Compression of Morbidity and Mortality: Separate or Related?

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Presented at

The Eighth International Longevity Risk and Capital Markets Solutions Conference

Waterloo Inn Conference Hotel

Waterloo, Ontario, Canada

September 7, 2012

Introduction

Compression of morbidity is a reduction over time in the total lifetime days of chronic disability, reflecting a balance between

(1) morbidity incidence rates, and

(2) case-continuance rates – generated by case-fatality and case-recovery rates.

Compression of mortality is a reduction over time in the variance, or variability, of age-at-death, leading to progressively more "rectangular" survival functions.

Each of the two types of compression is complex – making it difficult to assess the implications of change in one measure for change in the other.

Compression of Morbidity –

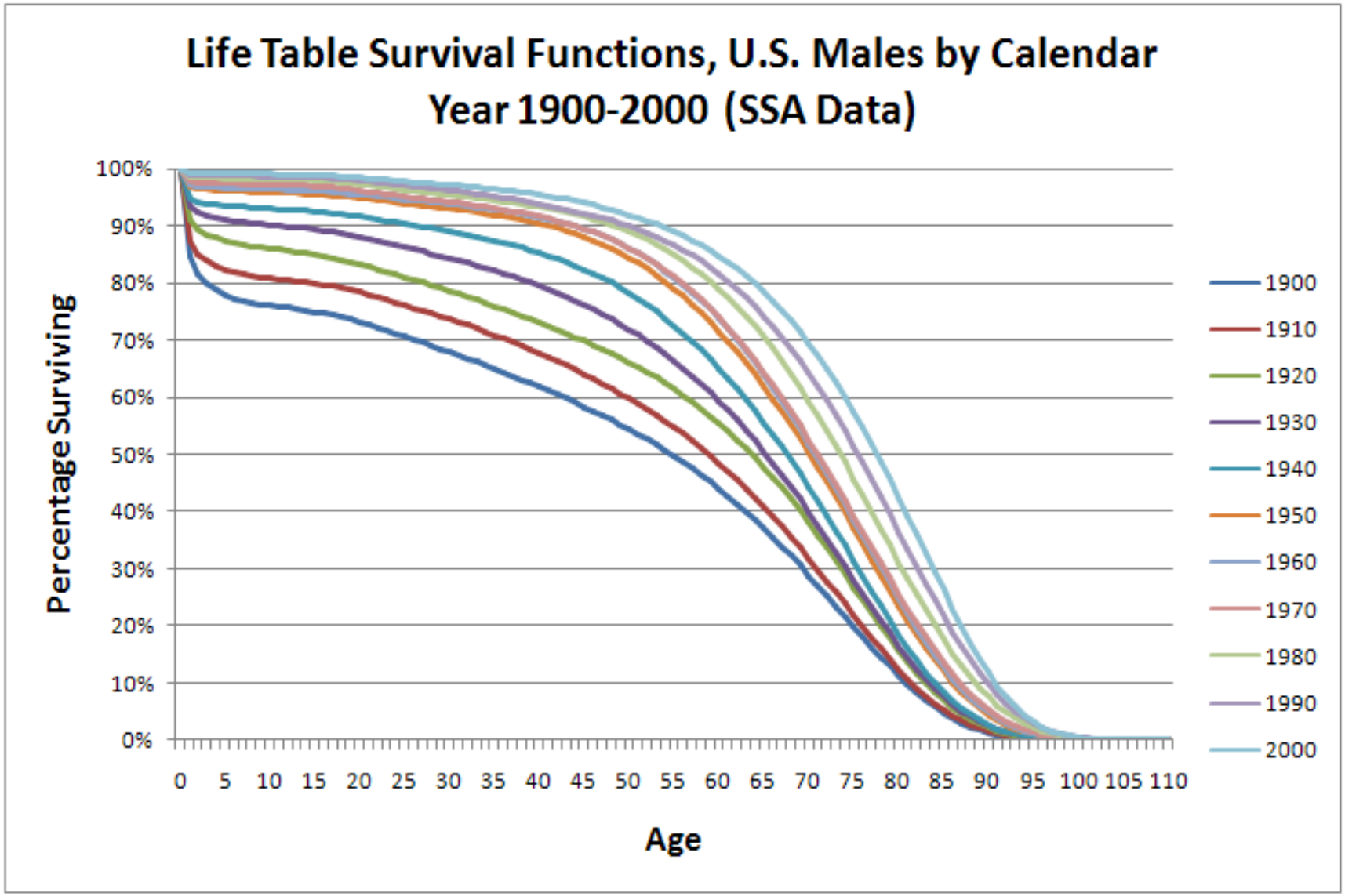
Chronic disability includes limitations in activities of daily living (ADLs) and cognitive impairment (CI) – two risks covered by long-term care insurance (LTCI).

