95	80.67	79.15	1.52
Median age	83.58	82.76	0.82	86.40	86.96	-0.56
Upper Quartile age	88.22	87.44	0.77	91.39	90.06	1.33
Inter quartile range	10.40	10.57	-0.17	10.72	10.91	-0.19
e_{65}	17.83	16.75	1.07	20.62	20.03	0.59

2.16 Switzerland

The mortality assumed in the previous study for the population and for pensioners is compared with the most recent population mortality experience available from the Human Mortality Database for Switzerland. An update of the mortality experience most commonly assumed for pension benefits in Switzerland has not been made available.

2.16.1 Switzerland: population mortality

The population mortality experience in Switzerland in 2007 available on the Human Mortality Database has been used in this study, without any adjustments. In the previous study, the 2003 population mortality experience in Switzerland available from the Human Mortality Database was used for comparison with the assumed pension-related mortality tables.

2.16.2 Switzerland: mortality assumptions used to assess retirement liabilities within pension funding valuations

The mortality tables currently most commonly used for pension fund liability calculations in Switzerland have not been made available. In this study, the most recent population mortality experience is compared with the mortality tables assumed for pension benefits in the previous study, the EVK2000 mortality tables. The EVK2000 mortality tables are based on the experience of a large population of civil servants (the Federal Pension Fund) in Switzerland.

2.16.3 Switzerland: projected mortality

The EVK2000 tables do not include projection of future improvements in mortality.

2.16.4 Switzerland: results

A summary of the results obtained from a comparative analysis of the population mortality experience in Switzerland in 2007 and the EVK2000 mortality tables assumed for retirement related benefits is given in Table 2.16.1. From the table it can be seen that the present value of annuity rates derived on the basis of the mortality tables assumed for pension liability calculations are lower than annuity rates derived from current population mortality experience for both males and females. For example, assuming a discount rate of 3% per annum, the present value of the annuity rate assumed for pension liability calculations at age 65 is 4.1% lower than the annuity rate derived from the population mortality for males and 5.7% lower for females, when expressed as a percentage of the population value. When a reversionary widow's pension of 60% of a male member's pension is included, the percentage difference between male annuity rates at age 65 is -3.7% assuming a discount rate of 3%.

Figure 2.16.1 and Table 2.16.2 show comparisons of the observed probabilities of death (q_x rates) based on the most recent (2007) population mortality experience and the mortality tables assumed for pension benefits. It can be seen that the EVK2000 mortality tables generally exhibit heavier mortality than the observed population mortality for both males and females. For example, the probability from the EVK2000 mortality tables that a 65-year old male will die before his 66th birthday is 19% higher than the probability derived from the male population experience in Switzerland. The corresponding probability for a 65-year old female is nearly twice the probability derived from the female population mortality experience. The same trends are depicted in Figure 2.16.2 which shows the ratios of probabilities of death from the mortality tables assumed for pension benefits to probabilities of death derived from the male and female population mortality experiences respectively.

Figure 2.16.3 shows age-related ratios of female probabilities of death to male probabilities of death based on the pension-related tables and population mortality experience separately. From the graph, it can be seen that while the difference between male and female population mortality rates is generally decreasing as age increases (the ratios increasing), the ratios of pension related mortality rates are decreasing to a minimum at about age 75 and thereafter exhibit a generally increasing pattern.

Table 2.16.3 and Figure 2.16.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the EVK2000 mortality tables with corresponding expected future lifetime values for the population. Clearly, life expectancy values derived from the EVK2000 tables are lower than life expectancy values derived from the population mortality experiences for both males and females. For example, on the basis of the EVK2000 mortality tables, the life expectancy at age 65 is 4.8% lower for males and 6.8% lower for females compared to the observed male and female population experiences respectively (Tables 2.16.1 and 2.16.3).

Figures 2.16.5, 2.16.6, 2.16.7 and 2.16.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering age 65 (Figure 2.16.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to at least age 88 on the basis of the EVK2000 mortality tables and to about age 82.7 years on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to age 96.5 years on the basis of the EVK2000 mortality tables and to about age 89 years on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to about age 92.7 years on the basis of the PERF 2000P mortality tables and to about age 86.6 years on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to about age 98.8 years on the basis of the PERF 2000P mortality tables and to about age 92.4 years on the basis of the female population experience.

Figures 2.108, 2.109, 2.110 and 2.111 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering the distribution of age at death given survival to age 65 (Figure 2.110 and the associated table), it is noted that the EVK2000 tables for males have a greater spread than the corresponding male population mortality, while the EVK2000 tables for females have a lower spread than the corresponding female population mortality as measured by the inter-quartile range. It is further noted that whereas a male 65-year old member of a company pension scheme is expected to live to about age 82.6 years, one quarter of those alive at age 65 would be expected to live to at least age 90 years approximately.

Table 2.16.1

Switzerland: Summary Statistics

age x = 50

	male				female			
	population	EVK2000	difference	percentage difference	population	EVK2000	difference	percentage difference
e_x	31.22	30.30	-0.93	-3.0	35.38	33.25	-2.13	-6.0
a_x : 3%	19.17	18.80	-0.37	-1.9	20.84	19.95	-0.90	-4.3
a_x : 6%	13.22	13.06	-0.16	-1.2	13.97	13.55	-0.42	-3.0

age x = 60

	male				female			
	population	EVK2000	difference	percentage difference	population	EVK2000	difference	percentage difference
e_x	22.48	21.48	-1.00	-4.4	26.24	24.40	-1.84	-7.0
a_x : 3%	15.25	14.71	-0.54	-3.6	17.18	16.20	-0.98	-5.7
a_x : 6%	11.29	10.96	-0.32	-2.8	12.35	11.78	-0.57	-4.6
$a_x + .6a_{x\|y}$: 3%	17.94	17.36	-0.59	-3.3				

age x = 65

	male				female			
	population	EVK2000	difference	percentage difference	population	EVK2000	difference	percentage difference
e_x	18.45	17.56	-0.89	-4.8	21.86	20.37	-1.48	-6.8
a_x : 3%	13.13	12.58	-0.54	-4.1	15.06	14.21	-0.86	-5.7
a_x : 6%	10.08	9.73	-0.35	-3.5	11.25	10.72	-0.54	-4.8
$a_x + .6a_{x\|y}$: 3%	15.90	15.30	-0.60	-3.7				

age x = 70

	male				female			
	population	EVK2000	difference	percentage difference	population	EVK2000	difference	percentage difference
e_x	14.67	13.98	-0.69	-4.7	17.61	16.58	-1.03	-5.9
a_x : 3%	10.90	10.44	-0.46	-4.2	12.75	12.12	-0.62	-4.9
a_x : 6%	8.70	8.38	-0.32	-3.7	9.91	9.51	-0.40	-4.1

Table 2.16.2

Switzerland: One year probabilities of death (initial rates of mortality, q_x rates)

age	male			female		
	population	EVK2000h65	ratio	population	EVK2000f65	ratio
50	0.003410	0.002778	0.81	0.001830	0.002611	1.43
55	0.005270	0.004629	0.88	0.003340	0.004061	1.22
60	0.007060	0.008774	1.24	0.004640	0.007047	1.52
65	0.012480	0.014800	1.19	0.006100	0.011435	1.87
70	0.019150	0.023400	1.22	0.009660	0.015500	1.60
75	0.031690	0.037660	1.19	0.017380	0.019893	1.14
80	0.056600	0.060424	1.07	0.032490	0.037287	1.15
85	0.102600	0.102215	1.00	0.072780	0.082492	1.13
90	0.160530	0.183822	1.15	0.125160	0.153106	1.22
95	0.265360	0.334958	1.26	0.226970	0.254088	1.12

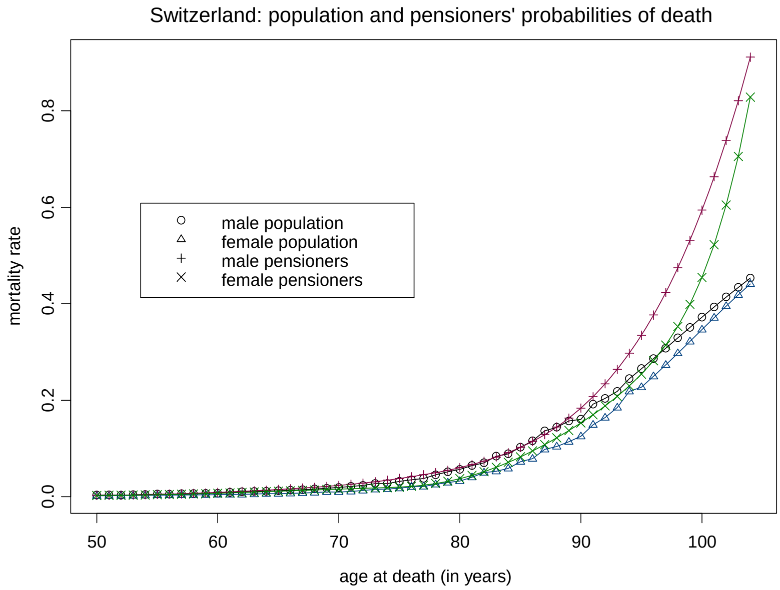


Figure 2.16.1

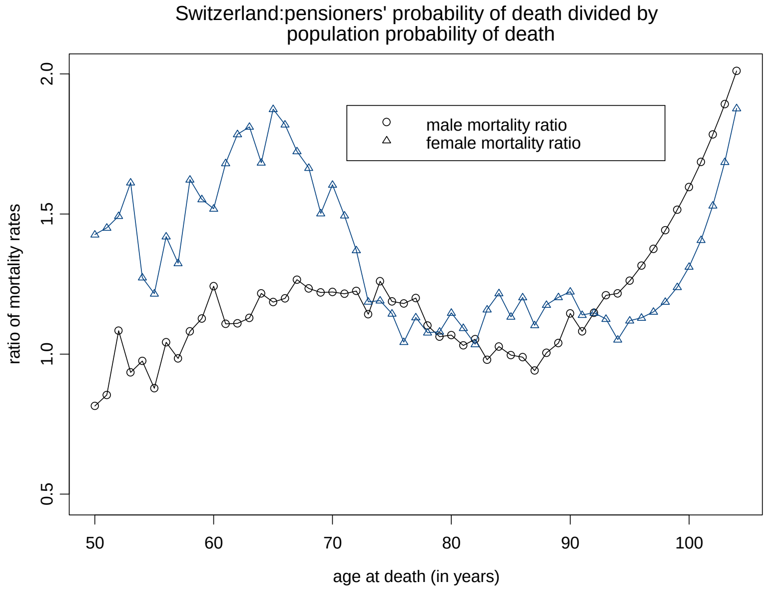


Figure 2.16.2

Figure 2.16.3

Table 2.16.3
Switzerland: Expected complete future lifetime in years

	male				female			
age	population	EVK2000h65	difference	percentage difference	population	EVK2000f65	difference	percentage difference
50	31.22	30.30	-0.93	-3.0	35.38	33.25	-2.13	-6.0
55	26.75	25.77	-0.98	-3.7	30.74	28.73	-2.01	-6.5
60	22.48	21.48	-1.00	-4.4	26.24	24.40	-1.84	-7.0
65	18.45	17.56	-0.89	-4.8	21.86	20.37	-1.48	-6.8
70	14.67	13.98	-0.69	-4.7	17.61	16.58	-1.03	-5.9
75	11.19	10.75	-0.45	-4.0	13.61	12.85	-0.75	-5.5
80	8.14	7.90	-0.24	-2.9	9.94	9.22	-0.72	-7.3
85	5.70	5.45	-0.25	-4.4	6.91	6.26	-0.65	-9.4
90	4.02	3.47	-0.55	-13.6	4.68	4.17	-0.50	-10.7
95	2.76	2.04	-0.72	-26.2	3.10	2.66	-0.43	-14.0

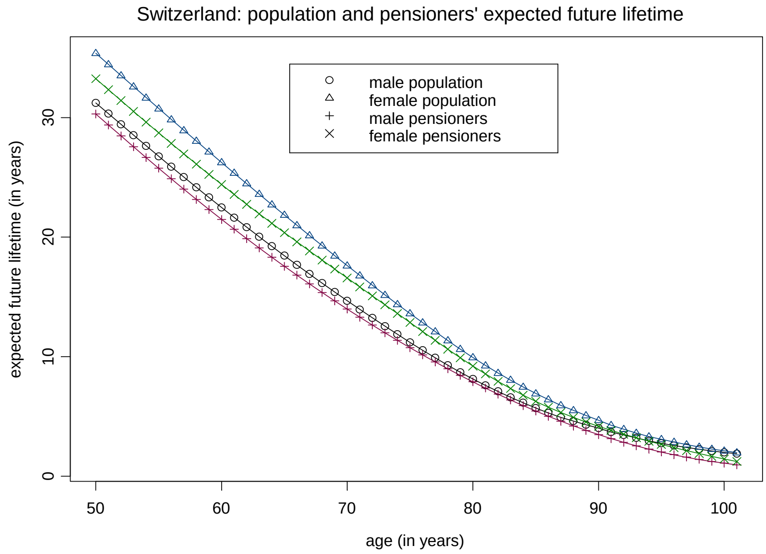


Figure 2.16.4

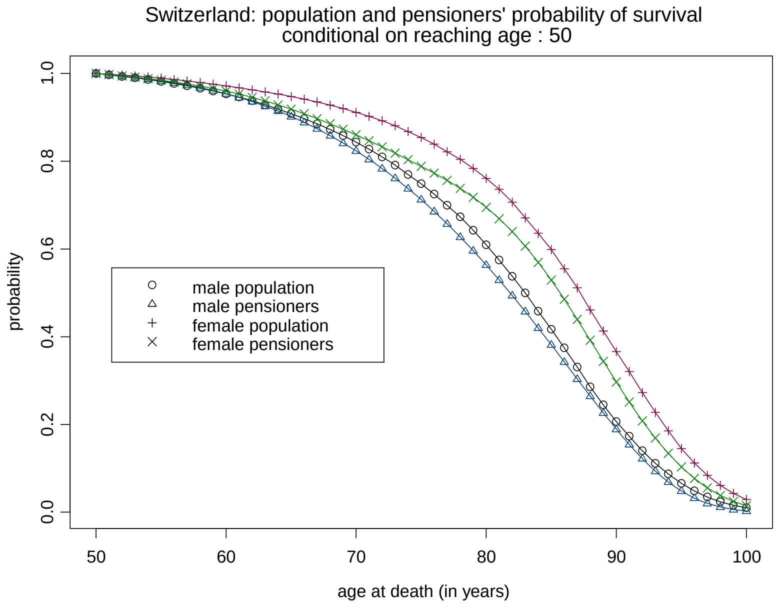


Figure 2.16.5

Switzerland: Distribution of age at death given survival to age 50

Summary Statistics

	male			female		
	population	EVK2000h65	difference	population	EVK2000f65	difference
Lower quartile age	74.94	73.48	-1.46	80.44	77.34	-3.10
Median age	83.00	81.83	-1.17	87.23	85.66	-1.56
Upper quartile age	88.87	88.37	-0.50	92.50	91.03	-1.47
Inter quartile range	13.93	14.90	0.96	12.06	13.69	1.63
e_{50}	31.22	30.30	-0.93	35.38	33.25	-2.13

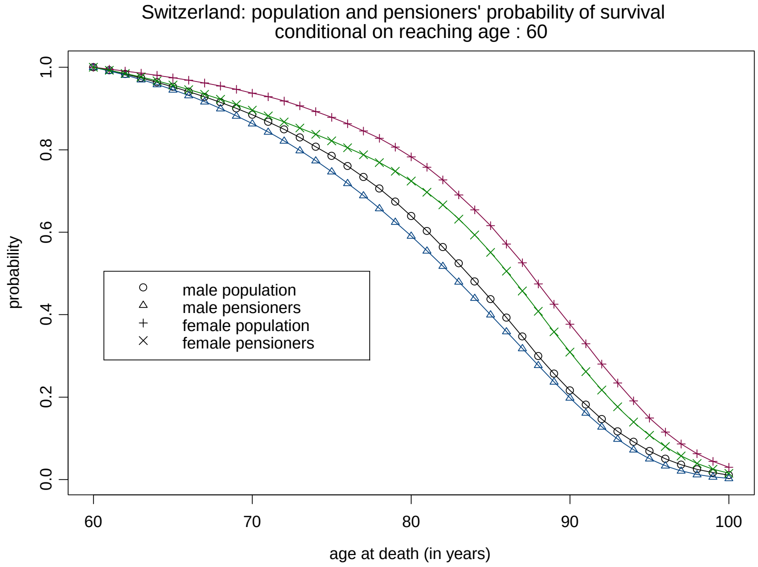


Figure 2.16.6

Switzerland: Distribution of age at death given survival to age 60

Summary Statistics

	male			female		
	population	EVK2000h65	difference	population	EVK2000f65	difference
Lower quartile age	76.39	74.89	-1.50	81.25	78.90	-2.35
Median age	83.56	82.47	-1.08	87.51	86.12	-1.39
Upper quartile age	89.17	88.68	-0.49	92.66	91.27	-1.40
Inter quartile range	12.77	13.78	1.01	11.42	12.37	0.95
e_{60}	22.48	21.48	-1.00	26.24	24.40	-1.84

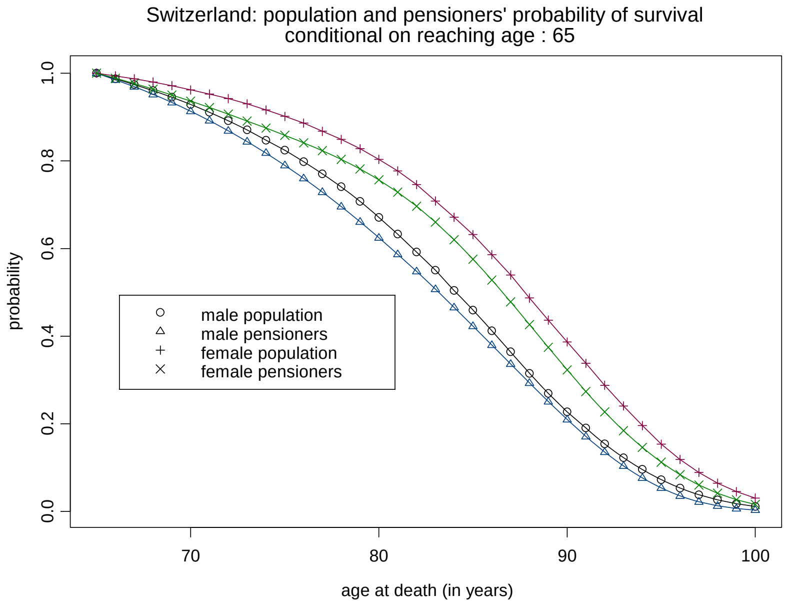


Figure 2.16.7

Switzerland: Distribution of age at death given survival to age 65
Summary Statistics

	male			female		
	population	EVK2000h65	difference	population	EVK2000f65	difference
Lower quartile age	77.69	76.33	-1.36	81.87	80.23	-1.64
Median age	84.09	83.18	-0.92	87.75	86.57	-1.19
Upper quartile age	89.46	89.02	-0.44	92.80	91.51	-1.29
Inter quartile range	11.77	12.69	0.92	10.93	11.27	0.35
e_{65}	18.45	17.56	-0.89	21.86	20.37	-1.48

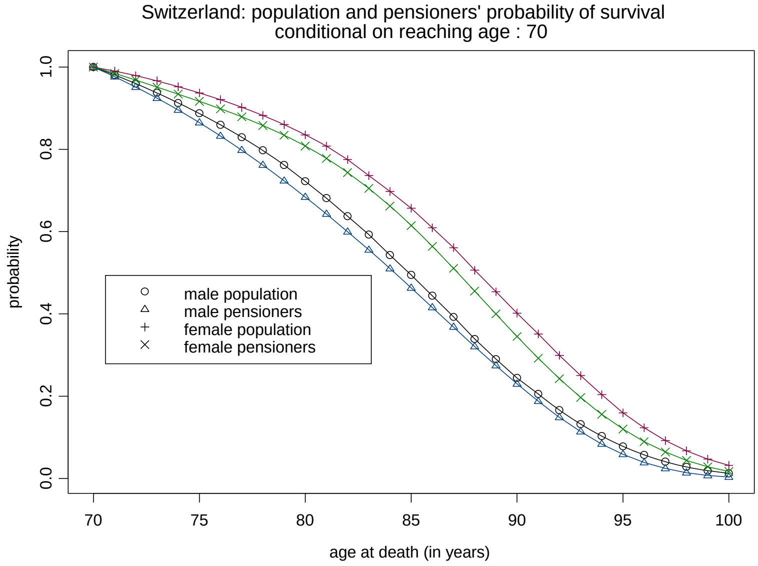


Figure 2.16.8

Switzerland: Distribution of age at death given survival to age 70

Summary Statistics

	male			female		
	population	EVK2000h65	difference	population	EVK2000f65	difference
Lower quartile age	79.30	78.31	-0.99	82.65	81.82	-0.84
Median age	84.89	84.21	-0.68	88.12	87.19	-0.92
Upper quartile age	89.88	89.55	-0.33	93.00	91.85	-1.15
Inter quartile range	10.58	11.24	0.65	10.35	10.03	-0.31
e_{70}	14.67	13.98	-0.69	17.61	16.58	-1.03

2.16.5 Switzerland results: comparison with previous study

Figures 2.16.9 and 2.16.10 compare the probabilities of death shown in Figure 2.16.1 with probabilities of death for the population in 2003, the population experience used in the previous study, for males and females separately. The expected future lifetimes are compared in Figures 2.16.11 and 2.16.12. Clearly, there has been an improvement in the population mortality between 2003 and 2007 at all ages for both males and females. From the annualised percentage changes in expected future lifetime shown in Tables 2.16.4 and 2.16.5, it is apparent that:

- the rate of improvement in mortality is higher for males at each age; and
- the rate of improvement increases with age.

We reiterate that the EVK2000 mortality tables have been assumed for pension benefits for comparative purposes only. The mortality tables currently in use for pension-related benefits in Switzerland have not been made available.

Table 2.13.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the 2007 male population in Switzerland would be expected to live to about age 89.5 years, the same proportion of 65-year old males from the 2003 male population in Switzerland would be expected to live to age 88.9 years approximately, the actual difference being about seven months. For females, the difference from a similar comparison is higher: 25% of the 2007 female population in Switzerland alive at age 65 is expected to live to age 92.8 years while the same proportion from the 2003 female population is expected to live age 91.6 years, the actual difference being more than a year.