Other definitions focus on diagnosed diseases, but these occur earlier in the disablement process, thereby adding complexity.

Compression of Mortality –

Mortality compression is generally accompanied by increases in the mean age-at-death (also called life expectancy (LE)).

Otherwise, death rates at older ages would need to increase for the variances to decrease.


Life Table Survival Functions, U.S. Males by Calendar Year 1900-2000 (SSA Data)
Percentage Surviving
100%
90%
80%
70%
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50%
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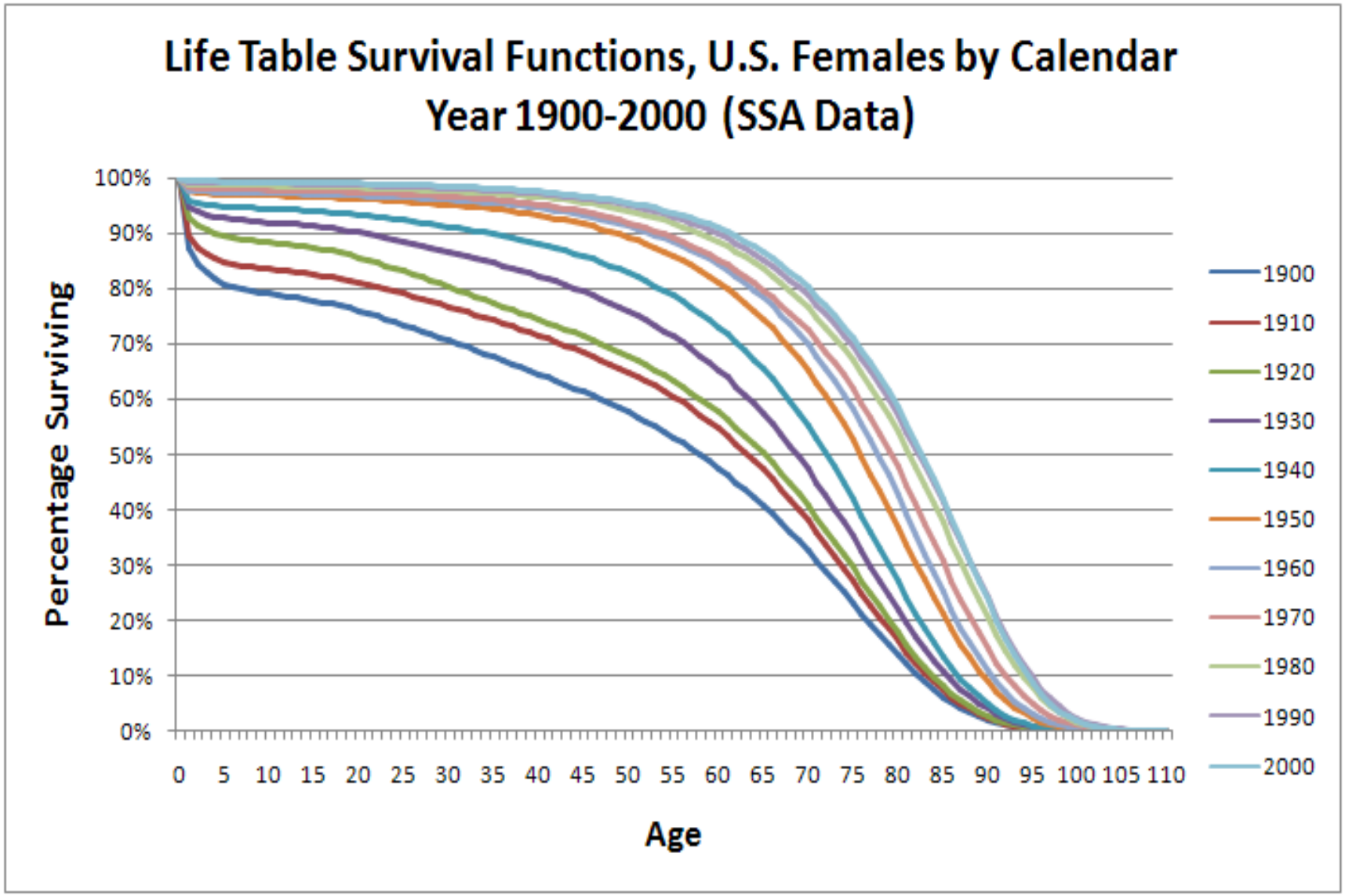
Life Table Survival Functions, U.S. Females by Calendar Year 1900-2000 (SSA Data)
Percentage Surviving
100%
90%
80%
70%
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0%
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110
Age
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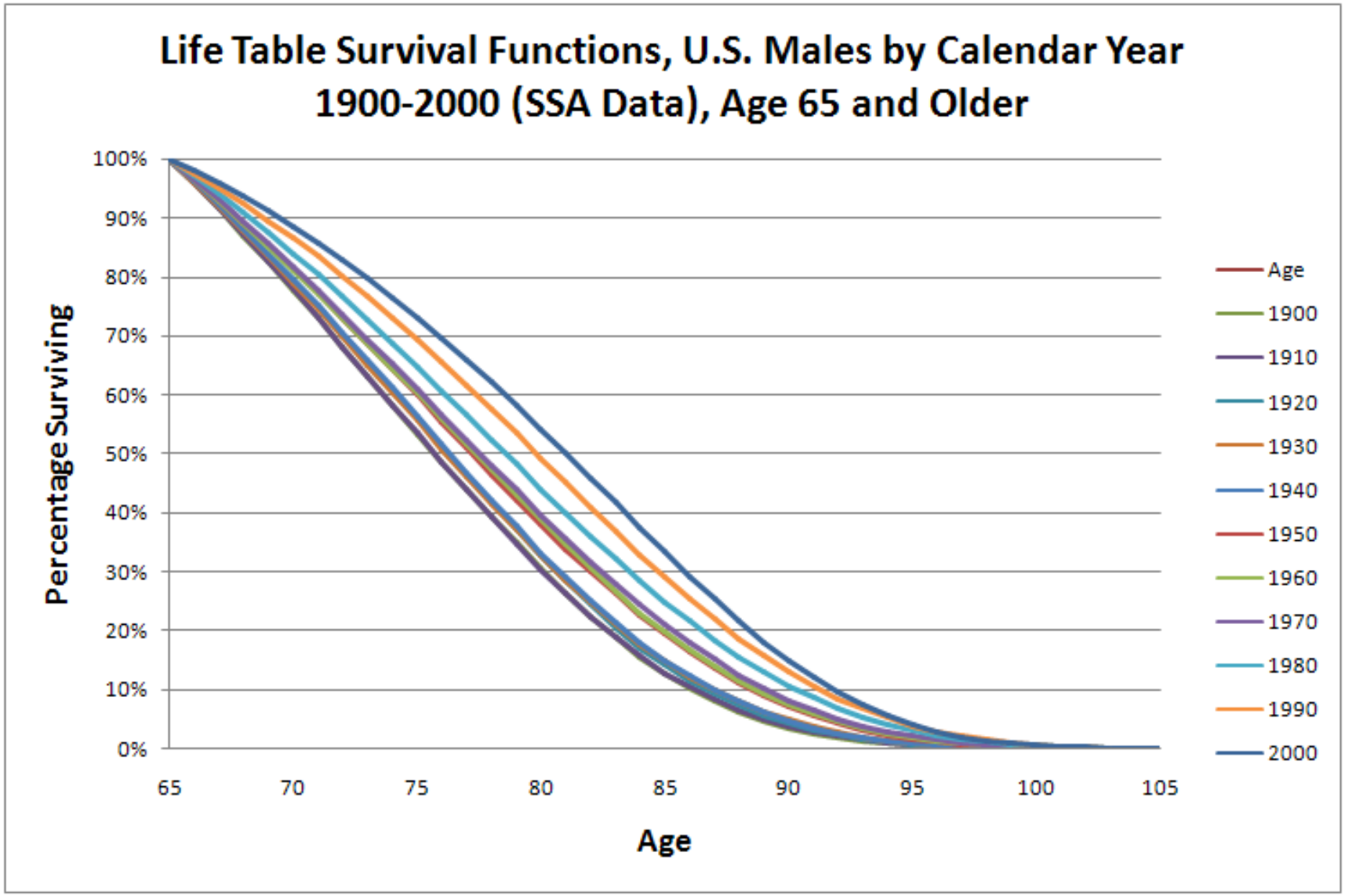
Life Table Survival Functions, U.S. Males by Calendar Year
1900-2000 (SSA Data), Age 65 and Older
Percentage Surviving
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
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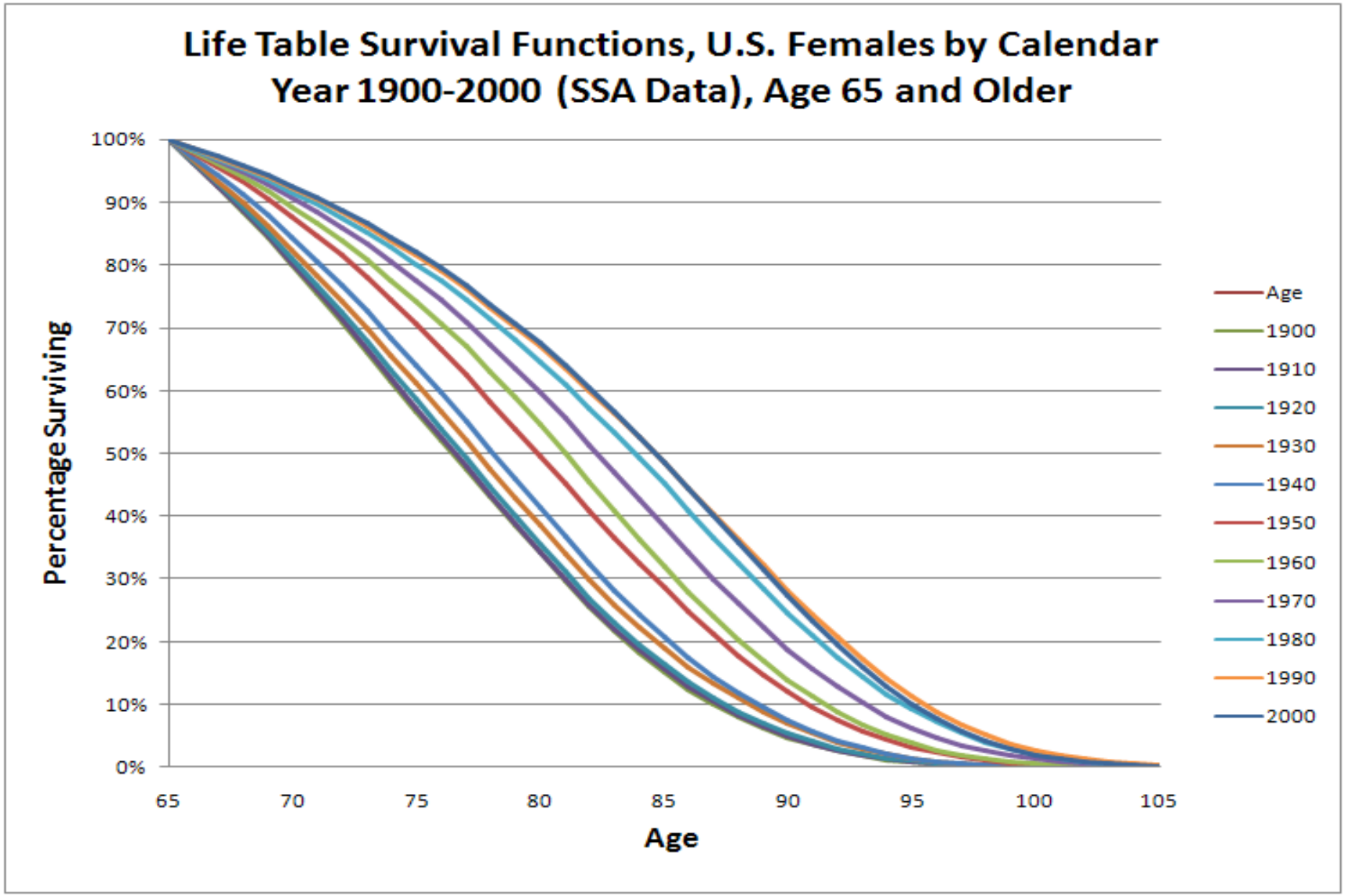
Life Table Survival Functions, U.S. Females by Calendar Year 1900-2000 (SSA Data), Age 65 and Older
Percentage Surviving
100%
90%
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50%
40%
30%
20%
10%
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65
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75
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100
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Age
Age
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