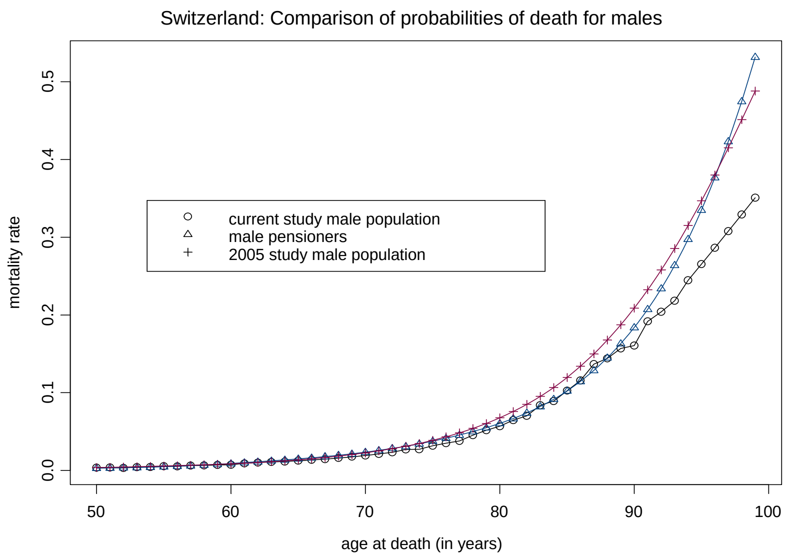


Figure 2.16.9

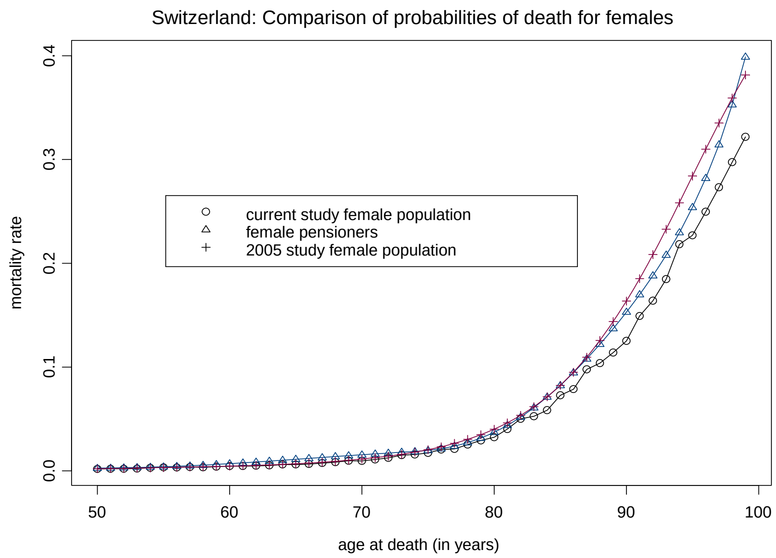


Figure 2.16.10

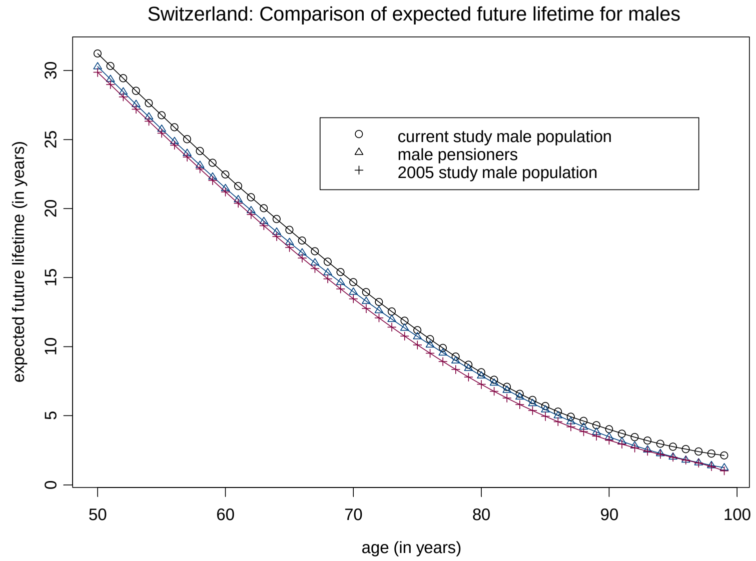


Figure 2.16.11

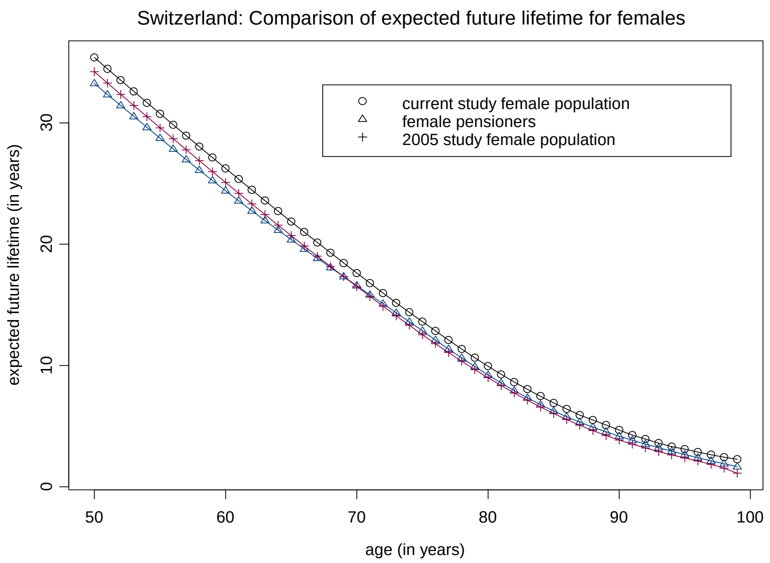


Figure 2.16.12

Table 2.16.4
Switzerland: Comparison of expected complete future lifetime for males

	EVK2000h65	Male population			
		2007 population	2003 population	difference	Annualised percentage difference
50	30.30	31.22	29.87	1.36	1.1%
55	25.77	26.75	25.45	1.30	1.3%
60	21.48	22.48	21.21	1.27	1.5%
65	17.56	18.45	17.19	1.27	1.8%
70	13.98	14.67	13.47	1.20	2.2%
75	10.75	11.19	10.14	1.06	2.6%
80	7.90	8.14	7.28	0.87	3.0%
85	5.45	5.70	4.96	0.74	3.7%
90	3.47	4.02	3.22	0.80	6.2%
95	2.04	2.76	1.99	0.77	9.7%

Table 2.16.5
Switzerland: Comparison of expected complete future lifetime for females

	EVK2000f65	Female population			
		2007 population	2003 population	difference	Annualised percentage difference
50	33.25	35.38	34.21	1.17	0.9%
55	28.73	30.74	29.59	1.15	1.0%
60	24.40	26.24	25.08	1.16	1.2%
65	20.37	21.86	20.71	1.15	1.4%
70	16.58	17.61	16.50	1.12	1.7%
75	12.85	13.61	12.54	1.07	2.1%
80	9.22	9.94	8.99	0.95	2.6%
85	6.26	6.91	6.04	0.87	3.6%
90	4.17	4.68	3.85	0.82	5.3%
95	2.66	3.10	2.38	0.72	7.6%

Table 2.16.6
Switzerland: Distribution of age at death given survival to age 65
Summary Statistics

	Male			female		
	2007 population	2003 population	difference	2007 population	2003 population	difference
Lower Quartile age	77.69	76.53	1.16	81.87	80.17	1.70
Median age	84.09	82.25	1.84	87.75	86.27	1.49
Upper Quartile age	89.46	88.86	0.59	92.80	91.58	1.22
Inter quartile range	11.77	12.33	-0.56	10.93	11.41	-0.49
e_{65}	18.45	17.19	1.27	21.86	20.71	1.15

2.17 United Kingdom

2.17.1 United Kingdom: population mortality

The 2006 population mortality experience for the United Kingdom available on the Human Mortality Database has been used in this study, without any adjustments. In the previous study, the 2001-2003 Interim Life Tables produced by the Government Actuary's Department (GAD) were used for comparison with pension-related mortality tables without any adjustments.

2.17.2 UK: mortality assumptions used to assess retirement liabilities within pension funding valuations

For occupational pension schemes in the UK, standard tables for pensioners published by The Continuous Mortality Investigations Committee (CMI) of The Actuarial Profession are usually used (with suitable adjustments to reflect any significant differences in the mortality experience of the scheme). In this study, the "S1" series tables, S1PMA and S1PFA mortality tables for males and females respectively are assumed for pension benefits. The tables are based on the 2000-2006 mortality data (collected by 30 June 2007) of members of self-administered pension schemes (SAPS) submitted by actuarial consultancies and are based on the amount of pension paid. The method of construction of the tables and the assumptions used are detailed in CMI Working papers 34 and 35 (2008).

In the previous study, the PMA92 and PFA92 mortality tables constructed from the 1991 to 1994 mortality experience of occupational pensioners whose pensions have been bought from UK life offices were assumed. These tables are also amounts-based mortality tables.

2.17.3 UK: projected mortality

The tables produced by the CMI allow for mortality improvements. The particular tables used in this study are mortality rates projected using the CMI_2009 Projection Model described in CMI Working papers 38, 39 and 41 (2009). The mortality tables assumed are thus the S1PMA_CMI_2009 and S1PFA_CMI_2009. (In this study the tables are referred to as simply S1PMA and S1PFA.) The structure of the model is based on the projection of annual rates of mortality improvement (i.e. the pace of change in mortality rates). The projection model assumes that ‘current’ (i.e. recently observed) rates of change blend over time into a ‘long-term’ rate of change specified by the user. The initial mortality improvement rates are based on the England and Wales population data. In this study, results presented are based on two long-term improvement rates: 1.25% and 1%, the tables assumed here being the mortality rates projected to 2020.

In the previous study, the mortality tables assumed were the mortality rates projected to the calendar year 2010 (PMAC10 and PFAC10), incorporating the CMI’s medium cohort projection basis to reflect further improvements in mortality since the tables were published.

2.17.4 UK: results

A summary of the results obtained from a comparative analysis of the UK population mortality experience in 2006 and the projected S1PMA/S1PFA tables assumed for retirement related benefits is given in Tables 2.17.1a and 2.17.1b. From the tables it can be seen that the present value of annuity rates derived on the basis of the S1PMA and the S1PFA mortality tables assumed for pension liability calculations are higher than annuity rates derived on the basis of the current population mortality, which is consistent with lighter mortality experience for pensioners. For example, assuming a discount rate of 3% per annum and a long-term improvement rate of 1% in pensioners’ mortality, the difference between the present value of the annuity rate assumed for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 18.4% for males and 12.4% for females, expressed as a percentage of the population value. The corresponding percentage differences assuming a long – term mortality improvement rate of 1.25% in pensioners’ mortality are 18.9% for males and 12.8% for females. When a reversionary widow’s pension of 60% of a male member’s pension is included, the percentage differences between male annuity rates at age 65 are 12.6% and 13% assuming long term improvement rates of 1% and 1.25% respectively, and a discount rate of 3%.

Figures 2.17.1a, 2.17.1b, and Tables 2.17.2a, 2.17.2b show comparisons of the observed probabilities of death (q_x rates) based on the 2006 population mortality experience and the projected S1PMA/S1PFA mortality tables. It can be seen that for both the S1PMA and the S1PFA mortality tables exhibit considerably lighter mortality than the observed population at all ages except for females aged 55 years and under. For example, assuming a long-term mortality improvement rate of 1%, the probability from the S1PMA mortality tables that a 65-year male will die before his 66th birthday is 54% of the probability derived from the UK male population experience. The corresponding proportion for a 65-year old female is 63%. The same trends are depicted in Figures 2.17.2a and 2.17.2b which show the ratios of probabilities of death from the S1PMA and the S1PFA mortality tables to probabilities of death derived from the male and female population mortality experiences respectively.

Figures 2.17.3a and 2.17.3b show age-related ratios of female probabilities of death to male probabilities of death based on pension-related tables and population mortality experience. For the population mortality experience, the difference between male and female mortality rates is generally decreasing as age increases with the female mortality rates being consistently lower than male mortality rates. In contrast, for the assumed pensioners' tables, females under age 55 experience heavier mortality than females from the general population.

Tables 2.17.3a, 2.17.3b and Figures 2.17.4a, 2.17.4b show comparisons of expected future lifetime (e_x) values for an individual aged x based on the projected S1PMA and S1PFA mortality tables with corresponding expected future lifetime values for the population. Expressed as a percentage of the expected future lifetime value derived from the population mortality experience, the proportional differences at age 65 are: 23.1% for males and 16% for females, assuming a long-term improvement rate of 1% (Tables 2.17.1a and 2.17.3a); 23.8% for males and 16.6% for females, assuming a long-term improvement rate of 1.25% (Tables 2.17.1b and 2.17.3b). Based on the S1PMA and S1PFA mortality tables using a 1% long-term mortality improvement rate, the life expectancy at age 65 is 3.97 years longer for males and 3.19 years longer for females compared to the observed male and female population respectively. The corresponding differences when a long-term improvement rate of 1.25% is assumed are 4.1 years for males and 3.32 years for females.

Figures 2.17.5a, 2.17.5b, 2.17.6a, 2.17.6b, 2.17.7a, 2.17.7b, 2.17.8a, 2.17.8b and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \leq k \leq 100-x$. Considering age 65 and a 1% long-term mortality improvement rate (Figures 2.17.7a and the associated table), it is noted that whereas a 65-year old male would be expected to live to age 86.2 on the basis of the S1PMA tables and to age 82.23 years on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to age 92.5 years on the basis of the S1PMA mortality tables and to age 88.58 years on the basis of the male population mortality experience. For females, whereas a 65-year old female would be expected to live to age 88.16 years on the basis of the S1PFA tables and to about age 85 on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to age 94.6 years on the basis of the S1PFA tables and to about age 91.7 years on the basis of the female population experience.

Table 2.17.1a

UK: Summary Statistics (CMI_2009_1% projection basis for pensioners)

age x = 50

	male				female			
	population	S1PMA	difference	percentage difference	population	S1PFA	difference	percentage difference
e_x	29.67	34.38	4.71	15.9	33.14	36.34	3.20	9.7
a_x : 3%	18.49	20.39	1.90	10.3	19.94	21.07	1.13	5.7
a_x : 6%	12.89	13.75	0.85	6.6	13.57	14.00	0.43	3.2

age x = 60

	male				female			
	population	S1PMA	difference	percentage difference	population	S1PFA	difference	percentage difference
e_x	21.12	25.51	4.38	20.8	24.19	27.57	3.37	13.9
a_x : 3%	14.51	16.78	2.27	15.6	16.12	17.75	1.62	10.1
a_x : 6%	10.85	12.12	1.26	11.6	11.77	12.61	0.85	7.2
$a_x + .6a_{x\|y}$: 3%	17.20	19.02	1.81	10.6				

age x = 65

	male				female			
	population	S1PMA	difference	percentage difference	population	S1PFA	difference	percentage difference
e_x	17.23	21.20	3.97	23.1	19.98	23.16	3.19	16.0
a_x : 3%	12.38	14.66	2.28	18.4	13.98	15.70	1.73	12.4
a_x : 6%	9.60	10.99	1.39	14.5	10.59	11.59	1.00	9.4
$a_x + .6a_{x\|y}$: 3%	15.12	17.03	1.91	12.6				

age x = 70

	male				female			
	population	S1PMA	difference	percentage difference	population	S1PFA	difference	percentage difference
e_x	13.64	17.13	3.49	25.6	16.00	18.88	2.88	18.0
a_x : 3%	10.20	12.42	2.22	21.7	11.71	13.45	1.74	14.9
a_x : 6%	8.20	9.68	1.47	18.0	9.22	10.32	1.11	12.0

Table 2.17.1b

UK: Summary Statistics CMI_2009_1.25% projection basis for pensioners

age x = 50

	male				female			
	population	S1PMA	difference	percentage difference	population	S1PFA	difference	percentage difference
e_x	29.67	34.53	4.86	16.4	33.14	36.49	3.35	10.1
a_x : 3%	18.49	20.44	1.96	10.6	19.94	21.12	1.18	5.9
a_x : 6%	12.89	13.77	0.88	6.8	13.57	14.02	0.45	3.3

age x = 60

	male				female			
	population	S1PMA	difference	percentage difference	population	S1PFA	difference	percentage difference
e_x	21.12	25.64	4.51	21.4	24.19	27.70	3.51	14.5
a_x : 3%	14.51	16.83	2.32	16.0	16.12	17.80	1.68	10.4
a_x : 6%	10.85	12.14	1.29	11.9	11.77	12.64	0.87	7.4
$a_x + .6a_{x\|y}$: 3%	17.20	19.07	1.87	10.9				

age x = 65

	male				female			
	population	S1PMA	difference	percentage difference	population	S1PFA	difference	percentage difference
e_x	17.23	21.33	4.10	23.8	19.98	23.29	3.32	16.6
a_x : 3%	12.38	14.72	2.34	18.9	13.98	15.76	1.79	12.8
a_x : 6%	9.60	11.02	1.42	14.8	10.59	11.62	1.03	9.7
$a_x + .6a_{x\|y}$: 3%	15.12	17.09	1.97	13.0				

age x = 70

	male				female			
	population	S1PMA	difference	percentage difference	population	S1PFA	difference	percentage difference
e_x	13.64	17.25	3.61	26.5	16.00	19.01	3.01	18.8
a_x : 3%	10.20	12.48	2.28	22.4	11.71	13.52	1.81	15.4
a_x : 6%	8.20	9.72	1.51	18.4	9.22	10.36	1.14	12.4

Table 2.17.2a

UK: One-year probabilities of death (q_x rates) CMI_2009_1% projection basis for pensioners

age	male			female		
	population	S1PMA	ratio	population	S1PFA	ratio
50	0.003790	0.002915	0.77	0.002610	0.003544	1.36
55	0.005920	0.003906	0.66	0.003690	0.003883	1.05
60	0.008950	0.004934	0.55	0.005430	0.004240	0.78
65	0.014890	0.007969	0.54	0.009080	0.005742	0.63
70	0.023980	0.012695	0.53	0.015030	0.008969	0.60
75	0.040290	0.021005	0.52	0.026900	0.015311	0.57
80	0.069160	0.037858	0.55	0.047260	0.028912	0.61
85	0.113760	0.072469	0.64	0.084480	0.056184	0.67
90	0.173740	0.128929	0.74	0.141850	0.104987	0.74
95	0.257140	0.226535	0.88	0.229020	0.192419	0.84

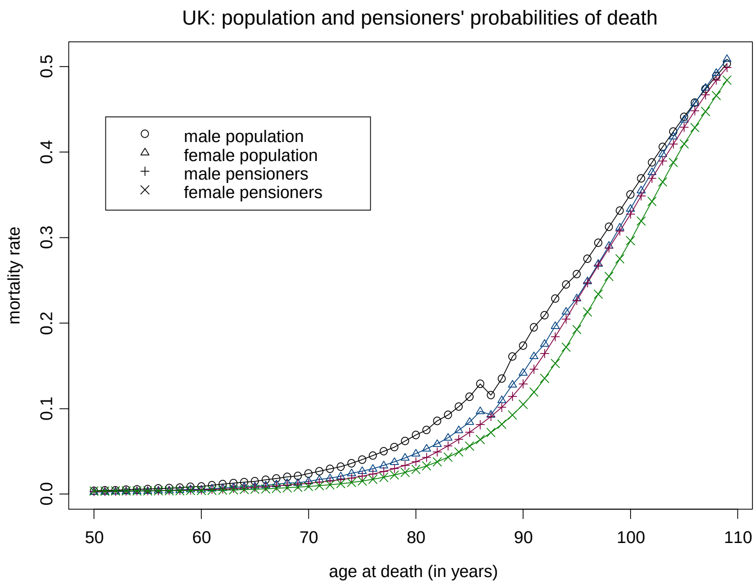


Figure 2.17.1a: CMI_2009_1% projection basis for pensioners

Table 2.17.2b

UK: One-year probabilities of death (q_x rates) CMI_2009_1.25% projection basis

	male			female		
age	population	S1PMA	ratio	population	S1PFA	ratio
50	0.003790	0.002846	0.75	0.002610	0.003460	1.33
55	0.005920	0.003838	0.65	0.003690	0.003814	1.03
60	0.008950	0.004873	0.54	0.005430	0.004188	0.77
65	0.014890	0.007872	0.53	0.009080	0.005671	0.62
70	0.023980	0.012539	0.52	0.015030	0.008859	0.59
75	0.040290	0.020746	0.51	0.026900	0.015122	0.56
80	0.069160	0.037391	0.54	0.047260	0.028556	0.60
85	0.113760	0.071185	0.63	0.084480	0.055190	0.65
90	0.173740	0.125859	0.72	0.141850	0.102492	0.72
95	0.257140	0.220886	0.86	0.229020	0.187626	0.82

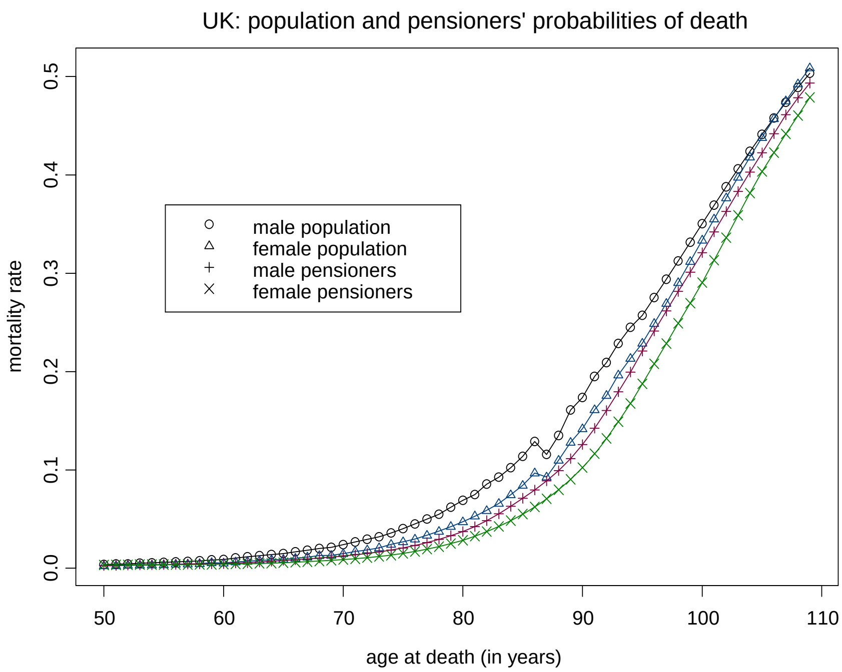


Figure 2.17.1b: CMI_2009_1.25% projection basis for pensioners

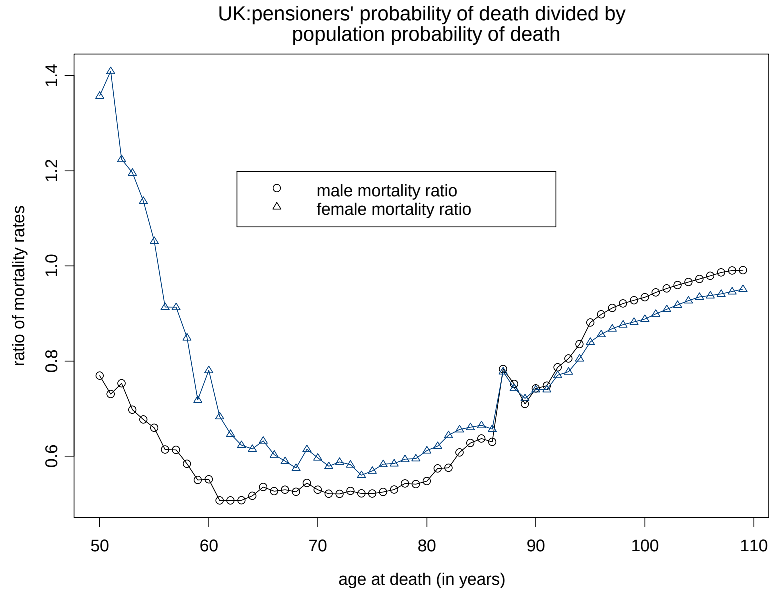


Figure 2.17.2a: CMI_2009_1% projection basis for pensioners

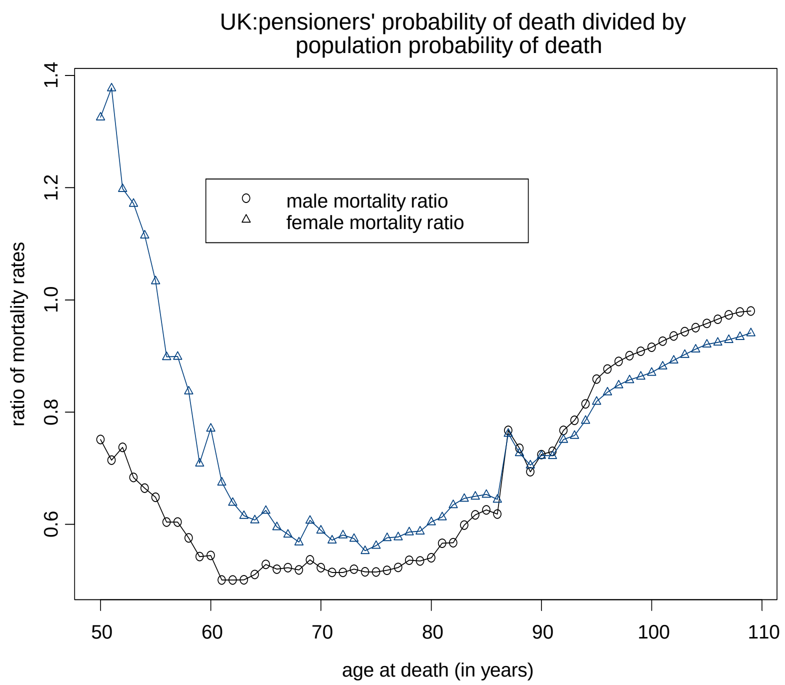


Figure 2.17.2b: CMI_2009_1.25% projection basis for pensioners

Figure 2.17.3a: CMI_2009_1% projection basis for pensioners

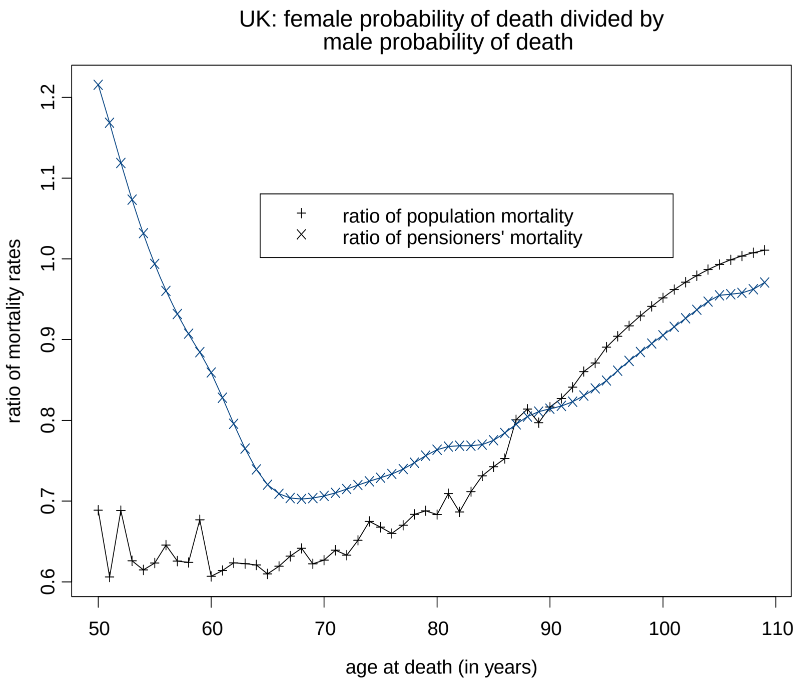


Figure 2.17.3b: CMI_2009_1.25% projection basis for pensioners

Table 2.17.3a
UK: Expected complete future lifetime in years CMI_2009_1% projection basis for pensioners