Life Expectancy at and beyond Age *x* in Year *y*

$$e_{D\,x,y} = \int_0^{\infty} {}_t p_{x,y}\ dt$$

where

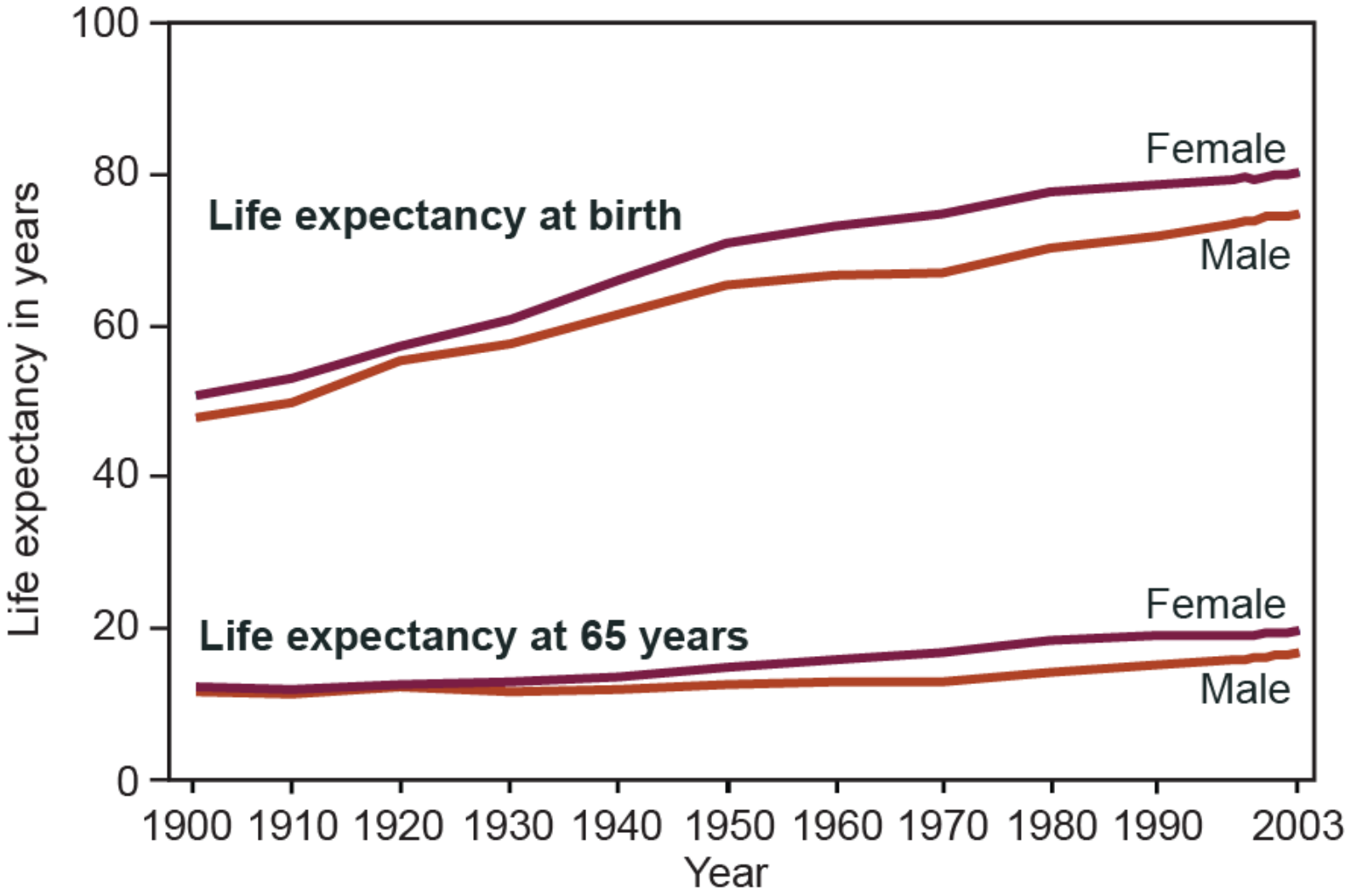
$${}_t p_{x,y} = l_{x+t,y} \big/ l_{x,y}$$

and

$$l_{x,y} = \text{ survival function value at age } x$$

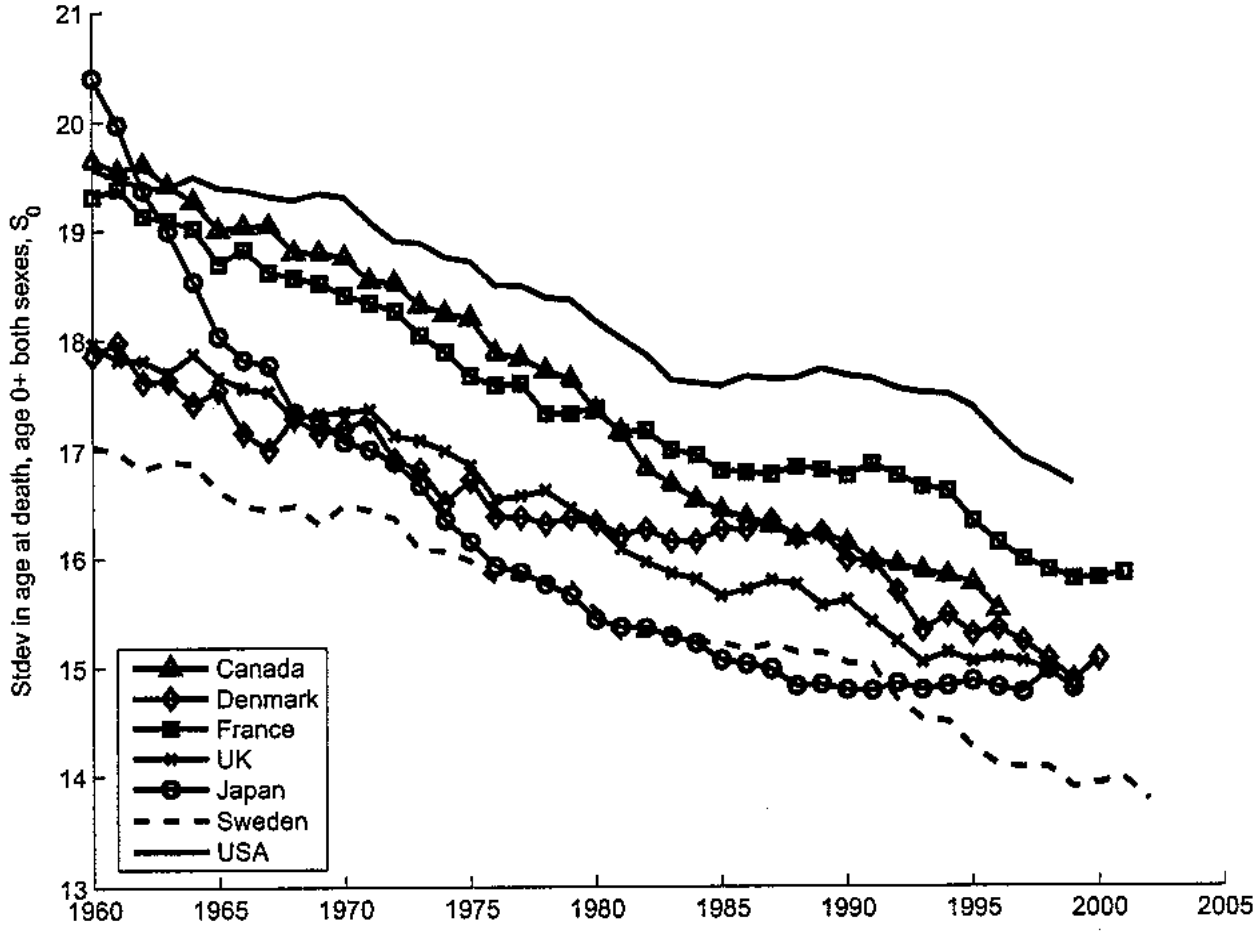
$$\cong \exp\left(-\sum_{t=0}^{x-1} m_{t,y}\right)$$