	male				female			
age	population	S1PMA	difference	percentage difference	population	S1PFA	difference	percentage difference
50	29.67	34.38	4.71	15.9	33.14	36.34	3.20	9.7
55	25.30	29.92	4.62	18.2	28.59	31.97	3.38	11.8
60	21.12	25.51	4.38	20.8	24.19	27.57	3.37	13.9
65	17.23	21.20	3.97	23.1	19.98	23.16	3.19	16.0
70	13.64	17.13	3.49	25.6	16.00	18.88	2.88	18.0
75	10.42	13.31	2.89	27.7	12.35	14.81	2.46	19.9
80	7.73	9.86	2.13	27.5	9.19	11.10	1.91	20.8
85	5.64	6.97	1.33	23.6	6.58	7.92	1.35	20.5
90	3.96	4.72	0.76	19.3	4.51	5.39	0.88	19.5
95	2.88	3.17	0.28	9.9	3.14	3.58	0.44	14.0

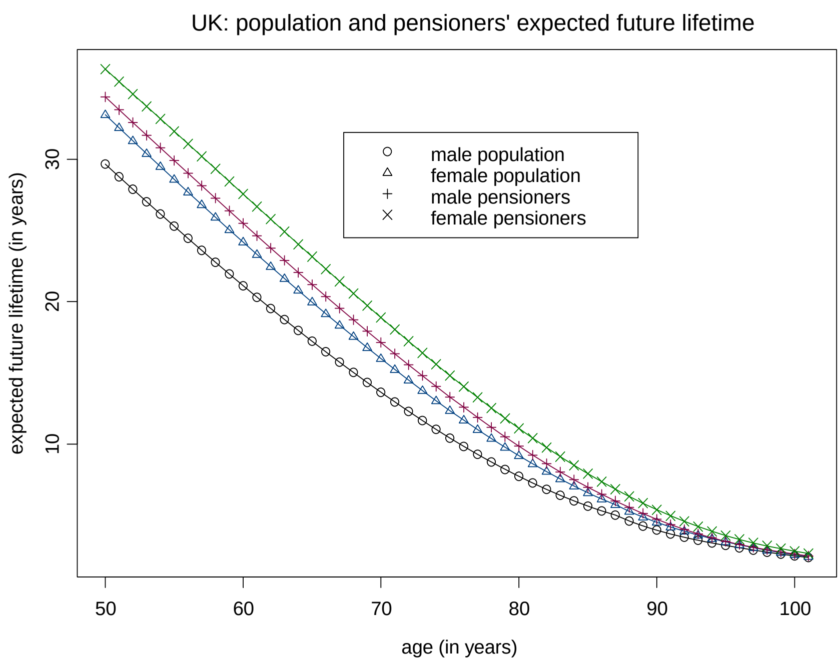


Figure 2.17.4a: CMI_2009_1% projection basis for pensioners

Table 2.17.3b
UK: Expected complete future lifetime in years CMI_2009_1.25%

age	male				female			
	population	S1PMA	difference	percentage difference	population	S1PFA	difference	percentage difference
50	29.67	34.53	4.86	16.4	33.14	36.49	3.35	10.1
55	25.30	30.05	4.75	18.8	28.59	32.11	3.52	12.3
60	21.12	25.64	4.51	21.4	24.19	27.70	3.51	14.5
65	17.23	21.33	4.10	23.8	19.98	23.29	3.32	16.6
70	13.64	17.25	3.61	26.5	16.00	19.01	3.01	18.8
75	10.42	13.42	3.00	28.8	12.35	14.93	2.58	20.9
80	7.73	9.97	2.24	28.9	9.19	11.22	2.03	22.0
85	5.64	7.08	1.43	25.4	6.58	8.03	1.46	22.2
90	3.96	4.81	0.85	21.6	4.51	5.49	0.98	21.6
95	2.88	3.24	0.35	12.3	3.14	3.65	0.51	16.3

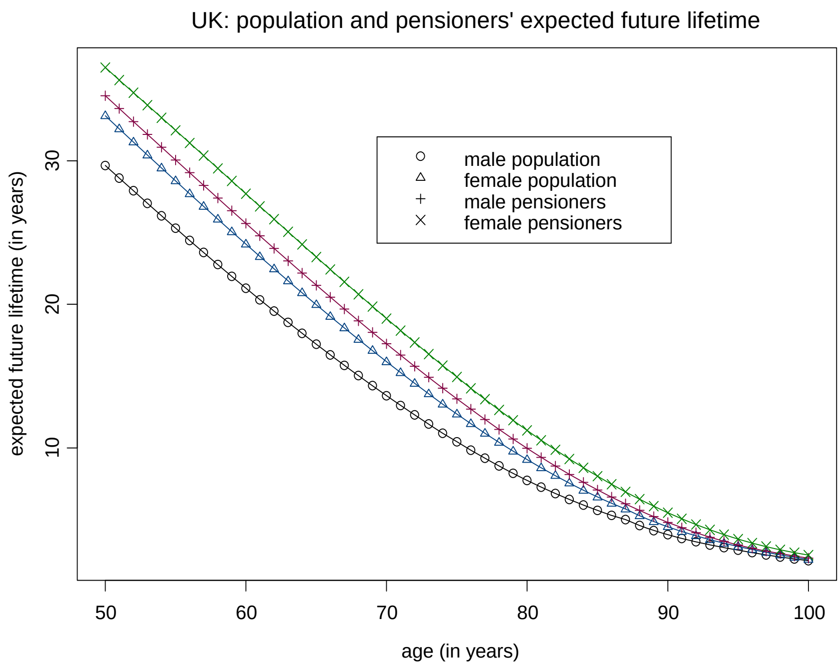


Figure 2.17.4b: CMI_2009_1.25% projection basis for pensioners

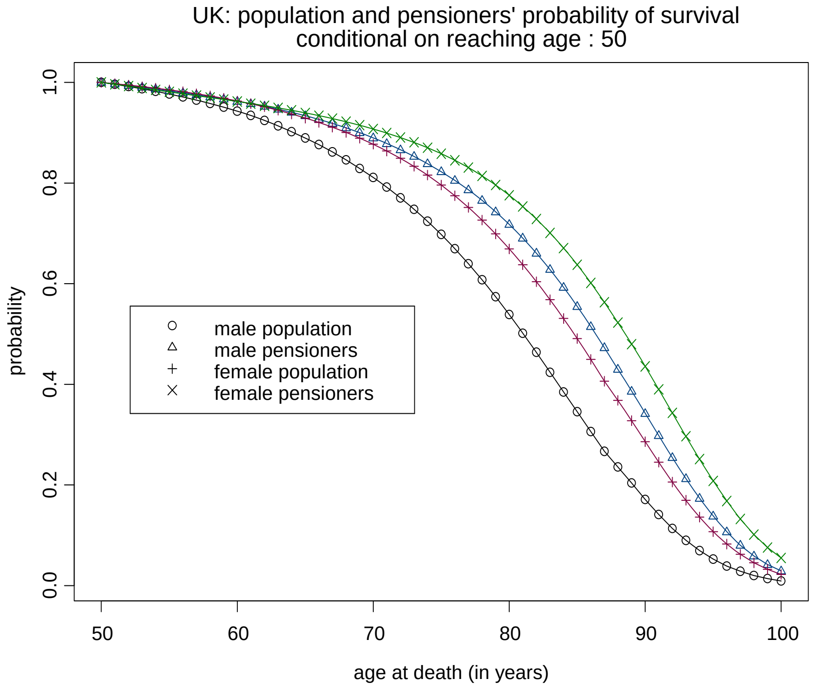


Figure 2.17.5a: CMI_2009_1% projection basis for pensioners

UK: Distribution of age at death given survival to age 50: CMI_2009_1% projection basis

Summary Statistics

	male			female		
	population	S1PMA	difference	population	S1PFA	difference
Lower Quartile age	72.09	78.32	6.23	77.93	81.86	3.93
Median age	81.97	86.65	4.68	84.22	88.47	4.24
Upper Quartile age	87.46	92.89	5.43	90.12	94.97	4.85
Inter quartile range	15.37	14.57	-0.80	12.18	13.11	0.92
e_{50}	29.67	34.38	4.71	33.14	36.34	3.20

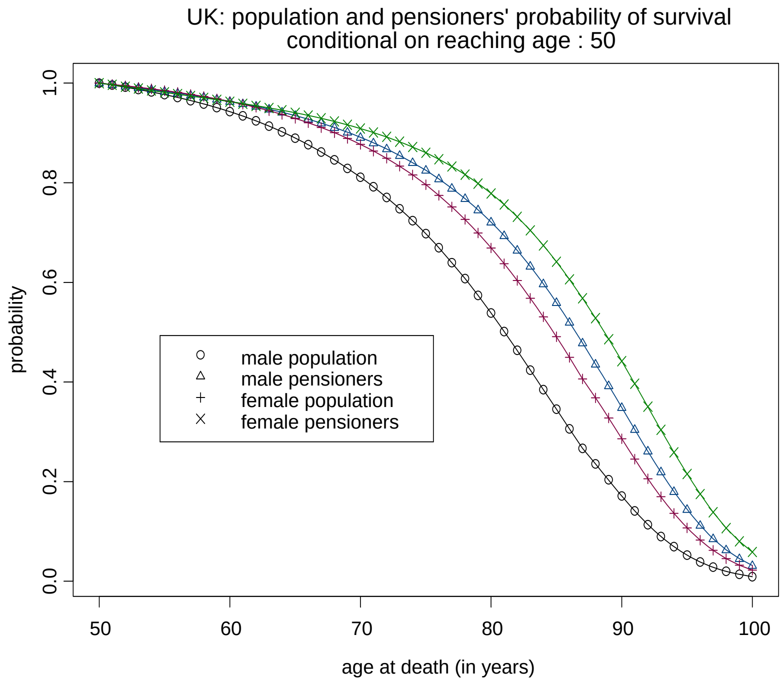


Figure 2.17.5b: CMI_2009_1.25% projection basis for pensioners

UK: Distribution of age at death given survival to age 50 CMI_2009_1.25%

Summary Statistics

	male			female		
	population	S1PMA	difference	population	S1PFA	difference
Lower Quartile age	72.09	78.19	6.10	77.93	81.75	3.81
Median age	81.97	86.53	4.56	84.22	88.33	4.11
Upper Quartile age	87.46	92.73	5.27	90.12	94.80	4.68
Inter quartile range	15.37	14.54	-0.84	12.18	13.05	0.87
e_{50}	29.67	34.53	4.86	33.14	36.49	3.35

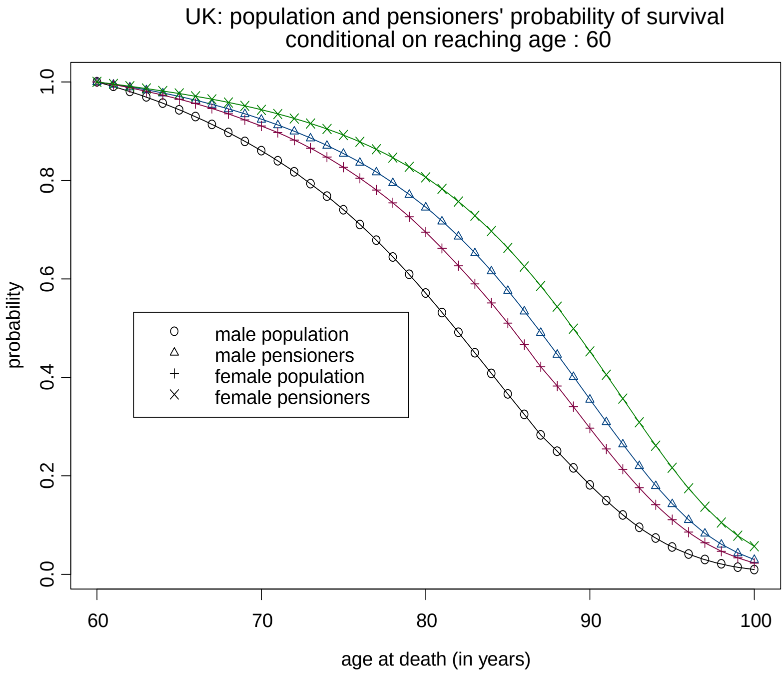


Figure 2.17.6a: CMI_2009_1% projection basis for pensioners

UK: Distribution of age at death given survival to age 60: CMI_2009_1% projection basis

Summary Statistics

	male			female		
	population	S1PMA	difference	population	S1PFA	difference
Lower Quartile age	74.36	79.17	4.81	78.85	82.75	3.90
Median age	81.21	86.20	4.99	85.77	88.02	2.26
Upper Quartile age	89.00	92.67	3.67	91.89	94.75	2.86
Inter quartile range	14.64	13.50	-1.14	13.04	12.00	-1.04
e_{60}	21.12	25.51	4.38	24.19	27.57	3.37

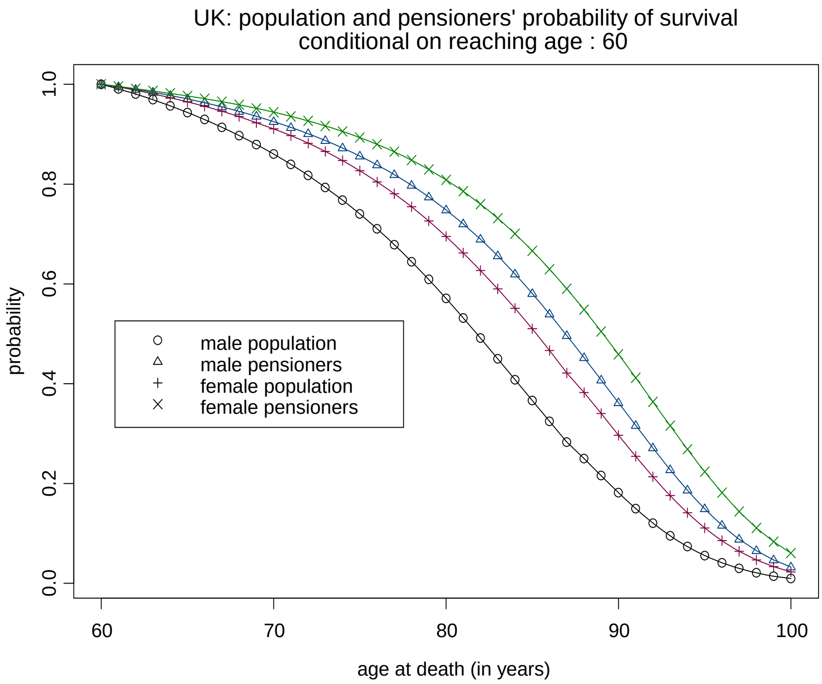


Figure 2.17.6b: CMI_2009_1.25% projection basis for pensioners

UK: Distribution of age at death given survival to age 60 CMI_2009_1.25%

Summary Statistics

	male			Female		
	population	S1PMA	difference	population	S1PFA	difference
Lower Quartile age	74.36	79.06	4.71	78.85	82.65	3.81
Median age	81.21	86.08	4.87	85.77	89.90	4.13
Upper Quartile age	89.00	92.51	3.51	91.89	94.58	2.70
Inter quartile range	14.64	13.45	-1.20	13.04	11.93	-1.11
e_{60}	21.12	25.64	4.51	24.19	27.70	3.51

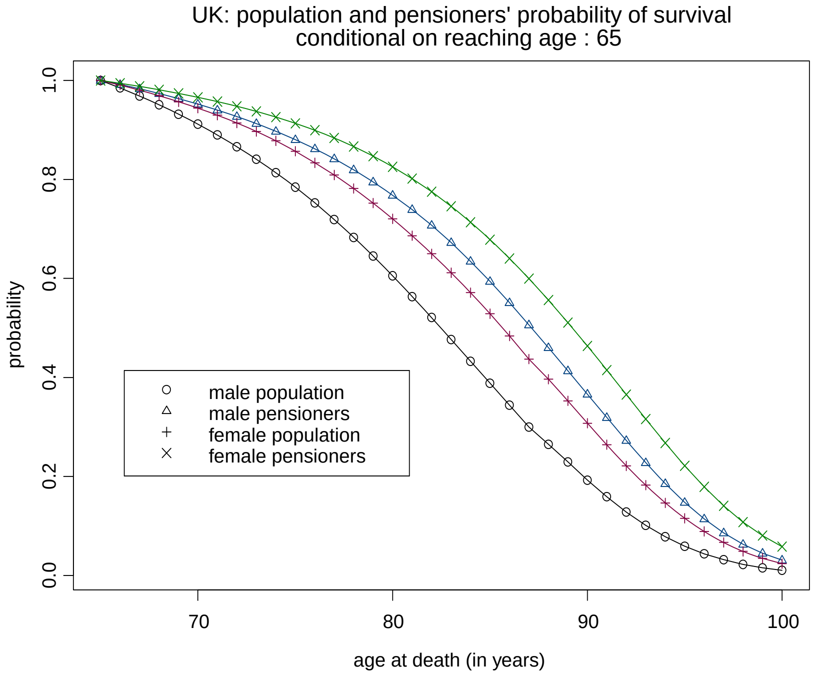


Figure 2.17.7a: CMI_2009_1% projection basis for pensioners

UK: Distribution of age at death given survival to age 65 CMI_2009_1%

Summary Statistics

	male			female		
	population	S1PMA	difference	population	S1PFA	difference
Lower Quartile age	76.92	80.37	3.46	79.92	82.14	2.21
Median age	82.52	87.87	5.34	85.36	89.77	4.41
Upper Quartile age	88.58	92.50	3.92	91.67	94.62	2.95
Inter quartile range	11.67	12.13	0.46	11.75	12.48	0.73
e_{65}	17.23	21.20	3.97	19.98	23.16	3.19

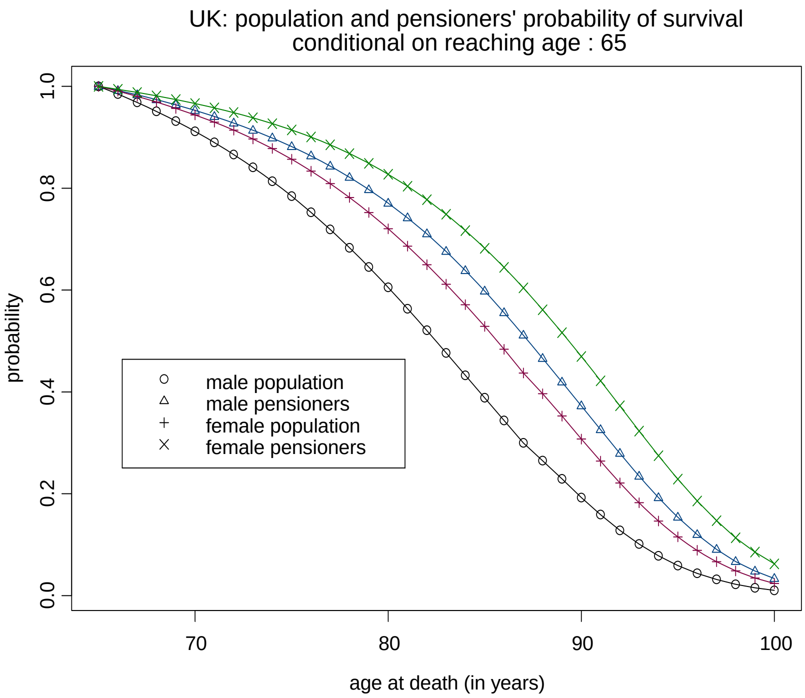


Figure 2.17.7b: CMI_2009_1.25% projection basis for pensioners

UK: Distribution of age at death given survival to age 65 CMI_2009_1.25%
Summary Statistics

	male			female		
	population	S1PMA	difference	population	S1PFA	difference
Lower Quartile age	76.92	80.28	3.36	79.92	82.04	2.12
Median age	82.52	87.75	5.22	85.36	89.64	4.29
Upper Quartile age	88.58	92.34	3.76	91.67	94.46	2.78
Inter quartile range	11.67	12.06	0.40	11.75	12.42	0.67
e_{65}	17.23	21.33	4.10	19.98	23.29	3.32

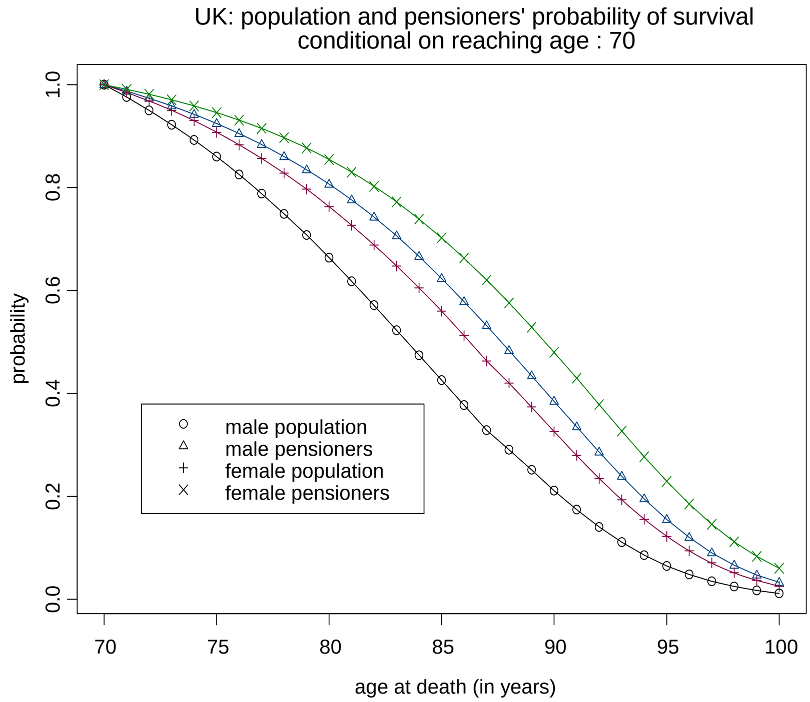


Figure 2.17.8a: CMI_2009_1% projection basis for pensioners

UK: Distribution of age at death given survival to age 70 CMI_2009_1%

Summary Statistics

	male			female		
	population	S1PMA	Difference	population	S1PFA	difference
Lower Quartile age	77.03	81.22	4.19	80.64	83.34	2.70
Median age	83.53	87.35	3.81	86.75	89.41	2.66
Upper Quartile age	89.97	92.23	2.27	91.34	94.43	3.09
Inter quartile range	12.94	11.01	-1.92	10.70	11.10	0.39
e_{70}	13.64	17.13	3.49	16.00	18.88	2.88

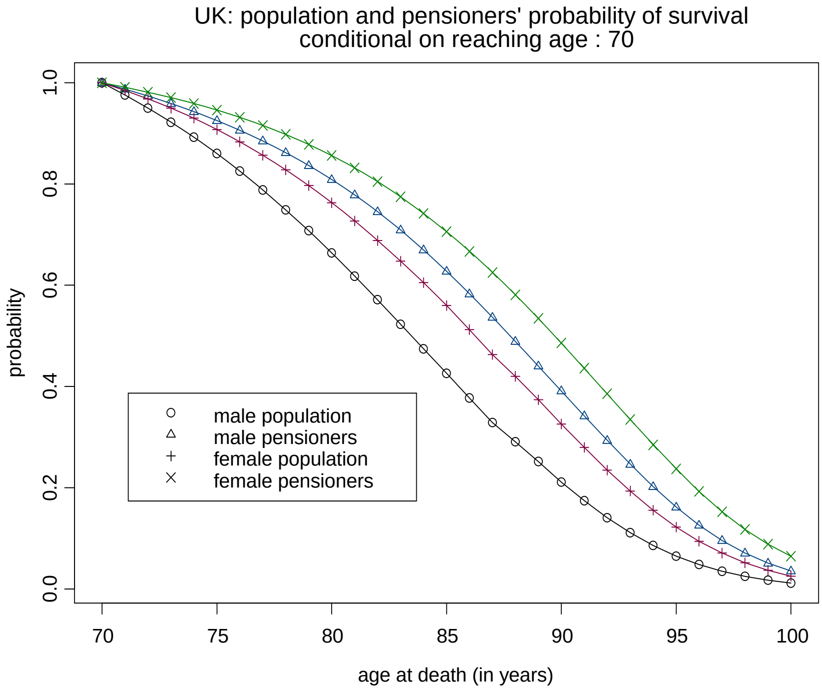


Figure 2.17.8b: CMI_2009_1.25% projection basis for pensioners

UK: Distribution of age at death given survival to age 70 CMI_2009_1.25%
Summary Statistics

	male			female		
	population	S1PMA	Difference	population	S1PFA	difference
Lower Quartile age	77.03	81.14	4.11	80.64	83.25	2.61
Median age	83.53	87.23	3.70	86.75	89.29	2.54
Upper Quartile age	89.97	92.08	2.11	91.34	94.27	2.93
Inter quartile range	12.94	10.95	-1.99	10.70	11.02	0.32
e_{70}	13.64	17.25	3.61	16.00	19.01	3.01

2.17.5 UK results: comparison with previous study

Figures 2.17.9a, 2.17.9b, 2.17.10a and 2.17.10b compare the probabilities of death shown in Figures 2.17.1a and 2.17.1b with probabilities of death from the 2001-2003 Interim Life Tables, the population mortality experience used in the previous study, and the PMAC10/PFAC10 mortality tables for males and females separately. The expected future lifetimes are compared in Figures 2.17.11a, 2.17.11b, 2.17.12a and 2.17.12b.

Clearly, there has been an improvement in population mortality between 2001-2003 and 2006 at all ages for both males and females. From the annualised percentage changes in expected future lifetime for the population shown in Tables 2.17.4 and 2.17.5, it is apparent that the rate of improvement in population mortality at each age is higher for males. In calculating the annualised percentage changes in expected future lifetime, the Interim Life Tables 2001-2003 have been assumed to pertain to the year 2002.

For pensioners, the differences at each age between the PMA92C10 and the projected S1PMA mortality tables assumed for pension-related benefits would appear to indicate a longer expected future lifetime under the earlier basis for males aged under 60 years. On the other hand, females are expected to live longer at each age on the basis of the earlier PFA92C10 mortality basis compared to the current projected S1PFA basis.

Table 2.17.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the 2006 UK male population would be expected to live to age 88.4 years, the same proportion of 65-year old males from the 2001-2003 UK male population would be expected to live to age 87.9 years approximately, the actual difference being about half a year. For females, the difference from a similar comparison is higher: 25% of the 2006 female UK population alive at age 65 is expected to live to about age 91.3 years while the same proportion from the 2001-2003 UK female population is expected to live to about age 90.7 years, the actual difference being about 8 months. For pensioners, on the basis of the projected S1PMA mortality table, the upper 25% of 65-year old males would be expected to live longer than on the basis of the PMA92C10, whilst the upper 25% of females would be expected to live longer on the basis of the PFA92C10.

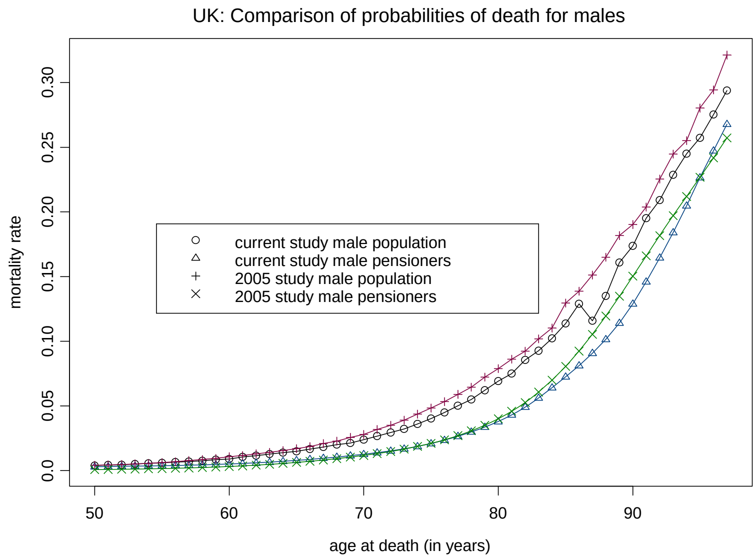


Figure 2.17.9a: CMI_2009_1% projection basis for pensioners

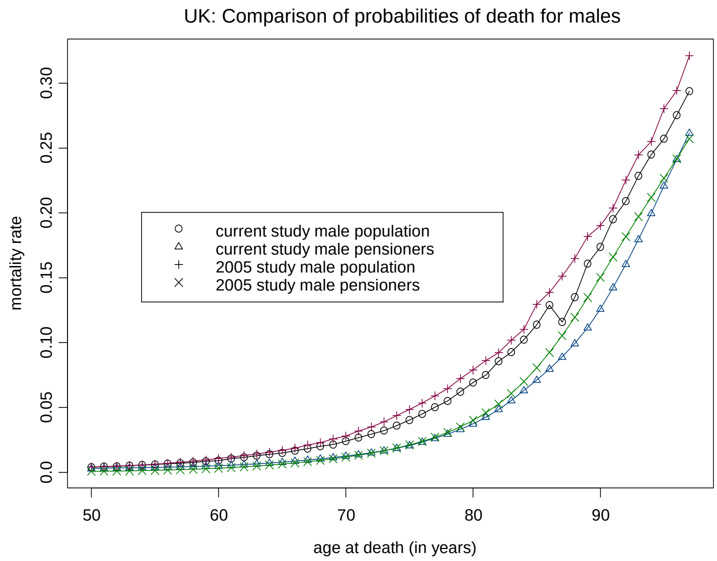


Figure 2.17.9b: CMI_2009_1.25% projection basis for pensioners

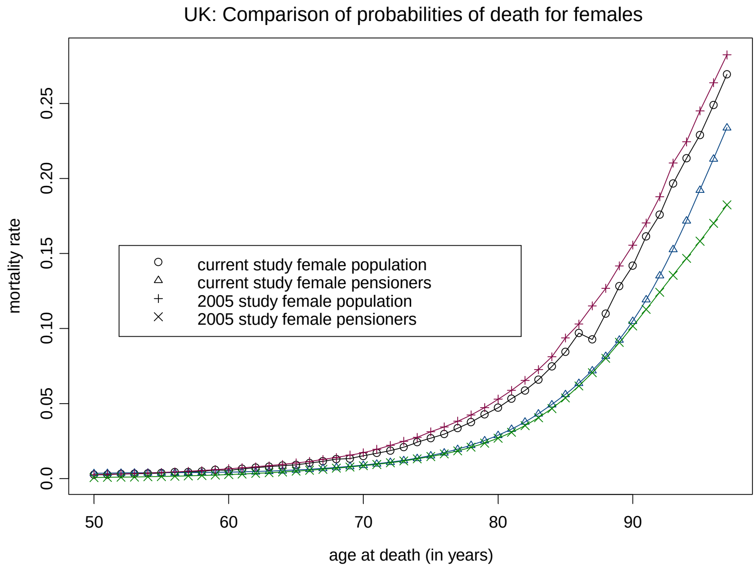


Figure 2.17.10a: CMI_2009_1% projection basis for pensioners

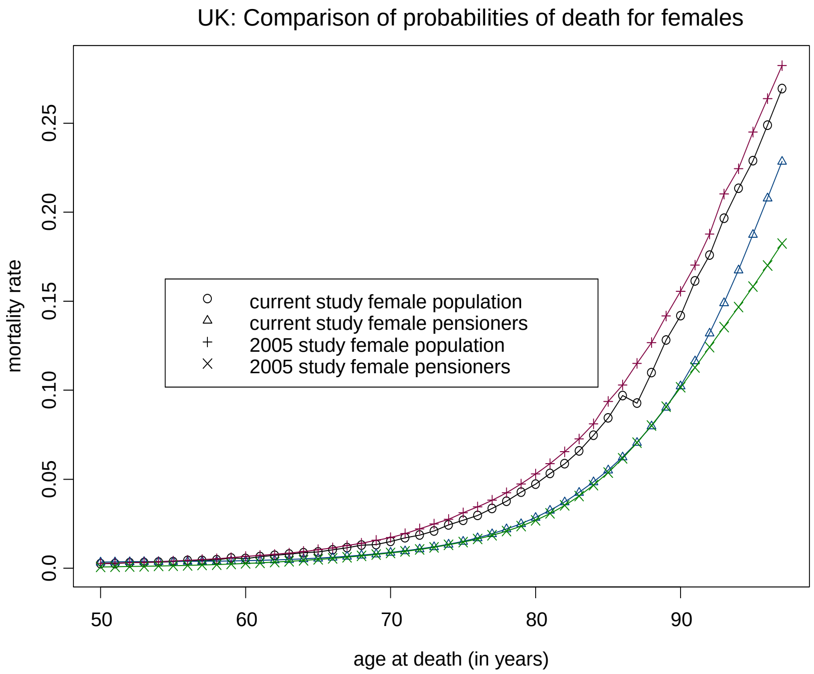


Figure 2.17.10b: CMI_2009_1.25% projection basis for pensioners

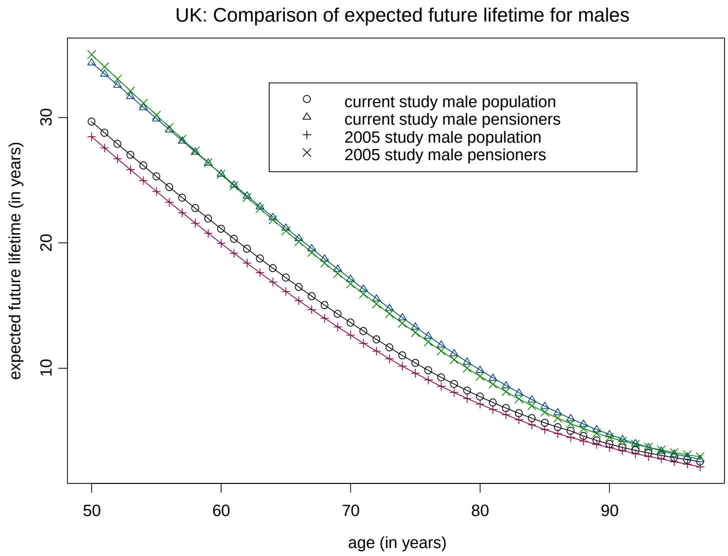


Figure 2.17.11a: CMI_2009_1% projection basis for pensioners

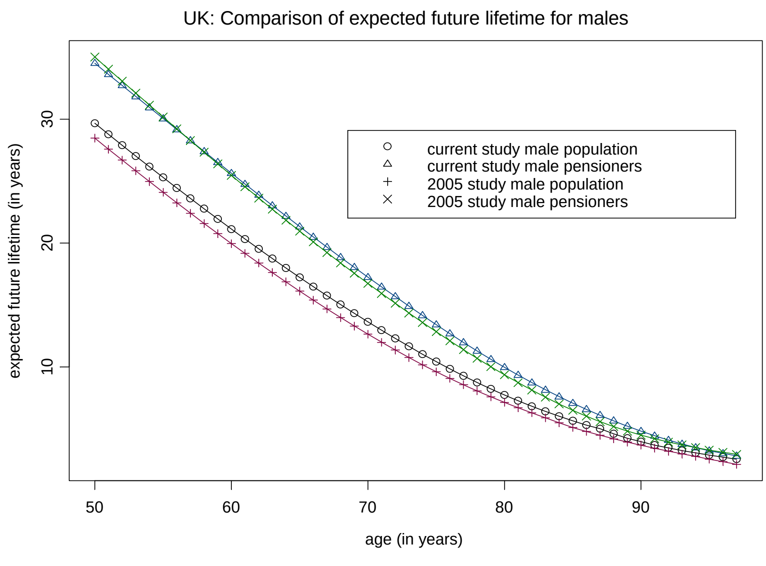


Figure 2.17.11b: CMI_2009_1.25% projection basis for pensioners

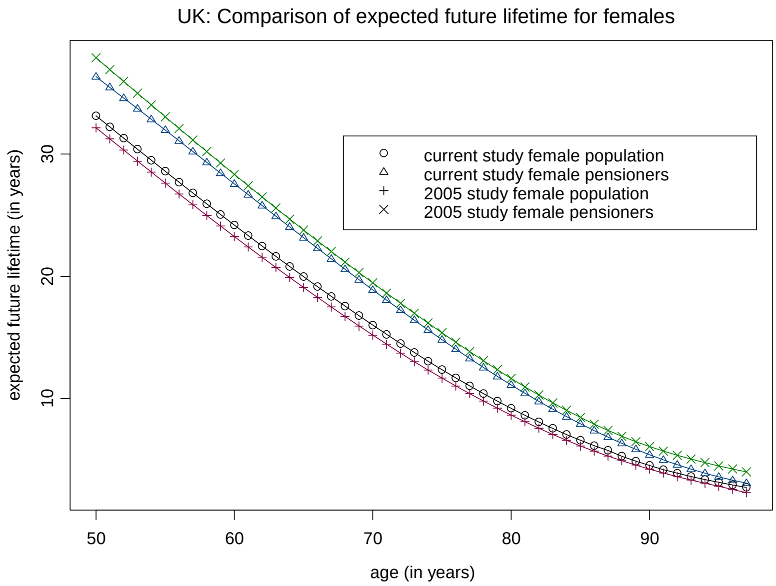


Figure 2.17.12a: CMI_2009_1% projection basis for pensioners

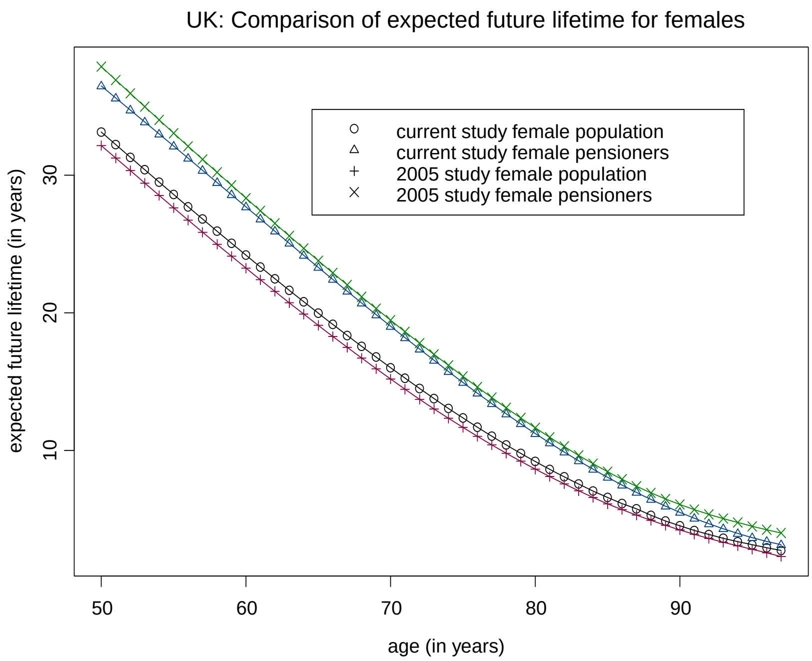


Figure 2.17.12b: CMI_2009_1.25% projection basis for pensioners

Table 2.17.4
UK: Comparison of expected complete future lifetime for males

	S1PMA			Male population			
	CMI_2009_1.25%	CMI_2009_1%	PMA92C10	2006 population	2002 population	difference	Annualised percentage difference
50	34.53	34.38	35.02	29.67	28.47	1.20	1.0%
55	30.05	29.92	30.18	25.30	24.10	1.20	1.2%
60	25.64	25.51	25.47	21.12	19.95	1.17	1.5%
65	21.33	21.20	20.96	17.23	16.13	1.10	1.7%
70	17.25	17.13	16.74	13.64	12.64	1.00	2.0%
75	13.42	13.31	12.84	10.42	9.61	0.81	2.1%
80	9.97	9.86	9.36	7.73	7.14	0.59	2.1%
85	7.08	6.97	6.50	5.64	5.11	0.53	2.6%
90	4.81	4.72	4.49	3.96	3.69	0.27	1.8%
95	3.24	3.17	3.29	2.88	2.55	0.33	3.2%

Table 2.17.5
UK: Comparison of expected complete future lifetime for females

	S1PFA			Female population			
	CMI_2009_1.25%	CMI_2009_1%	PFA92C10	2006 population	2002 population	difference	Annualised percentage difference
50	36.49	36.34	37.89	33.14	32.16	0.98	0.8%
55	32.11	31.97	33.06	28.59	27.63	0.97	0.9%
60	27.70	27.57	28.34	24.19	23.25	0.95	1.0%
65	23.29	23.16	23.79	19.98	19.08	0.89	1.2%
70	19.01	18.88	19.46	16.00	15.18	0.82	1.4%
75	14.93	14.81	15.38	12.35	11.66	0.69	1.5%
80	11.22	11.10	11.64	9.19	8.63	0.56	1.6%
85	8.03	7.92	8.45	6.58	6.11	0.47	1.9%
90	5.49	5.39	6.06	4.51	4.21	0.30	1.8%
95	3.65	3.58	4.48	3.14	2.80	0.34	3.0%

Table 2.17.6
UK: Distribution of age at death given survival to age 65
Summary Statistics

	Male			female		
	2006 population	2002 population	difference	2006 population	2002 population	difference
Lower Quartile age	76.08	75.98	0.10	79.08	78.88	0.20
Median age	82.48	81.80	0.67	85.64	84.28	1.36
Upper Quartile age	88.42	87.93	0.49	91.33	90.68	0.65
Inter quartile range	12.33	11.94	0.39	12.25	11.80	0.45
e_{65}	17.23	16.13	1.10	19.98	19.08	0.89

Summary Statistics based on the S1PXA tables projected to 2020 and the PXA92C10

	Male			female		
	CMI_2009 _1.25%	CMI_2009 _1%	PMA92C10	CMI_2009 _1.25%	CMI_2009 _1%	PFA92C10
Lower Quartile age	80.28	80.37	80.75	82.04	82.14	83.32
Median age	87.75	87.87	86.78	89.64	89.77	89.58
Upper Quartile age	92.34	92.50	91.71	94.46	94.62	94.93
Inter quartile range	12.06	12.13	10.96	12.42	12.48	11.61
e_{65}	21.33	21.20	20.96	23.29	23.16	23.78

2.18 United States

2.18.1 United States: population mortality

The United States population mortality experience in 2006 available on the Human Mortality Database has been used in this study, without any adjustments. In the previous study, the population mortality tables used for comparison with pension-related mortality tables were the United States Life Tables, 2002 prepared by the Division of Vital Statistics. No adjustments were made to the mortality rates.

2.18.2 USA: mortality assumptions used to assess retirement liabilities within pension funding valuations

The RP-2000 mortality tables have been assumed to be the most commonly used mortality tables for pension plans. The RP-2000 tables were constructed from the 1990-94 mortality experience, and then projected to the base year 2000. However, the Society of Actuaries in the US is currently calling for a study/project to update the RP-2000 mortality tables.

2.18.3 USA: projected mortality

The RP-2000 tables allow for projections to calendar years beyond 2000. In this study, the rates applicable to year 2010 have been assumed to be the most widely used mortality rates. In the previous study, the rates applicable to the year 2000 were assumed to be the most widely used mortality rates for pension liability calculations.

2.18.4 USA: results

A summary of the results obtained from an analysis of US population mortality experience in 2006 and the RP-2000 mortality tables assumed for pension benefits is given in Table 2.18.1. From the table it can be seen that the present value of annuity rates derived on the basis of the RP-2000 mortality tables assumed for pension liability calculations are marginally higher than annuity rates derived on the basis of the 2006 population mortality. For example, assuming a discount rate of 3% per annum, the difference between the present value of the annuity rate derived for pension liability calculations and the annuity rate derived from the population mortality at age 65 is 5.1% for males and 1.3% for females, when expressed as a proportion of the population value. When a reversionary widow's pension of 60% of a male member's pension is included, the percentage difference between male annuity rates at age 65 is 2.4% assuming a discount rate of 3%.

Figure 2.18.1 and Table 2.18.2 compare the observed probabilities of death (q_x rates) based on the most recent (2006) population mortality experience with probabilities of death from the RP-2000 mortality tables. It can be seen that the RP-2000 mortality tables exhibit lighter mortality than the observed male population at ages below 85 years for males and at most ages for females. For example, the probability from the RP-2000 mortality tables that a 65-year old male will die before his 66^{th} birthday is 68% of the probability derived from the US male population experience. The corresponding proportion for a 65-year old female is 89%. The same trends are depicted in Figure 2.18.2 which shows the ratios of probabilities of death from the RP-2000 tables to probabilities of death derived from the male and female population mortality experiences as appropriate. A close examination of the ratios in Figure 2.18.2 shows that the RP-2000 mortality tables exhibit heavier mortality than the observed population for females at ages between 84 and 94 years.