Life expectancy



SOURCES: Centers for Disease Control and Prevention, National Center for Health Statistics, *Health, United States, 2006*, Figure 24.
Data from the National Vital Statistics System.

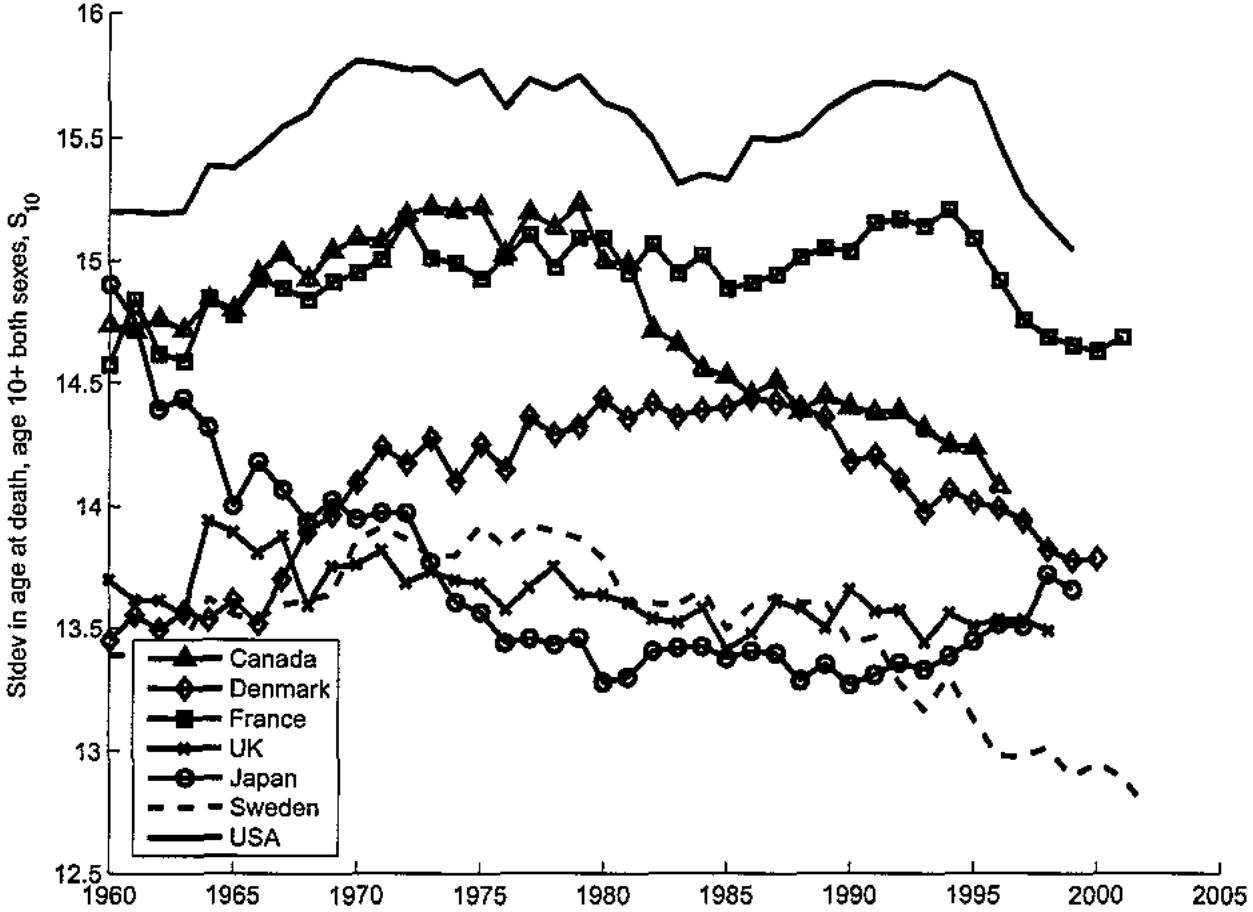
Figure 4: Unconditional standard deviations in the age at death, S_0, among 7 high-income countries since 1960