Figure 2.18.3 shows age-related ratios of female probabilities of death to male probabilities of death based on the RP-2000 pension-related tables and the 2006 US population mortality experience. For the population mortality experience, the differences between male and female mortality rates are generally decreasing as age increases. Clearly on the basis of the RP-2000 mortality tables, females experience lighter mortality than males at each age.

Table 2.18.3 and Figure 2.18.4 show comparisons of expected future lifetime (e_x) values for an individual aged x based on the RP-2000 tables with corresponding expected future lifetime values for the population. On the basis of the RP-2000 tables, male pensioners aged up to about 75 years are expected to live longer than males of the same age from the 2006 US population. However, above age 75, the expected future lifetime for males from the general population is higher than for the assumed pensioner tables. On the other hand females from the 2006 US population generally have lower expected future life time at all ages. The life expectancy for a male aged 65 is about 11 months longer on the basis of the RP2000 table compared to the observed male population mortality while the life expectancy of a 65-year old female is about four months longer.

Figures 2.18.5, 2.18.6, 2.18.7 and 2.18.8 and the associated tables show conditional survival probabilities for an individual aged x (${}_kp_x$), where x = 50, 60, 65 or 70 and $0 \le k \le 100-x$. Considering age 65 (Figure 2.18.7 and the associated table), it is noted that whereas a 65-year old male would be expected to live to about age 83.4 years on the basis of the RP-2000 mortality tables and to about age 82.5 years on the basis of the population mortality experience, 25% of the males alive at age 65 would be expected to live to age 89.4 years on the basis of the RP-2000 mortality tables and to age 88.9 years on the basis of the population mortality experience. For females, whereas a 65-year old female would be expected to live to age 85.5 years on the basis of the pension-related RP-2000 tables and to age 85.2 years on the basis of the female population mortality experience, 25% of the females alive at age 65 would be expected to live to about age 92.1 years on either basis.

It should be reiterated that the Society of Actuaries in the US is currently calling for a study/project to update the RP-2000 mortality tables.

Table 2.18.1

USA: Summary Statistics, population and RP-2000

age x = 50

	male				female			
	population	RP-2000	difference	percentage difference	population	RP-2000	difference	percentage difference
e_x	29.21	31.14	1.93	6.6	32.96	33.77	0.81	2.5
a_x : 3%	18.14	19.13	0.98	5.4	19.75	20.15	0.40	2.0
a_x : 6%	12.65	13.19	0.54	4.2	13.44	13.65	0.22	1.6

age x = 60

	male				female			
	population	RP-2000	difference	percentage difference	population	RP-2000	difference	percentage difference
e_x	21.18	22.49	1.31	6.2	24.27	24.70	0.43	1.8
a_x : 3%	14.44	15.28	0.84	5.8	16.06	16.30	0.24	1.5
a_x : 6%	10.76	11.31	0.55	5.1	11.68	11.83	0.15	1.2
$a_x + .6a_{x\|y}$: 3%	17.24	17.72	0.49	2.8				

age x = 65

	male				female			
	population	RP-2000	difference	percentage difference	population	RP-2000	difference	percentage difference
e_x	17.48	18.37	0.89	5.1	20.22	20.53	0.31	1.5
a_x : 3%	12.45	13.08	0.64	5.1	14.03	14.21	0.18	1.3
a_x : 6%	9.60	10.06	0.46	4.8	10.57	10.69	0.12	1.1
$a_x + .6a_{x\|y}$: 3%	15.26	15.63	0.37	2.4				

age x = 70

	male				female			
	population	RP-2000	difference	percentage difference	population	RP-2000	difference	percentage difference
e_x	14.09	14.56	0.47	3.3	16.43	16.65	0.22	1.3
a_x : 3%	10.43	10.83	0.40	3.8	11.91	12.05	0.14	1.2
a_x : 6%	8.32	8.65	0.33	3.9	9.30	9.40	0.09	1.0

Table 2.18.2
USA: One-year probabilities of death (Initial rates of mortality, q_x rates)

Age	male			female		
	population	RP-2000	ratio	population	RP-2000	ratio
50	0.005650	0.004459	0.79	0.003270	0.001975	0.60
55	0.008050	0.004874	0.61	0.004680	0.003258	0.70
60	0.010920	0.006975	0.64	0.006830	0.005897	0.86
65	0.017170	0.011654	0.68	0.011070	0.009857	0.89
70	0.025680	0.019091	0.74	0.017270	0.015923	0.92
75	0.040010	0.032859	0.82	0.026910	0.025937	0.96
80	0.063960	0.058213	0.91	0.044410	0.042767	0.96
85	0.098980	0.103244	1.04	0.074270	0.072923	0.98
90	0.135460	0.176202	1.30	0.116860	0.127784	1.09
95	0.209860	0.262189	1.25	0.192970	0.190654	0.99

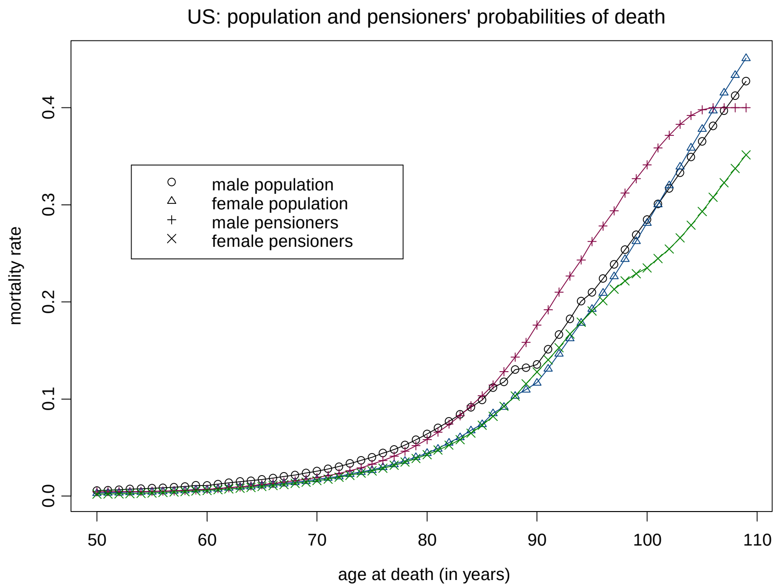


Figure 2.18.1

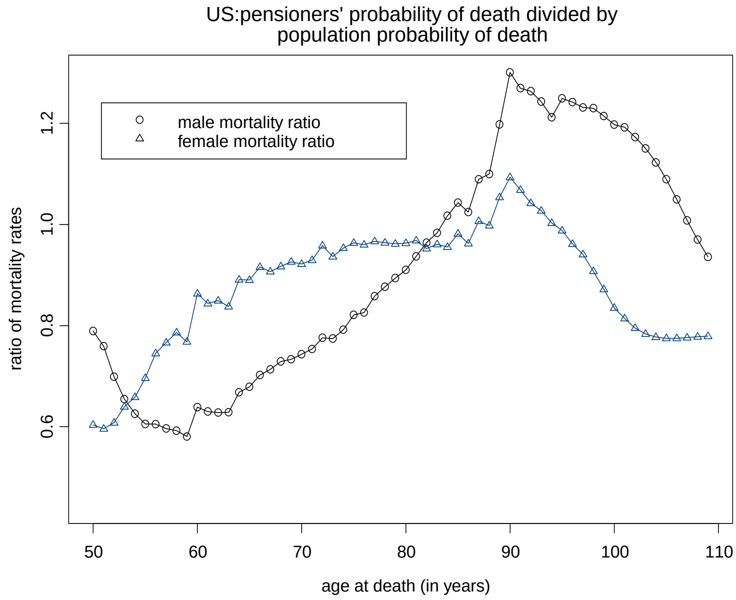


Figure 2.18.2

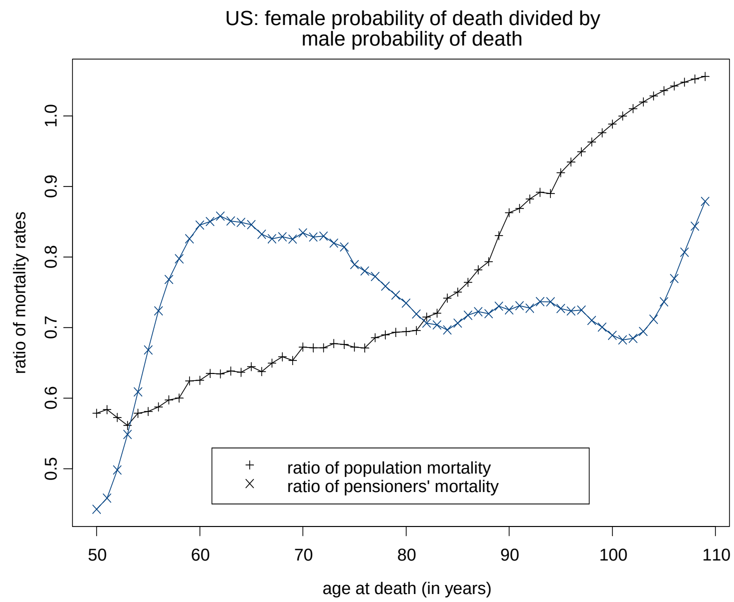


Figure 2.18.3

Table 2.18.3
USA, Expected complete future lifetime in years

	male				female			
	population	RP-2000 tables	difference	percentage difference	population	RP-2000 tables	difference	percentage difference
50	29.21	31.14	1.93	6.6	32.96	33.77	0.81	2.5
55	25.10	26.81	1.71	6.8	28.54	29.14	0.60	2.1
60	21.18	22.49	1.31	6.2	24.27	24.70	0.43	1.8
65	17.48	18.37	0.89	5.1	20.22	20.53	0.31	1.5
70	14.09	14.56	0.47	3.3	16.43	16.65	0.22	1.3
75	11.04	11.08	0.04	0.4	12.96	13.10	0.15	1.1
80	8.43	8.09	-0.34	-4.1	9.86	9.95	0.09	1.0
85	6.36	5.70	-0.65	-10.3	7.25	7.26	0.01	0.1
90	4.82	3.96	-0.86	-17.8	5.23	5.24	0.01	0.2
95	3.52	2.88	-0.64	-18.2	3.68	4.00	0.33	8.9

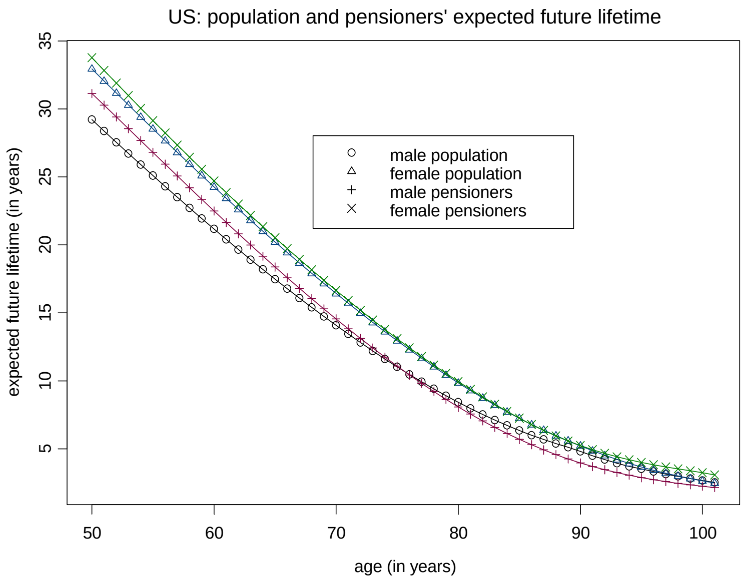


Figure 2.18.4

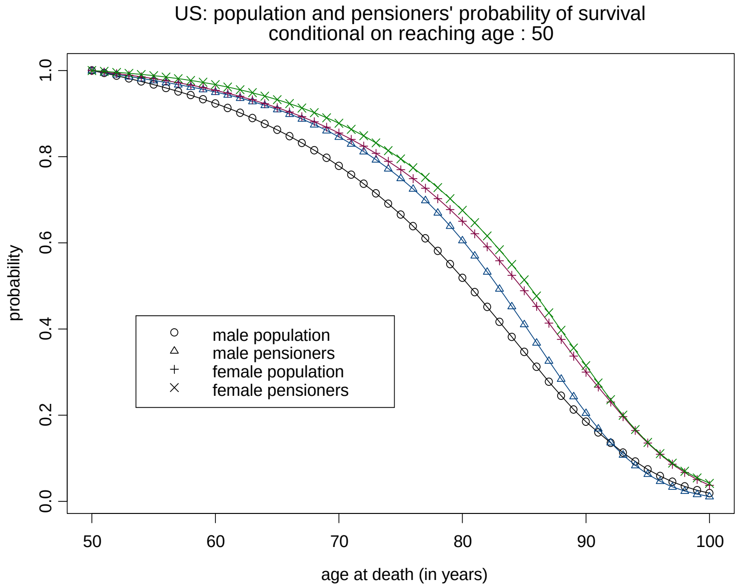


Figure 2.18.5

USA: Distribution of age at death given survival to age 50

Summary Statistics

	male			female		
	population	RP-2000 table	difference	population	RP-2000 table	difference
Lower Quartile age	71.40	75.00	3.60	75.95	77.09	1.14
Median age	80.56	82.84	2.28	84.69	85.38	0.69
Upper Quartile age	87.84	88.84	1.00	91.43	91.64	0.21
Inter quartile range	16.44	13.84	-2.60	15.48	14.55	-0.93
e_{50}	29.21	31.14	1.93	32.96	33.77	0.81

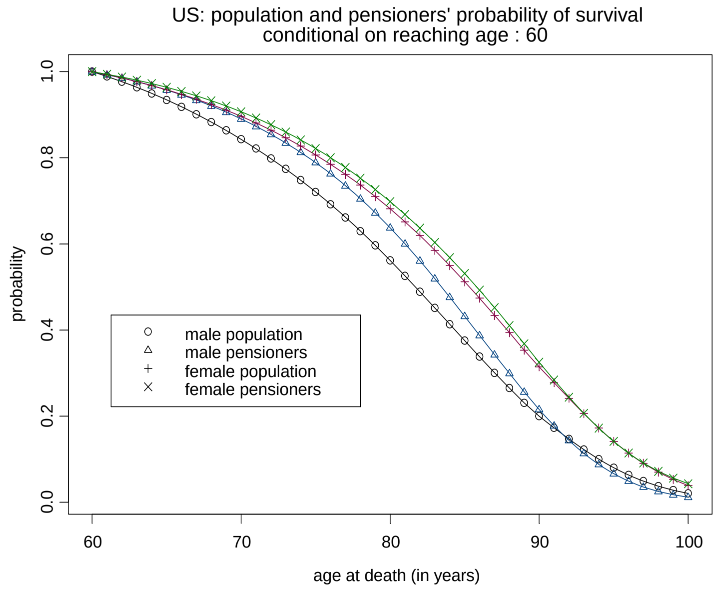


Figure 2.18.6

USA: Distribution of age at death given survival to age 60

Summary Statistics

	male			female		
	population	RP-2000 table	difference	population	RP-2000 table	difference
Lower Quartile age	73.45	76.47	3.02	77.47	78.10	0.64
Median age	81.70	83.45	1.75	85.32	85.81	0.48
Upper Quartile age	88.44	89.15	0.72	91.76	91.85	0.09
Inter quartile range	14.99	12.68	-2.30	14.29	13.75	-0.55
e_{60}	21.18	22.49	1.31	24.27	24.70	0.43

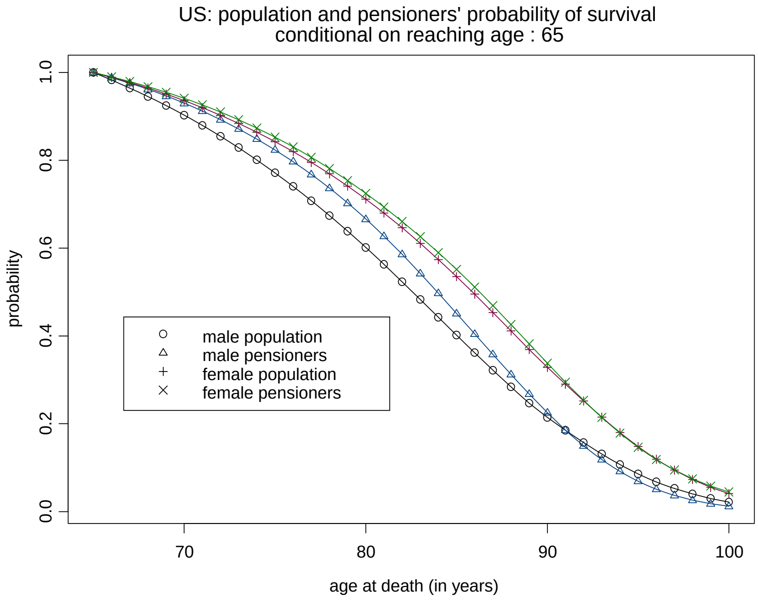


Figure 2.18.7

USA: Distribution of age at death given survival to age 65

Summary Statistics

	male			female		
	population	RP-2000 table	difference	population	RP-2000 table	difference
Lower Quartile age	75.75	77.57	1.81	78.68	79.13	0.44
Median age	82.58	83.94	1.37	85.88	86.27	0.39
Upper Quartile age	88.91	89.42	0.50	92.05	92.08	0.03
Inter quartile range	13.16	11.85	-1.31	13.37	12.96	-0.41
e_{65}	17.48	18.37	0.89	20.22	20.53	0.31

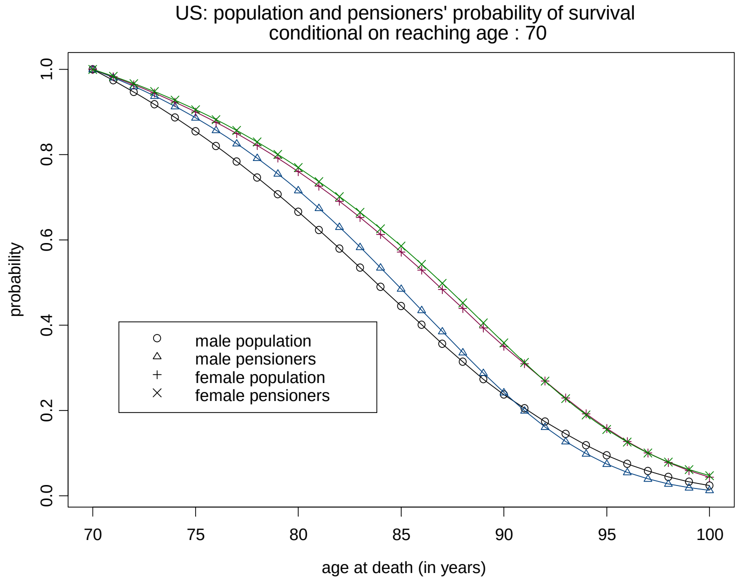


Figure 2.18.8

USA: Distribution of age at death given survival to age 70

Summary Statistics

	male			female		
	population	RP-2000 table	difference	population	RP-2000 table	difference
Lower Quartile age	77.91	79.14	1.23	80.30	80.60	0.30
Median age	83.78	84.70	0.93	86.65	86.96	0.32
Upper Quartile age	89.65	89.83	0.18	92.49	92.46	-0.02
Inter quartile range	11.74	10.69	-1.05	12.19	11.86	-0.32
e_{70}	14.09	14.56	0.47	16.43	16.65	0.22

2.18.5 USA results: comparison with previous study

Figures 2.18.9 and 2.18.10 compare the probabilities of death shown in Figure 2.18.1 with probabilities of death based on the 2002 US population mortality experience, and the RP-2000 mortality tables, for males and females separately. The expected future lifetimes are compared in Figures 2.18.11 and 2.18.12. Clearly, there has been an improvement in the population mortality between the 2002 experience and the 2006 experience at all ages for both males and females. From the annualised percentage changes in expected future lifetime for the population shown in Tables 2.18.4 and 2.18.5, it is apparent that the rate of improvement in population mortality is higher for males. In contrast, although the projected RP-2000 mortality tables assume improvements in mortality, the differences between mortality rates projected to 2000 and mortality rates projected to 2010 are relatively small at each age.

Table 2.18.6 is a comparison of the expected future lifetime for a life who has survived to age 65. Whereas 25% of 65-year old males from the 2006 US male population would be expected to live to age 88.9 years, the same proportion of 65-year old males from the 2002 male population would be expected to live to age 87.1 years approximately, the actual difference being 1.8 years. For females, the difference from a similar comparison is lower: 25% of the 2006 US female population alive at age 65 is expected to live to about age 92.1 years while the same proportion from the 2002 US female population is expected to live to age 91.9 years, the actual difference being about two months. On the other hand the corresponding differences in expected future lifetimes at age 65 derived from the RP-2000 mortality tables assumed for pensioners are: just over one year for males and about nine months for females.