Notes: Data are the square roots of variances of ages at death. The weights are life table deaths, ${}_nd_x$, for both sexes combined from the Human Mortality Database.

Source: Edwards RD, Tuljapurkar S. 2005. "Inequality in Life Spans and a New Perspective on Mortality Convergence Across Industrialized Countries," *Population and Development Review* 31(4), 645-675.

Figure 5: Conditional standard deviations in the age at death, S_{10}, among 7 high-income countries since 1960



Notes: Data are the standard deviation in ages at death above age 10 for both sexes combined from the Human Mortality Database. The weights are life table deaths, ${}_nd_x$. Human Mortality Database.

Source: Edwards RD, Tuljapurkar S. 2005. "Inequality in Life Spans and a New Perspective on Mortality Convergence Across Industrialized Countries," *Population and Development Review* 31(4), 645-675.

Theoretical Limit of Variance of Time to Death, *T*, at and beyond Age *x*

Gompertz Mortality Function

$$m_t = \alpha_x \times \exp(\beta t)$$

$$\text{var}(T) \cong \frac{\pi^2}{6\beta^2}$$

$$\text{stdev}(T) \cong \sqrt{\frac{\pi^2}{6\beta^2}}$$

Source: Pollard JH, Valkovics EJ. 1992. "The Gompertz Distribution and its Applications." *Genus* 48(3/4): 15-28.

Life Expectancy at Birth, 34 OECD Countries: Males

Country	1980	1990	1995	2000	2005	2006	**2007**	2008	2009	**2007 Rank**
Switzerland	72.3	74.0	75.4	77.0	78.7	79.2	**79.5**	79.8	79.9	1
Iceland	73.7	75.4	75.9	78.4	79.2	79.4	**79.4**	79.6	79.7	2
Japan	73.3	75.9	76.4	77.7	78.6	79.0	**79.2**	79.3	79.6	3
Australia	71.0	73.9	75.0	76.6	78.5	78.7	**79.0**	79.2	79.3	4
Sweden	72.8	74.8	76.2	77.4	78.4	78.7	**78.9**	79.1	79.4	5
Israel[3]	72.1	74.9	75.5	76.7	78.2	78.7	**78.7**	79.0	79.7	6
Italy	70.6	73.8	75.0	76.9	78.0	78.5	**78.7**	79.1	---	7
Canada	**71.7**	**74.4**	**75.0**	**76.3**	**77.7**	**78.0**	**78.3**	**---**	**---**	**8**
Norway	72.4	73.5	74.8	76.0	77.8	78.2	**78.3**	78.4	78.7	9
New Zealand	70.1	72.5	74.1	75.9	77.7	78.0	**78.2**	78.4	78.8	10
Netherlands	72.5	73.8	74.6	75.5	77.2	77.6	**78.0**	78.3	78.5	11
Spain	72.3	73.4	74.4	75.8	77.0	77.7	**77.8**	78.2	78.6	12
United Kingdom	70.2	72.9	74.0	75.5	77.1	77.3	**77.6**	77.8	78.3	13
Austria	69.0	72.3	73.3	75.2	76.6	77.1	**77.4**	77.8	77.6	14
France	70.2	72.8	73.8	75.2	76.7	77.1	**77.4**	77.6	*77.7	15
Germany[2]	69.6	72.0	73.3	75.1	76.7	77.2	**77.4**	77.6	77.8	16
Ireland	70.1	72.1	72.8	74.0	77.2	77.3	**77.4**	77.8	77.4	17
Belgium	69.9	72.7	73.5	74.6	76.2	76.6	**77.1**	76.9	77.3	18
Greece	73.0	74.7	75.0	75.5	76.8	77.2	**77.1**	77.7	77.8	19
Luxembourg	70.0	72.4	73.0	74.6	76.7	76.8	**76.7**	78.1	78.1	20
Denmark	71.2	72.0	72.7	74.5	76.0	76.1	**76.2**	76.5	76.9	21
Republic of Korea	61.8	67.3	69.6	72.3	75.1	75.7	**76.1**	76.5	76.8	22
Finland	69.3	71.0	72.8	74.2	75.6	75.9	**76.0**	76.5	76.6	23
Portugal	67.9	70.6	71.7	73.2	74.9	75.5	**75.9**	76.2	76.5	24
United States	**70.0**	**71.8**	**72.5**	**74.1**	**74.9**	**75.1**	**75.4**	**75.6**	**76.0**	**25**
Chile	---	69.4	71.5	73.7	74.9	75.5	**75.0**	75.1	*75.6	26
Slovenia	---	69.4	70.3	71.9	74.1	74.8	**74.6**	75.4	75.8	27
Czech Republic[1]	66.9	67.6	69.7	71.7	72.9	73.5	**73.8**	74.1	74.2	28
Mexico	64.1	67.7	69.7	71.3	72.2	72.4	**72.6**	72.7	72.9	29
Turkey	55.8	**65.4	67.2	69.0	70.9	71.1	**71.1**	71.4	71.5	30
Poland	66.0	66.2	67.6	69.7	70.8	70.9	**71.0**	71.3	71.5	31
Slovak Republic[1]	66.8	66.6	68.4	69.1	70.1	70.4	**70.5**	70.9	71.3	32
Hungary	65.5	65.1	65.3	67.4	68.6	69.0	**69.2**	69.8	70.0	33
Estonia	64.2	64.5	61.3	65.1	67.3	67.4	**67.1**	68.6	69.8	34