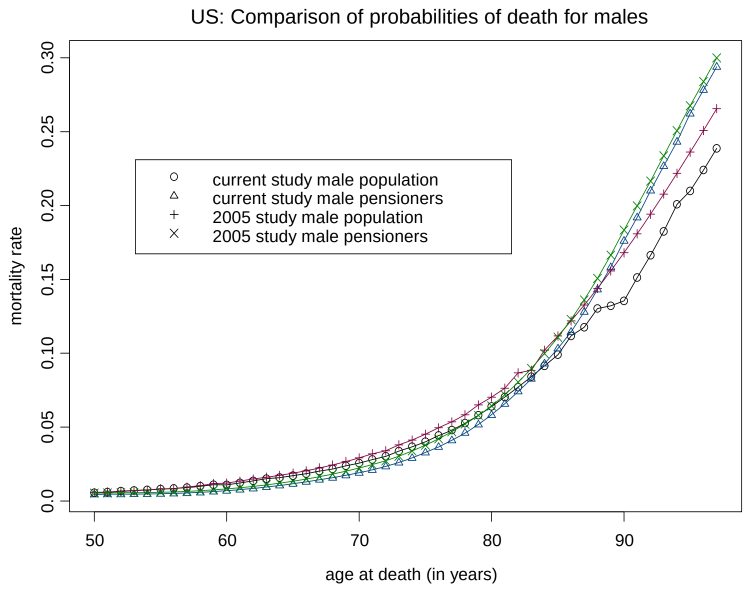


Figure 2.18.9

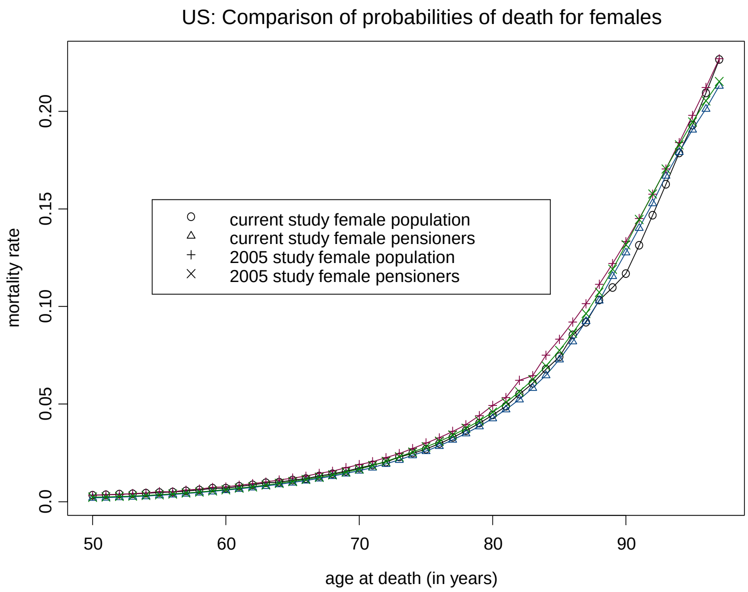


Figure 2.18.10

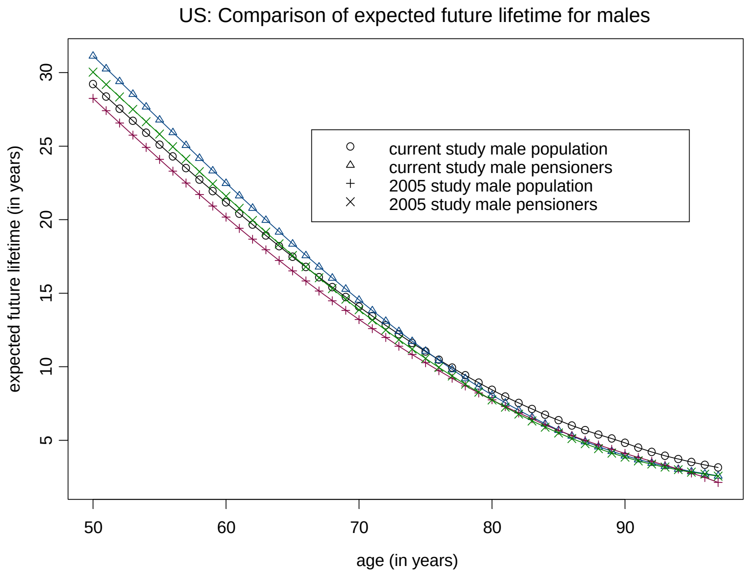


Figure 2.18.11

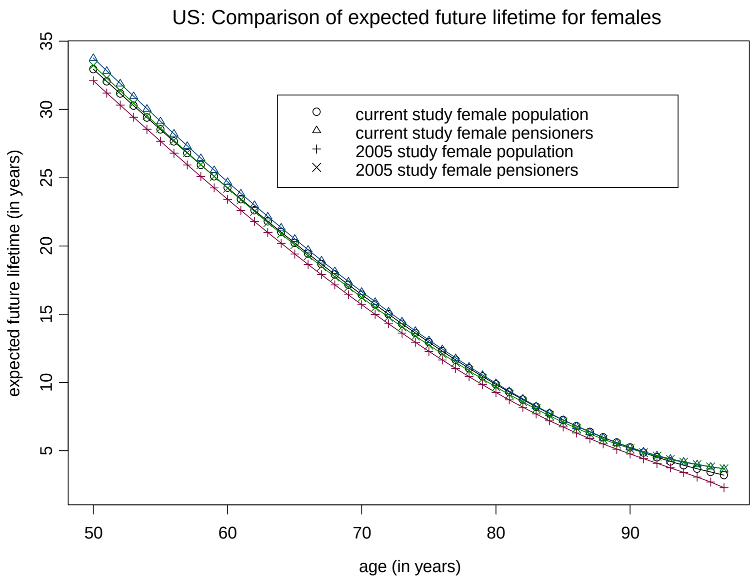


Figure 2.18.12

Table 2.18.4
USA: Comparison of expected complete future lifetime for males

age	RP-2000 males			male population			
	projected to 2010	projected to 2000	difference	2006	2002	difference	Annualised percentage difference
50	31.14	30.03	1.11	29.21	28.25	0.96	0.8%
55	26.81	25.82	1.00	25.10	24.10	1.00	1.0%
60	22.49	21.59	0.90	21.18	20.17	1.01	1.2%
65	18.37	17.57	0.80	17.48	16.53	0.96	1.4%
70	14.56	13.88	0.68	14.09	13.21	0.88	1.7%
75	11.08	10.57	0.52	11.04	10.27	0.77	1.9%
80	8.09	7.75	0.34	8.43	7.75	0.68	2.2%
85	5.70	5.49	0.21	6.36	5.68	0.68	3.0%
90	3.96	3.86	0.11	4.82	4.11	0.71	4.3%
95	2.88	2.84	0.04	3.52	2.77	0.75	6.8%

Table 2.18.5
USA: Comparison of expected complete future lifetime for females

age	RP-2000 females			female population			
	projected to 2010	projected to 2000	difference	2006	2002	difference	Annualised percentage difference
50	33.77	33.23	0.54	32.96	32.11	0.85	0.7%
55	29.14	28.64	0.50	28.54	27.67	0.86	0.8%
60	24.70	24.23	0.47	24.27	23.43	0.84	0.9%
65	20.53	20.08	0.45	20.22	19.42	0.80	1.0%
70	16.65	16.23	0.42	16.43	15.70	0.73	1.2%
75	13.10	12.74	0.36	12.96	12.29	0.67	1.4%
80	9.95	9.68	0.28	9.86	9.26	0.59	1.6%
85	7.26	7.09	0.17	7.25	6.73	0.52	1.9%
90	5.24	5.15	0.09	5.23	4.76	0.48	2.5%
95	4.00	3.97	0.03	3.68	3.07	0.61	5.0%

Table 2.18.6
USA: Distribution of age at death given survival to age 65
Summary Statistics for the population experience

	Male			female		
	2006 population	2002 population	difference	2006 population	2002 population	difference
Lower Quartile age	75.75	74.09	1.66	78.68	77.03	1.65
Median age	82.58	81.37	1.20	85.88	85.94	-0.07
Upper Quartile age	88.91	87.13	1.79	92.05	91.89	0.16
Inter quartile range	13.16	13.03	0.13	13.37	14.86	-1.49
e_{65}	17.48	16.53	0.96	20.22	19.42	0.80

Summary Statistics based on the RP-2000 Tables

	Male			female		
	projected to 2010	projected to 2000	difference	projected to 2010	projected to 2000	difference
Lower Quartile age	77.57	76.41	1.15	79.13	78.37	0.75
Median age	83.94	83.99	-0.05	86.27	85.31	0.96
Upper Quartile age	89.42	88.37	1.05	92.08	91.38	0.71
Inter quartile range	11.85	11.95	-0.10	12.96	13.00	-0.05
e_{65}	18.37	17.57	0.80	20.53	20.08	0.45

3. Cross – country analysis

3.1 Current study

The following figures highlight some of the important results from this research project for an individual aged 65. It should be noted that for Denmark, Netherlands, Norway, Sweden and Switzerland, the mortality tables assumed for pension benefits are the same tables assumed in the 2005 study. Mortality tables currently in use for pension benefits in these countries were not made available for this study.

Figure 3.1 shows the variation in observed population life expectancy for a male aged 65 within this group of countries. There is a difference of more than two years between Australia with the longest life expectancy and Denmark with the shortest.

Figure 3.2 shows the variation in the typical assumed life expectancy for a male 65-year-old member of a company pension scheme. The variations in assumed life expectancy are much wider than in the observed male population life expectancy. France has the highest life expectancy of 27.5 years while Denmark has the shortest life expectancy of 15.1 years, a difference of more than 12 years. However, it should be noted that in France the mortality assumed in the determination of pension benefits for both males and females is based on the female mortality experience.

Figure 3.3 illustrates the differences by showing the difference within each country between the observed national population life expectancy and the assumed life expectancy for pensioners in company pension schemes. For Denmark, Netherlands, and Switzerland, the assumed mortality tables for pension benefits would indicate a lower life expectancy for a 65-year old male member of a pension scheme than a male from the general population. For the rest of the countries in the group, the differences range from over 9 years in France to about 3 months in Sweden, Japan and Norway.

Figure 3.4 shows a similar illustration, but in terms of the ratio of mortality rates for males aged 65. The probability of death on the basis of the assumed mortality tables for male pension benefits ranges from being 38% higher than the male population mortality in Denmark to 75% lower in France.

Figures 3.5 to 3.8 show the same comparisons as Figures 3.1 to 3.4, but this time for females.

Figure 3.5 shows the variation in observed population life expectancy for a female aged 65 within this group of countries. There is a difference of about 4.5 years between Japan with the longest life expectancy and Denmark with the shortest.

Figure 3.6 shows the variation in the typical assumed life expectancy for a female 65-year-old member of a company pension scheme. The variations in assumed life expectancy are much wider than in the observed female population life expectancy. Spain has the highest life expectancy of 27.6 years while Denmark has the shortest life expectancy of 17.8 years, a difference of 9.8 years.

Figure 3.7 illustrates the differences by showing the difference within each country between the observed national female population life expectancy and the assumed life expectancy for female pensioners in company pension schemes. For Denmark, Netherlands, Norway, and Switzerland, the assumed mortality tables for pension benefits would indicate a lower life expectancy for a 65-year old female member of a pension scheme than a female from the general population. For the rest of the countries in the group, the differences range from about 6 years in Spain to about 4 months in the USA.

Figure 3.8 shows a similar illustration, but in terms of the ratio of mortality rates for females aged 65. The probability of death on the basis of the assumed mortality tables for female pension benefits ranges from being nearly twice that of the female population in Switzerland to 62% lower in Italy.

Figure 3.1

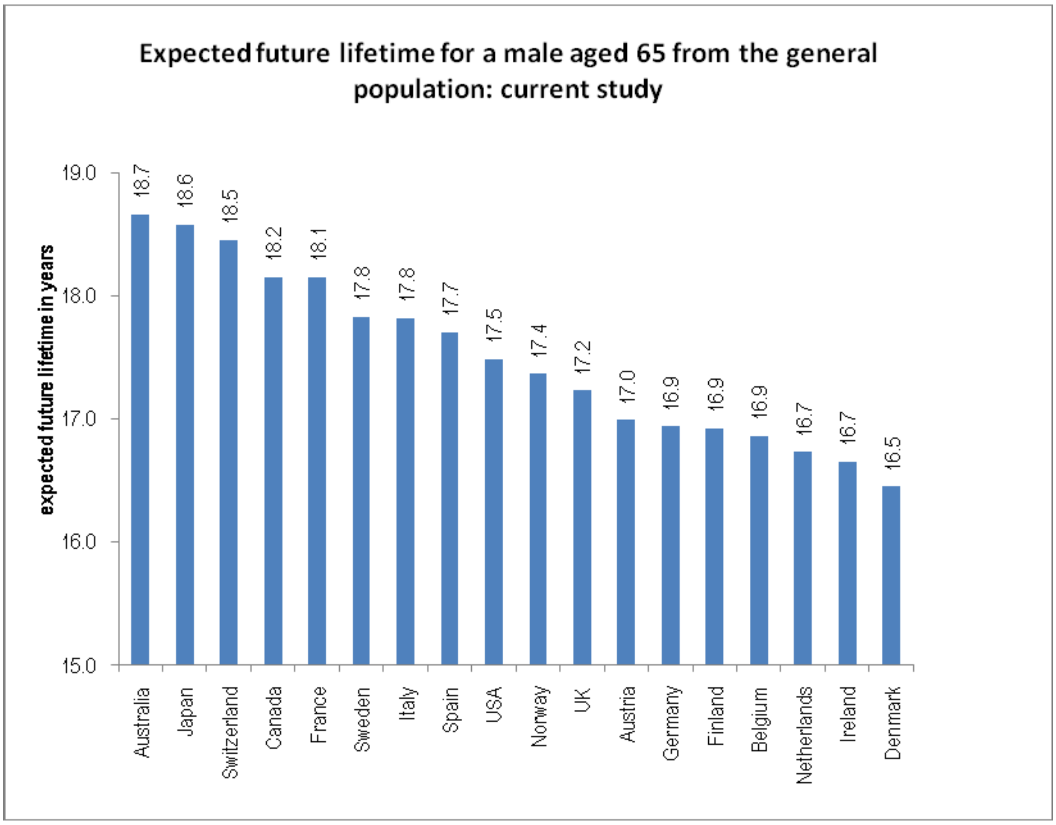


Figure 3.2

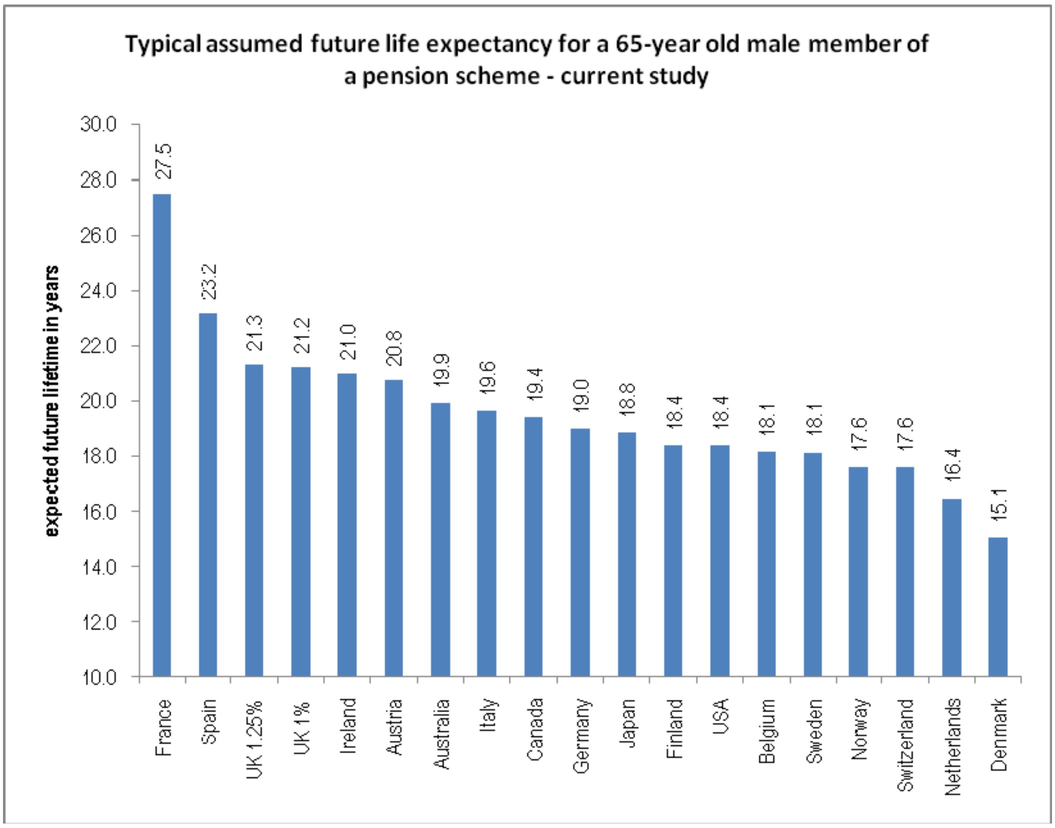


Figure 3.3

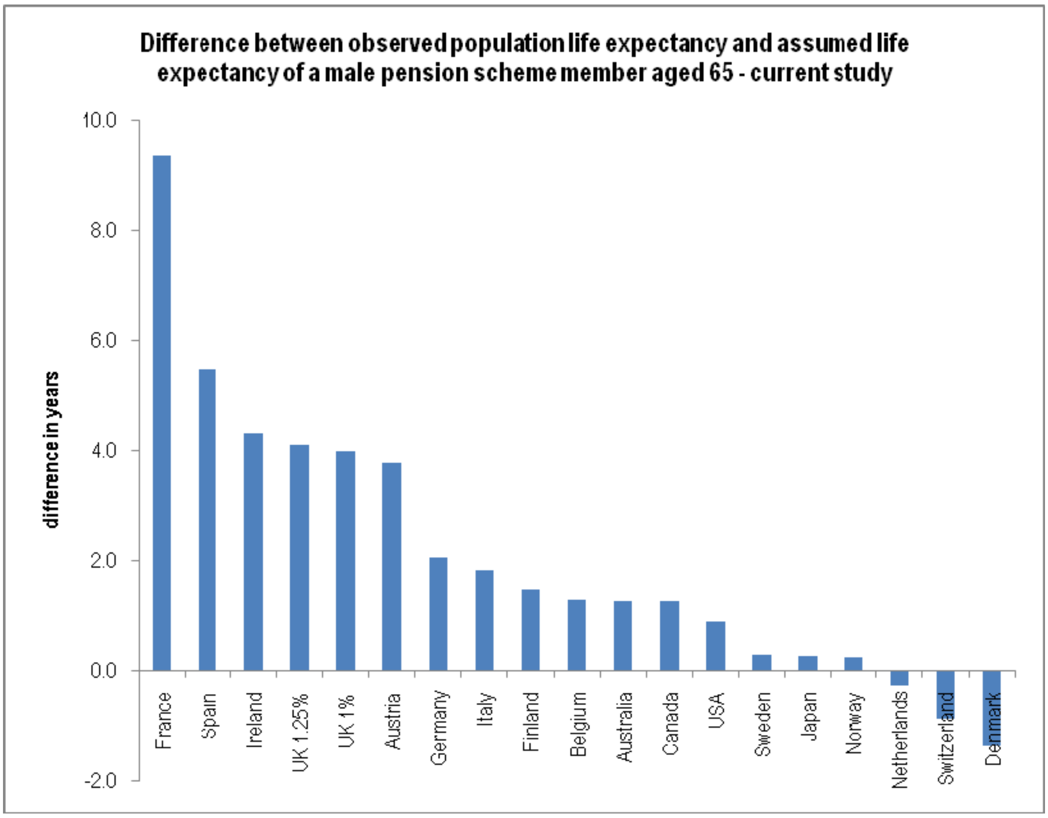


Figure 3.4

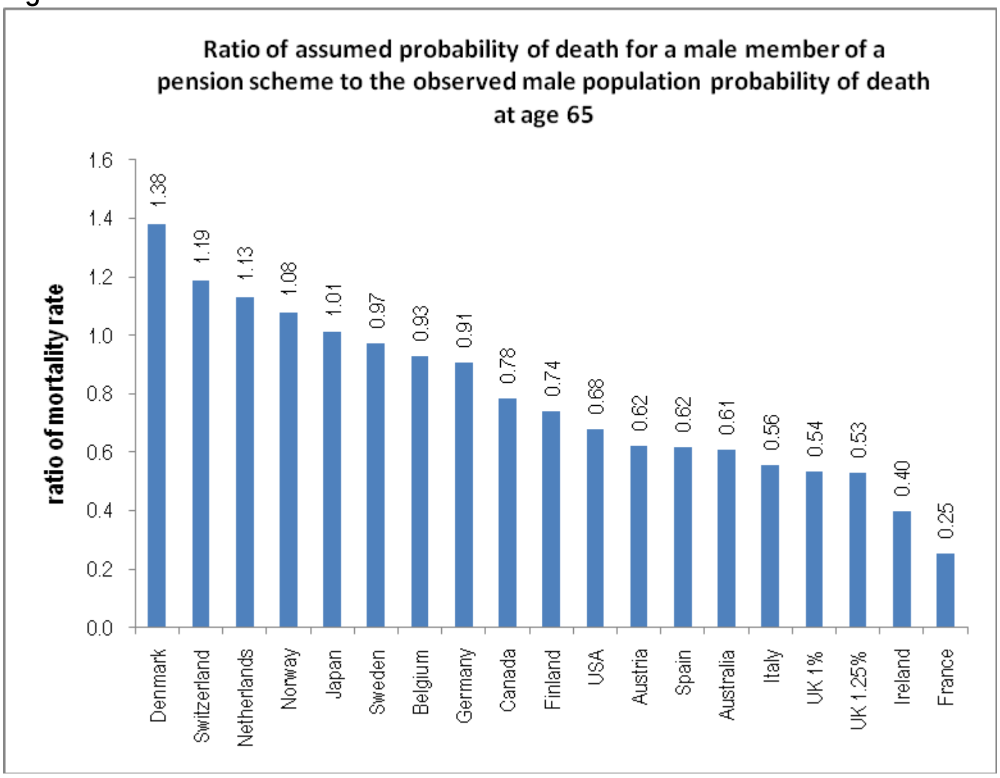


Figure 3.5

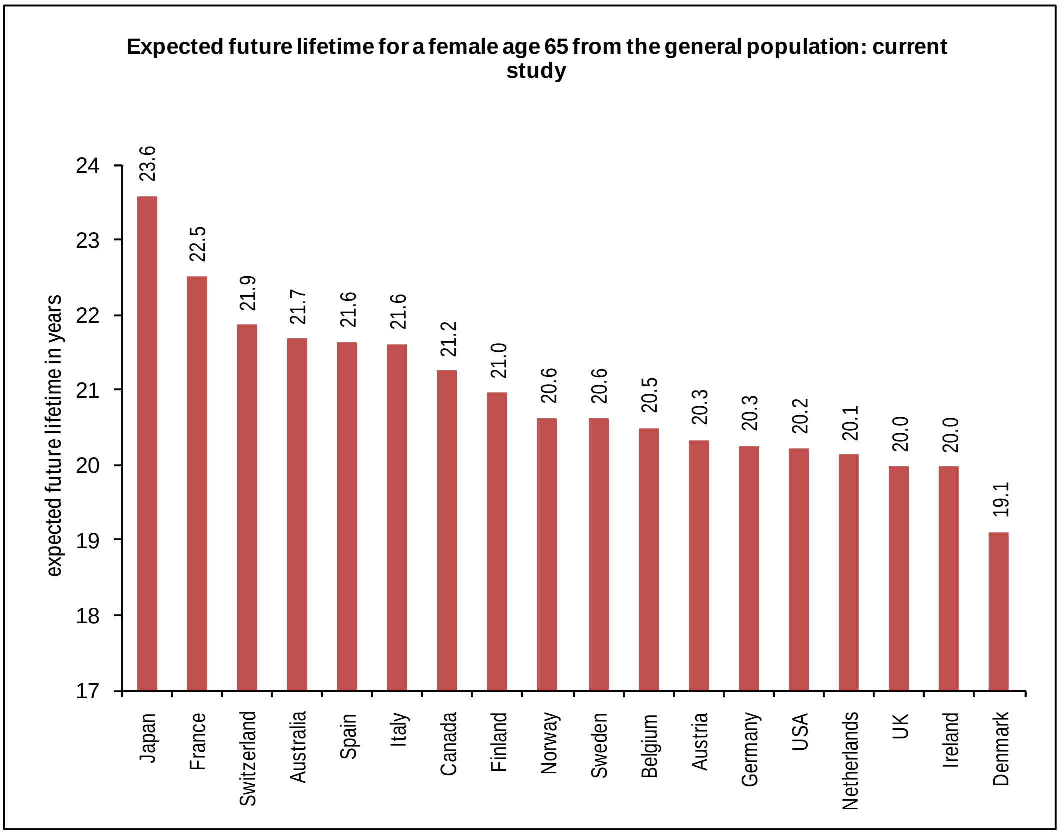


Figure 3.6

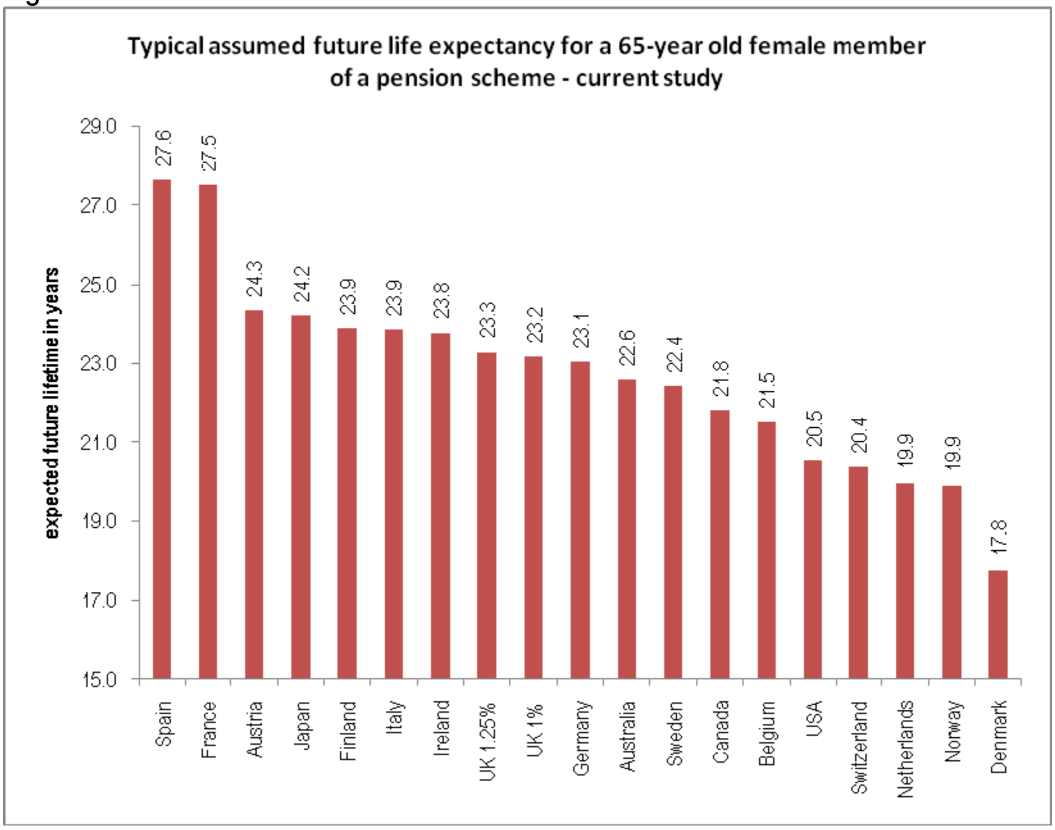


Figure 3.7

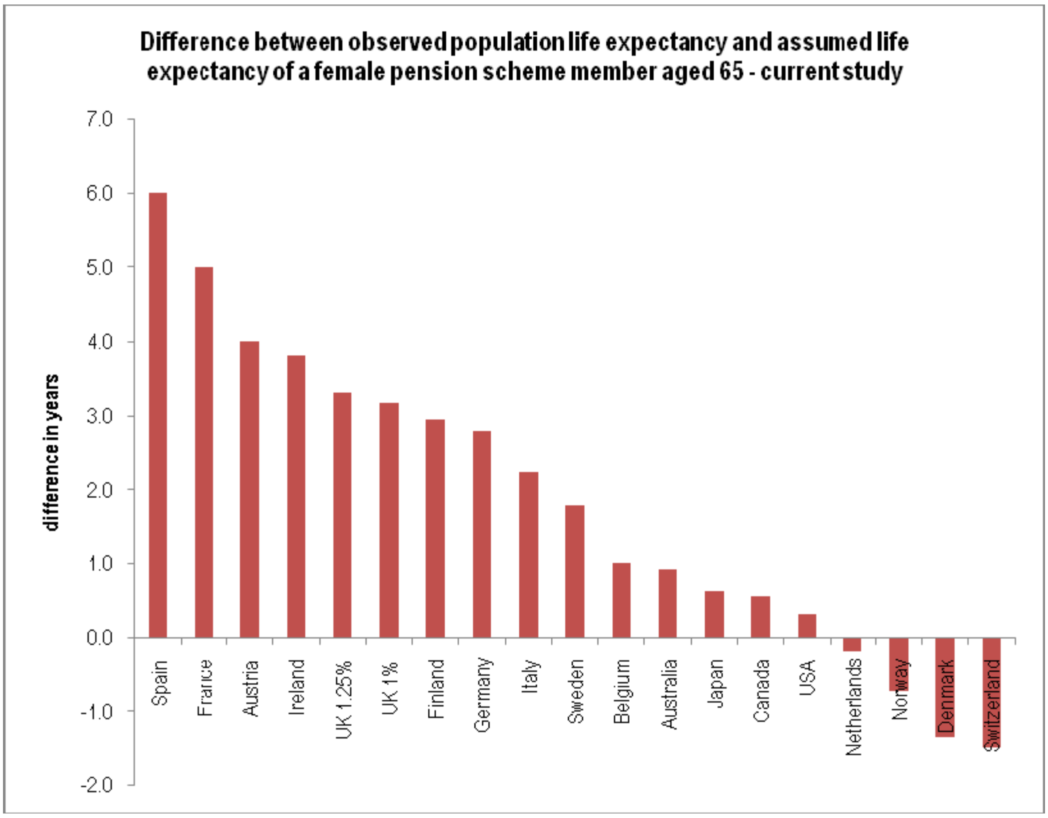
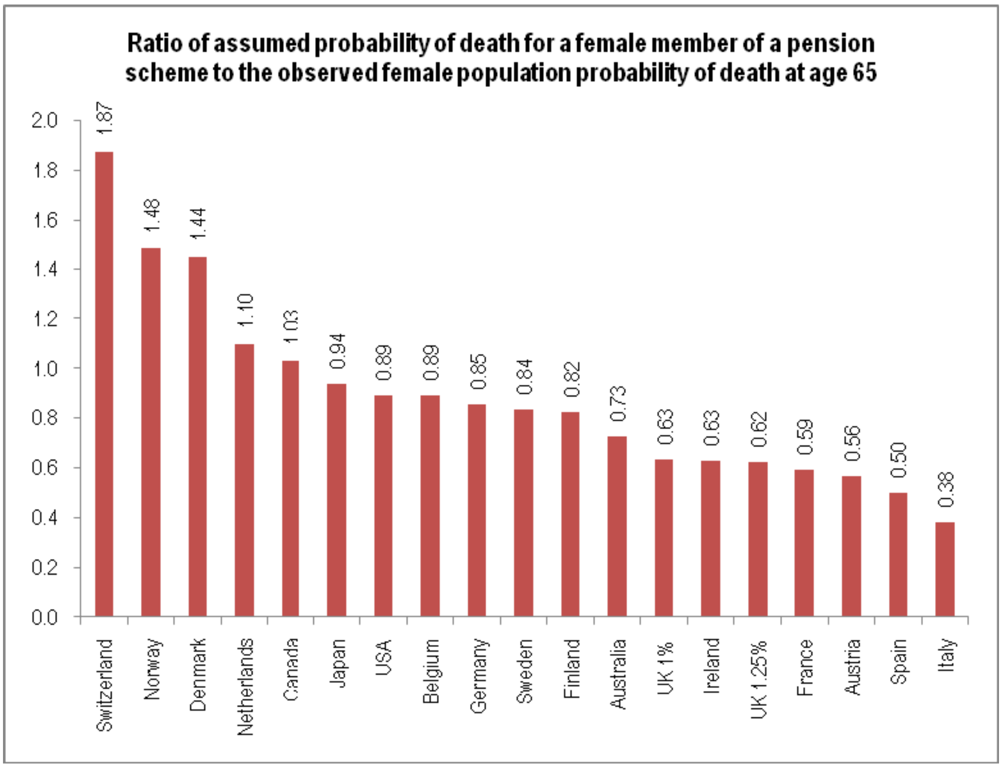


Figure 3.8



3.2 Comparison with Verrall et al. (2006a, 2006b)

Figures 3.9 to 3.14 show comparisons with results from the study carried out previously. The comparisons are only for those countries covered in the previous study so that results for Australia and Japan are not included.

Figure 3.9 shows the variation in observed population life expectancy for a male aged 65. As in the previous study, Switzerland has the highest male life expectancy at age 65 and Denmark has the lowest. However, as the population mortality experience across countries relates to differing years, the differences do not give a true reflection of improvements in mortality.

Figure 3.10 shows annualised percentage increases in male life expectancy based on the actual dates of the relevant population mortality experiences in the 2005 study and the current study. The annualised percentage increases range from 1.3% in Canada to 2.6% in The Netherlands.

Figure 3.11 shows a comparison of the difference within each country between the observed national male population life expectancy and the assumed life expectancy for male pensioners. In the previous study, the assumed mortality tables for pension benefits indicated a lower life expectancy for a 65-year old male member of a pension scheme for Denmark only. The fact that in this study, results for Denmark, Netherlands, and Switzerland would indicate a lower life expectancy for a 65-year old male member of a pension scheme than a male from the general population is very likely due to the fact that whilst there has been an obvious improvement in population mortality, the tables assumed for pension benefits in this study are the same as those assumed in the previous study for these countries. For the rest of the countries in the group, the differences range from over 9 years in France to about 3 months in Sweden, Japan and Norway.

Figure 3.12 shows the variation in observed population life expectancy for a female aged 65. As in the previous study, France has the highest female life expectancy and Denmark has the lowest.

Figure 3.13 shows annualised percentage increases in female life expectancy based on the actual dates of the relevant population mortality experiences in the 2005 study and the current study. The annualised percentage increases range from 0.7% in Canada and Sweden to 1.7% in The Netherlands. It is clear that for each of the countries shown, the average rate of mortality improvement in the female population is lower than the average rate of mortality improvement in the male population.

Figure 3.14 shows a comparison of the difference within each country between the observed national female population life expectancy and the assumed life expectancy for female pensioners. In the previous study, the assumed mortality tables for pension benefits indicated a lower life expectancy for a 65-year old male member of a pension scheme for Denmark and Switzerland only.

Figure 3.9

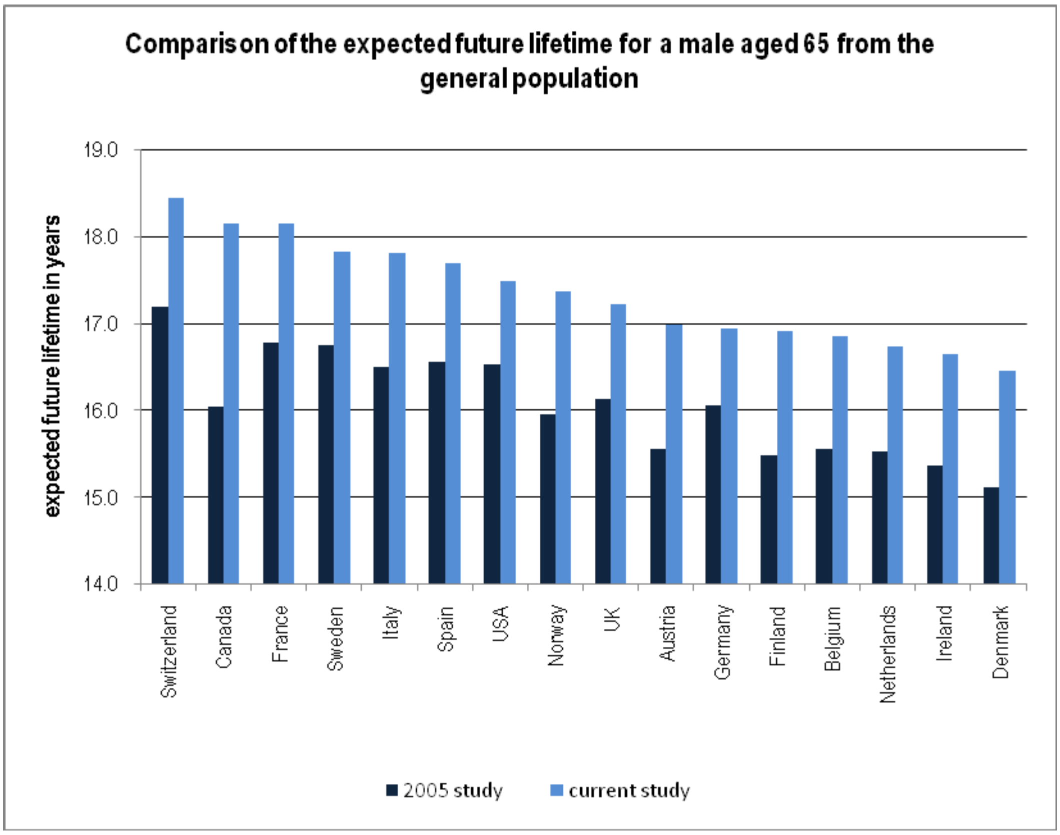


Figure 3.10

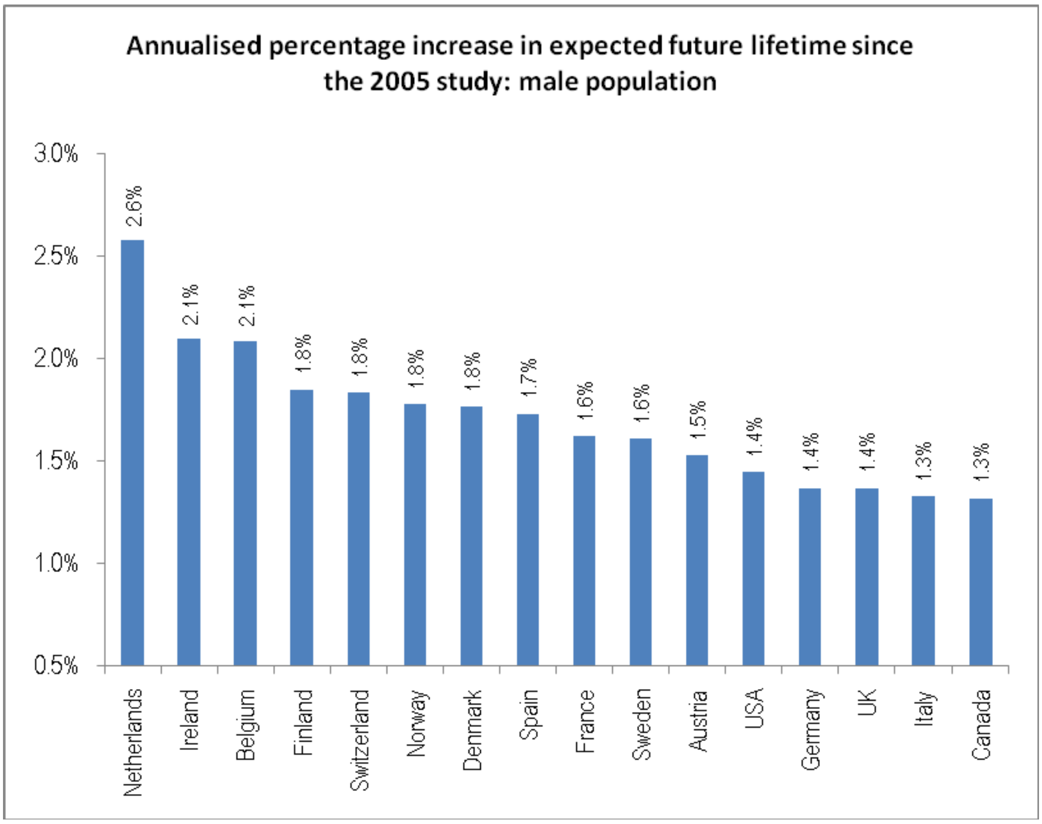


Figure 3.11

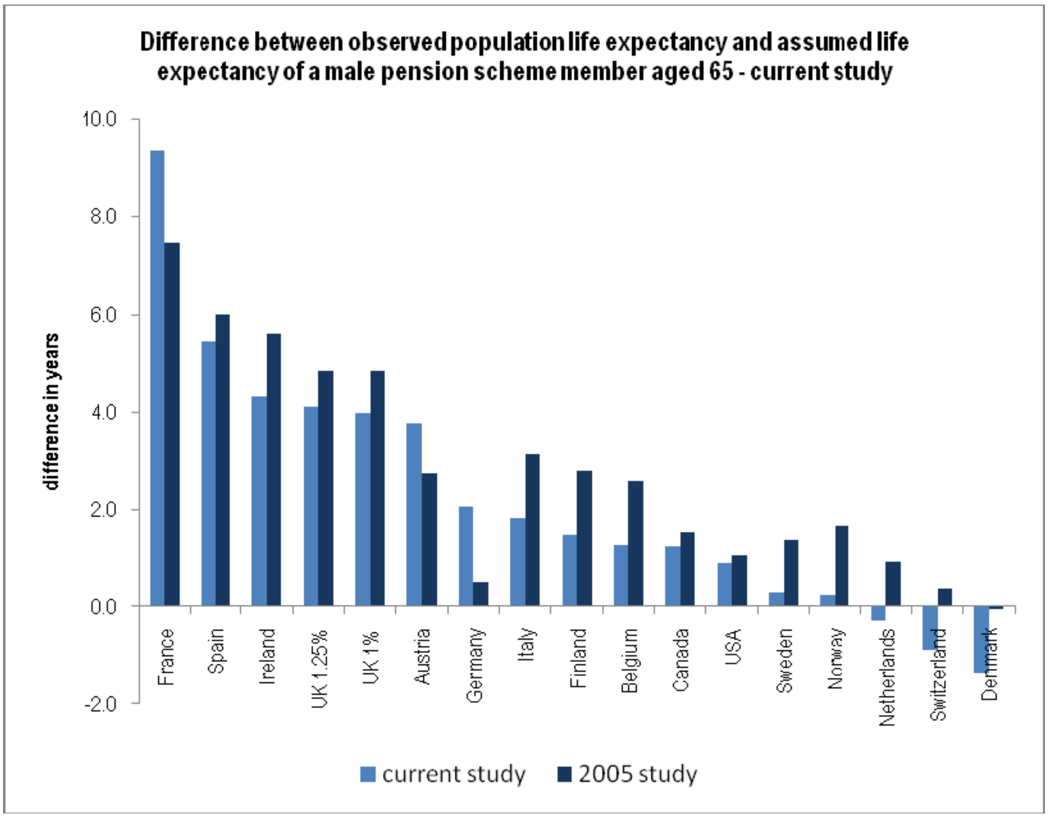


Figure 3.12

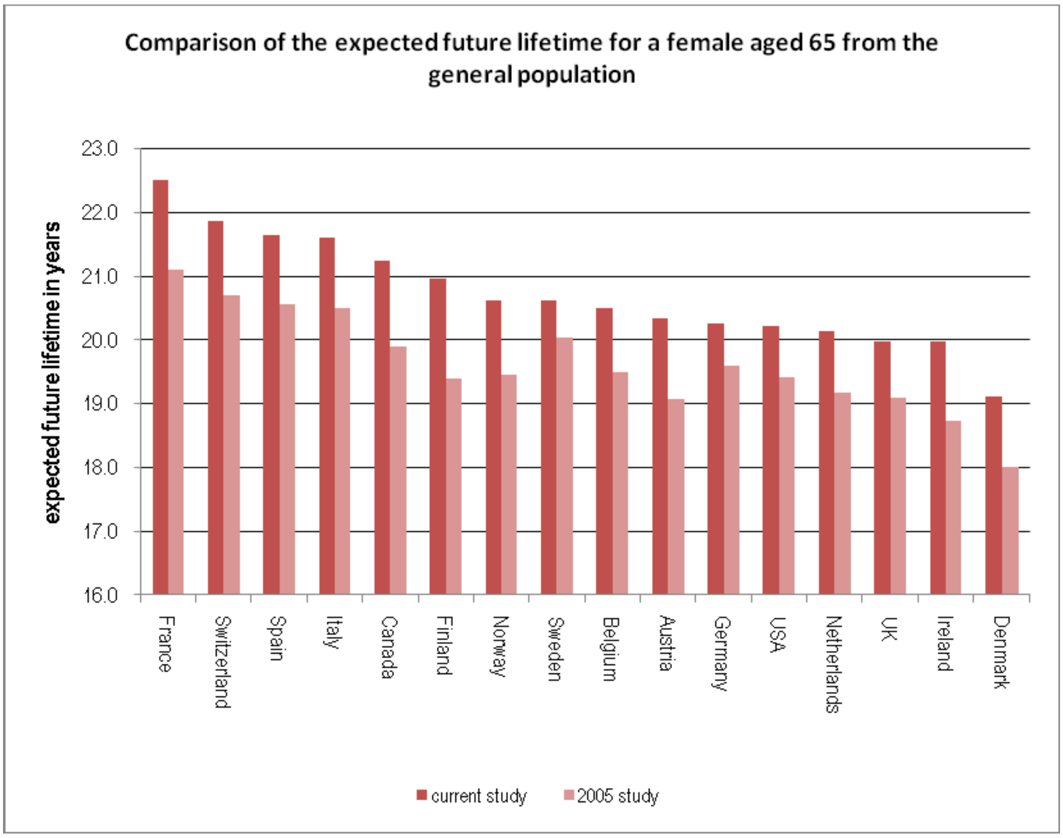


Figure 3.13

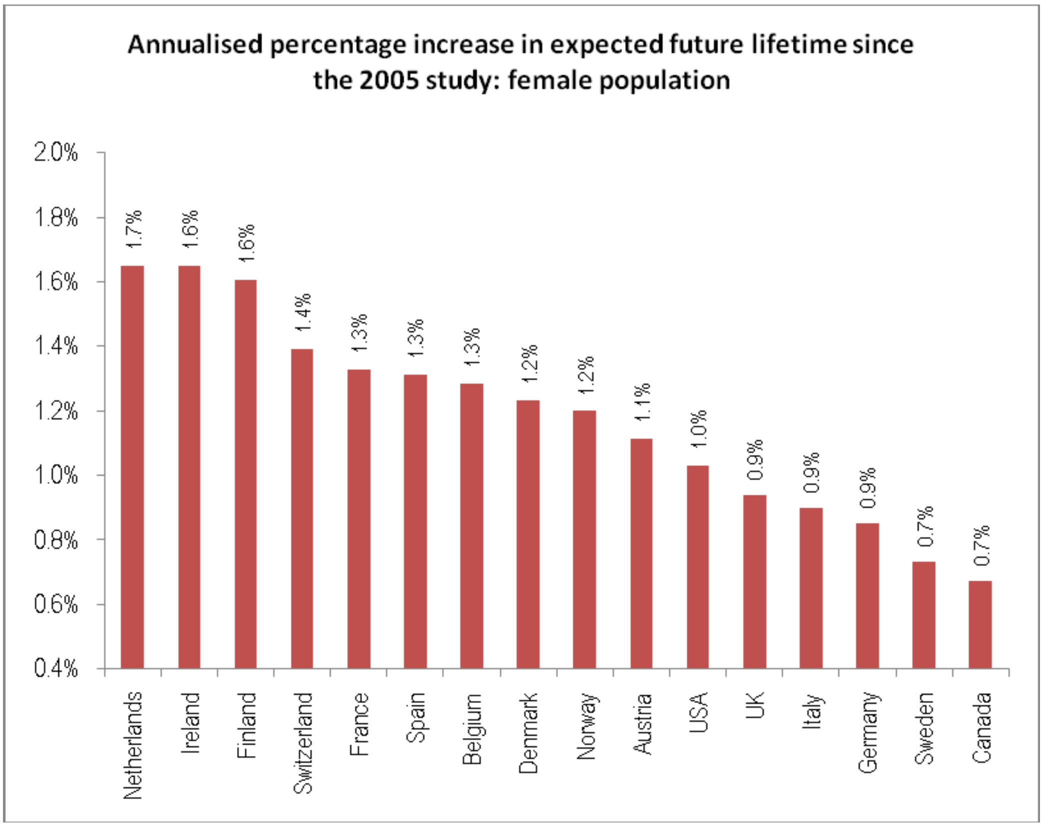
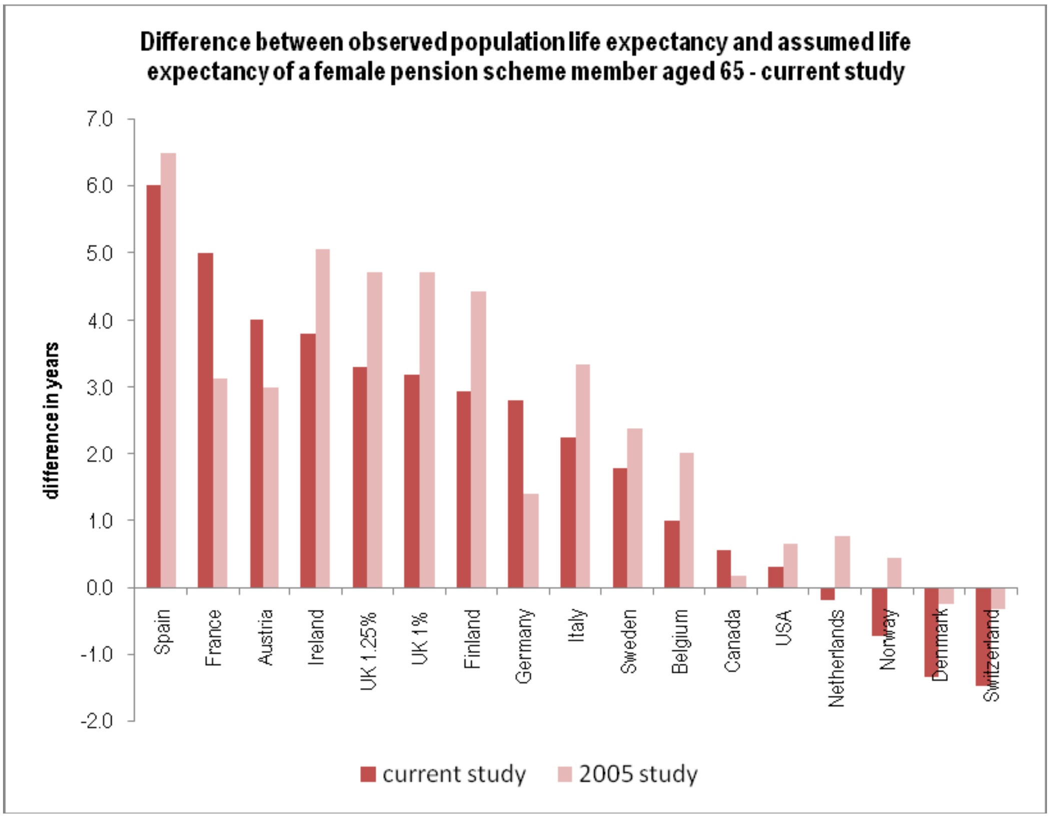


Figure 3.14



Life expectancy is one measure of the strength of the mortality assumptions. However, when considering pension liabilities, it is perhaps more appropriate to base the comparison on annuity values. This is a point which could be discussed more in relation to the disclosure of mortality assumptions: life expectancy is probably more intuitive and understandable, while the annuity value is probably better for a discussion of the valuation of the liability. In Figures 3.15 to 3.17, we have based the comparison on an annuity value for a male aged 65 with a 60% reversionary widow's pension for a female aged 62. Figure 3.17 reflects the differences between countries also shown in Figures 3.3 and 3.11.

Figure 3.15

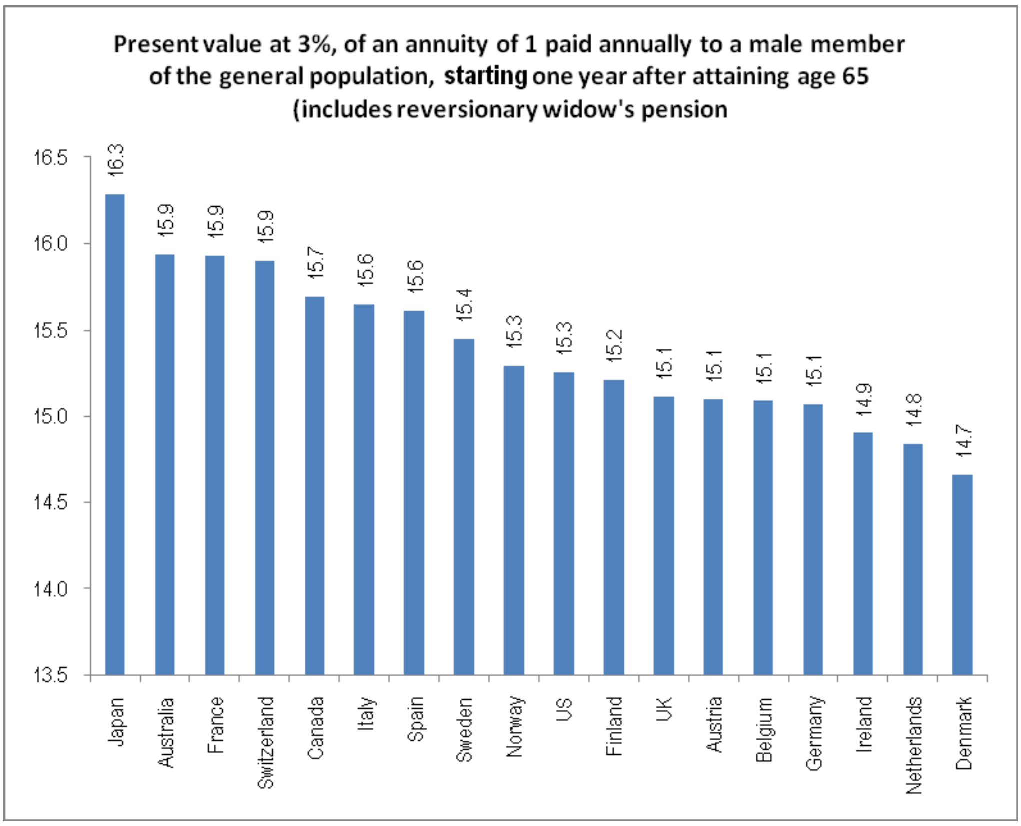


Figure 3.16

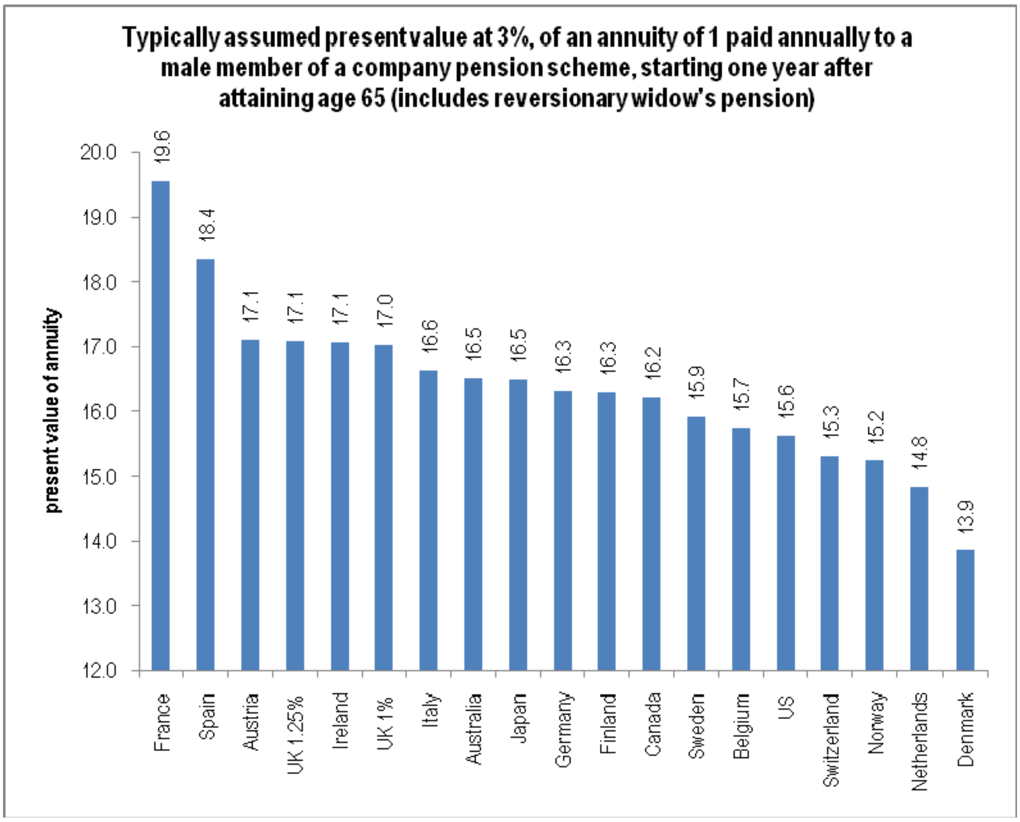
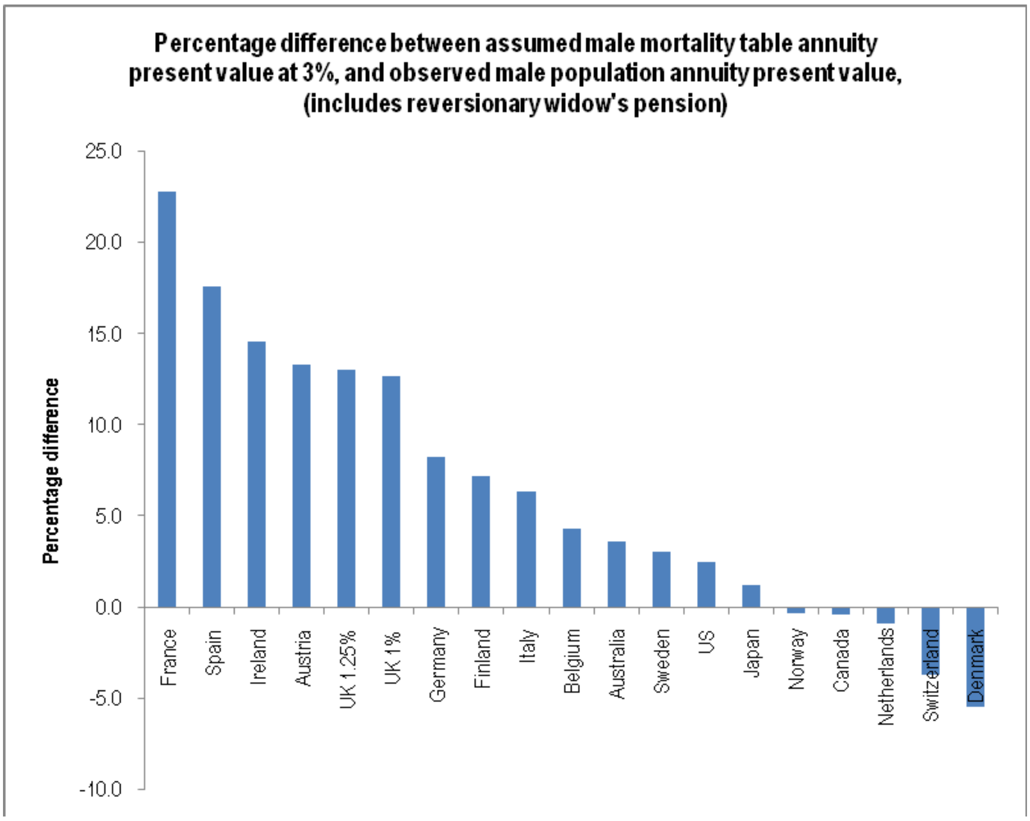


Figure 3.17



Pension liabilities are driven by the discounted value of annuity payments. Figures 3.18 and 3.19 compare a liability of £1000 million based on the assumptions for a UK pension scheme member to the equivalent liabilities if the assumptions were those assumed for each of the countries in the study. (Figure 3.18 involves scaling relative to an assumed long term improvement rate in mortality rates for the UK of 1% pa and Figure 3.19 involves scaling relative to an assumed long term improvement rate in mortality rates for the UK of 1.25% pa.) The Figures show that, for example, the liabilities based on the mortality assumptions used in France are higher than in the UK, whilst the liabilities based on the mortality assumptions used in Germany are lower than if based on the assumptions used in the UK.

Figure 3.18

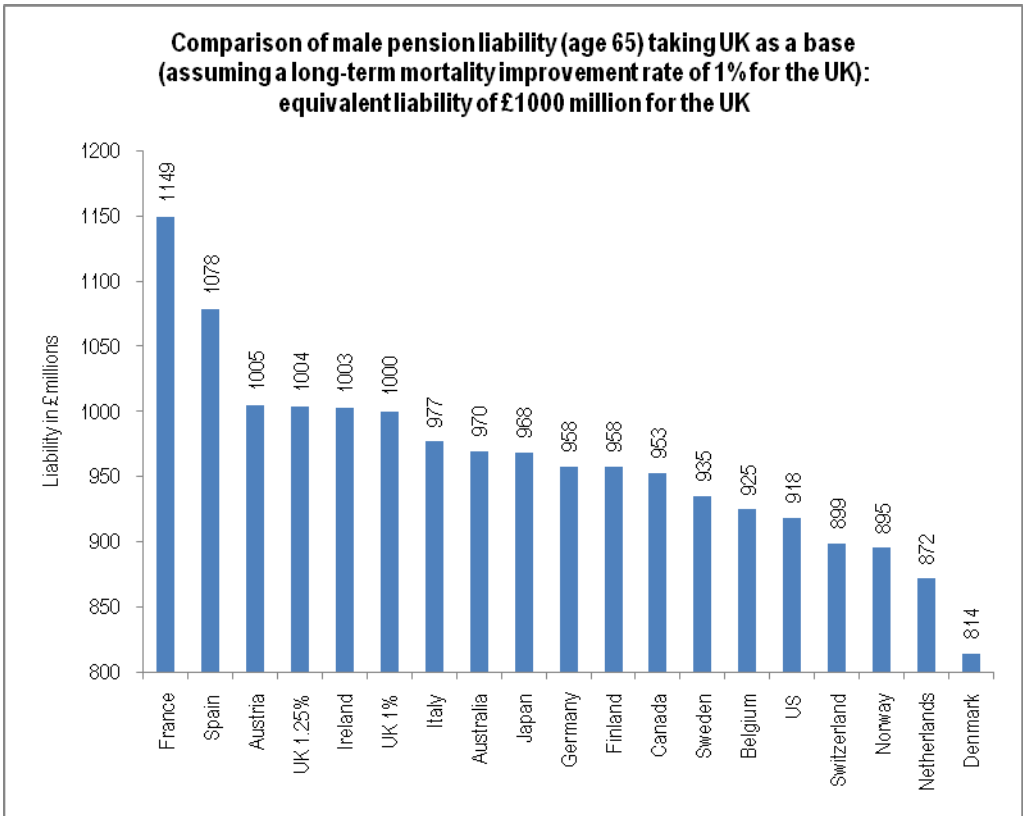
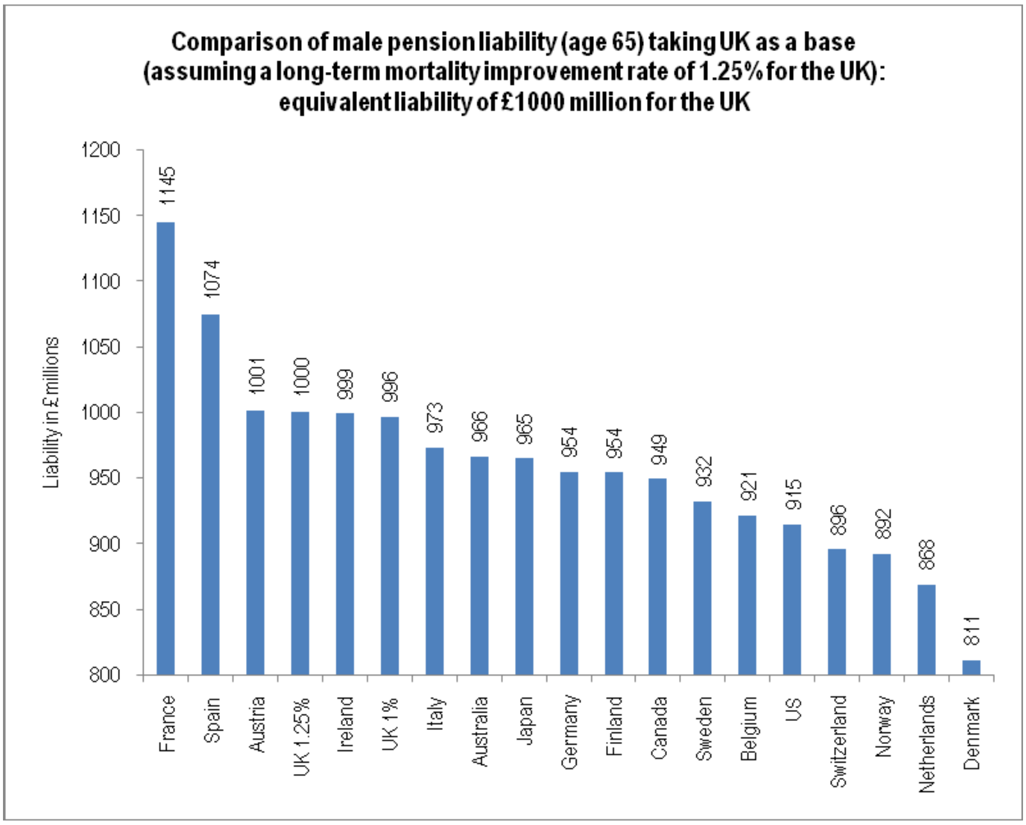


Figure 3.19



4. Conclusion

The conclusions of this study are similar to the previous study, in that the results indicate that current practice varies considerably across the EU. It is to be expected that the mortality assumptions used in company pension schemes should vary from country to country, due to variations in underlying population mortality as well as in variations of the profile of typical membership of a company pension scheme. However, it appears that, as with the previous study, the variations in mortality assumptions are much greater than would be justified by these factors alone. In particular, we believe that it would be worthwhile investigating whether the observed variation is due to the fact that some countries incorporate an allowance for expected future improvements in mortality, while others use tables that relate to mortality observed over a period in the past, without allowing for the fact that life expectancy continues to increase.

Verrall et al. (2006a,b) suggested that the effect of the difference in mortality assumptions could be viewed in terms of an "equivalent" difference in the discount rate. This is illustrated in Figures 4.1 and 4.2, which show the discount rates that must be used when the mortality assumptions from other countries are applied, in order to get the same liabilities as for the UK assumptions. Again, this is done using the two assumptions for mortality improvement in the UK. It can be seen that there is a significant difference between countries, and that the effect of this is emphasised by viewing it in terms of the discount rate; for example, we note a wide range of discount rates in Figure 4.1 corresponding to differences (compared to the UK assumption) of between +181 basis points and -114 basis points.

Figure 4.1

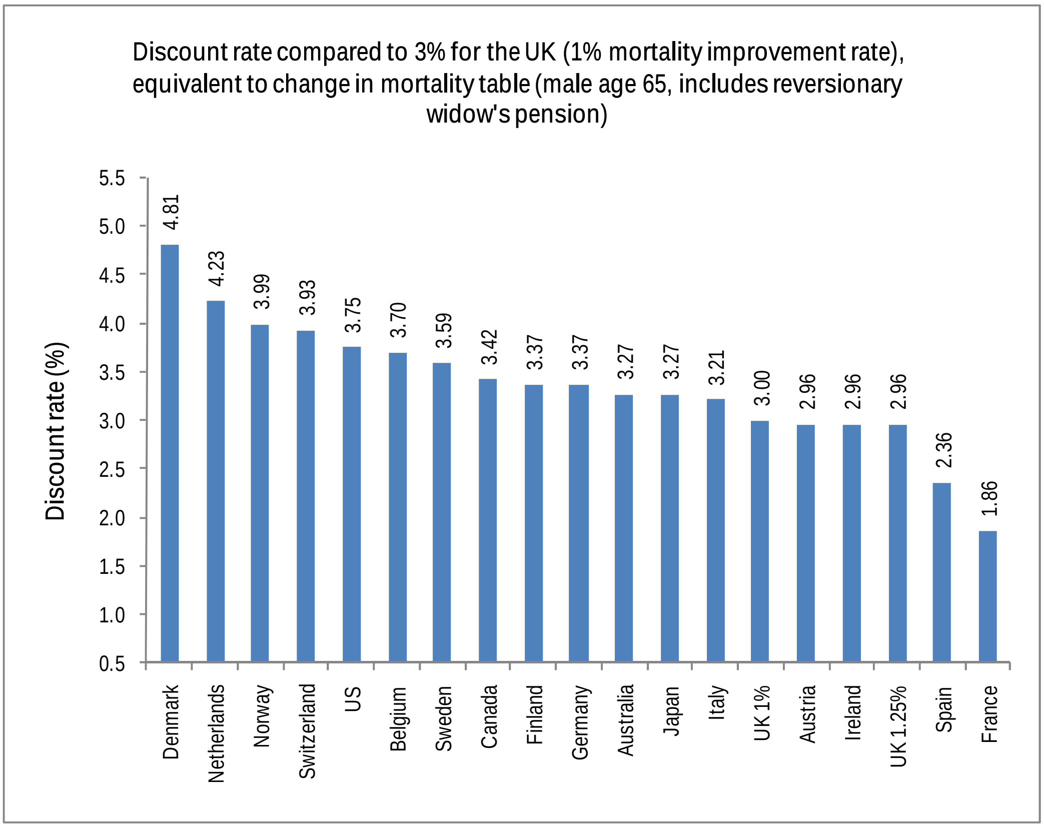
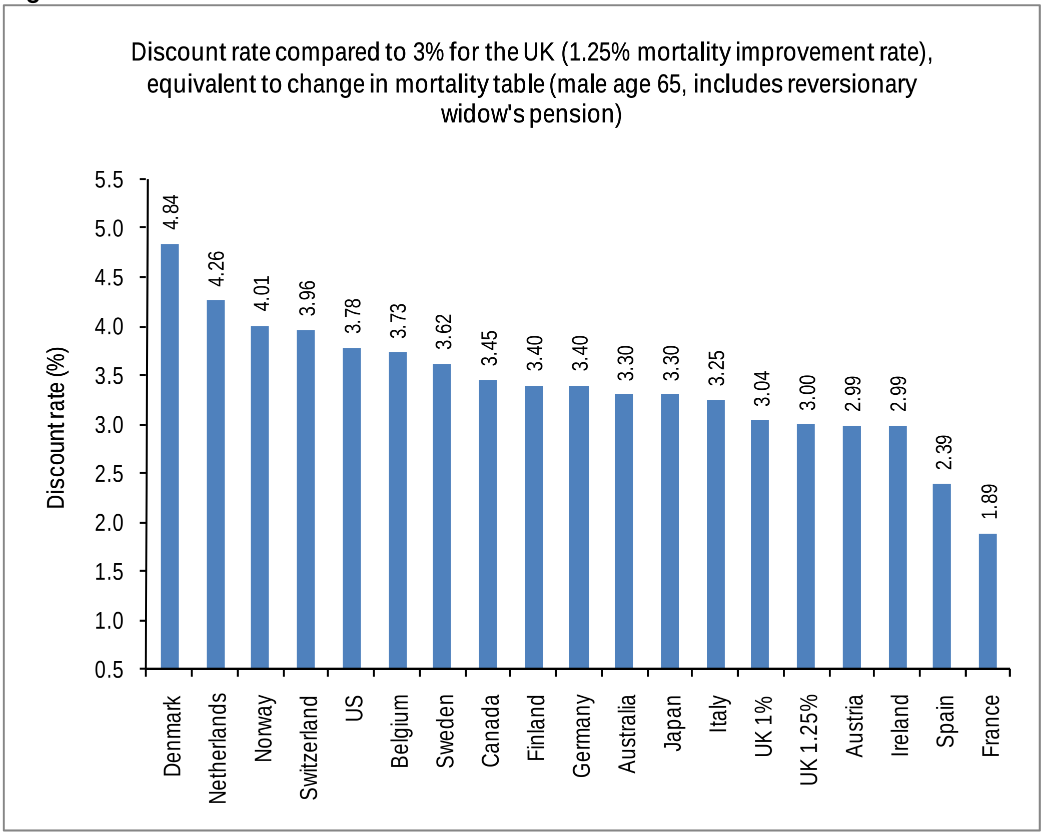


Figure 4.2



Figures 4.1 and 4.2 reinforce the conclusion that greater consistency and clarity should be sought in the assumptions underlying the calculation of pension liabilities.

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