Source: Centers for Disease Control and Prevention, National Center for Health Statistics, *Health, United States, 2011* , Table 21.

Life Expectancy at Birth, 34 OECD Countries: Females

Country	1980	1990	1995	2000	2005	2006	**2007**	2008	2009	**2007 Rank**
Japan	78.8	81.9	82.8	84.6	85.5	85.8	**86.0**	86.0	86.4	1
France	78.4	80.9	81.9	82.8	83.8	84.2	**84.4**	84.3	*84.4	2
Switzerland	79.0	80.9	81.9	82.8	84.0	84.2	**84.4**	84.6	84.6	3
Spain	78.5	80.6	81.8	82.9	83.7	84.4	**84.3**	84.5	84.9	4
Italy	77.4	80.3	81.5	82.8	83.6	84.2	**84.2**	84.5	---	5
Australia	78.1	80.1	80.8	82.0	83.3	83.5	**83.7**	83.7	83.9	6
Austria	76.1	79.0	80.1	81.2	82.2	82.8	**83.1**	83.3	83.2	7
Finland	78.0	79.0	80.4	81.2	82.5	83.1	**83.1**	83.3	83.5	8
Canada	**78.9**	**80.8**	**81.0**	**81.7**	**82.5**	**82.8**	**83.0**	**---**	**---**	**9**
Sweden	78.8	80.4	81.4	82.0	82.8	82.9	**83.0**	83.2	83.4	10
Iceland	79.7	80.5	80.0	81.8	83.1	83.0	**82.9**	83.0	83.3	11
Norway	79.3	79.9	80.9	81.5	82.7	82.9	**82.9**	83.2	83.2	12
Germany[2]	76.2	78.5	79.9	81.2	82.0	82.4	**82.7**	82.7	82.8	13
Republic of Korea	70.0	75.5	77.4	79.6	81.9	82.4	**82.7**	83.3	83.8	14
Belgium	76.7	79.5	80.4	81.0	81.9	82.3	**82.6**	82.6	82.8	15
Israel[3]	75.7	78.4	79.5	80.9	82.2	82.5	**82.4**	83.0	83.5	16
Netherlands	79.2	80.1	80.4	80.5	81.6	81.9	**82.3**	82.3	82.7	17
Luxembourg	75.6	78.7	80.6	81.3	82.3	81.9	**82.2**	83.1	83.3	18
New Zealand	76.2	78.4	79.5	80.8	82.0	82.2	**82.2**	82.4	82.7	19
Portugal	74.9	77.5	79.0	80.2	81.3	82.3	**82.2**	82.4	82.6	20
Ireland	75.6	77.7	78.3	79.2	81.6	82.1	**82.1**	82.4	82.5	21
Greece	77.5	79.5	80.0	80.6	81.6	81.9	**81.8**	82.3	82.7	22
Slovenia	---	77.2	77.8	79.1	81.3	81.9	**81.8**	82.3	82.3	23
United Kingdom	76.2	78.5	79.3	80.3	81.3	81.7	**81.8**	81.9	82.5	24
Chile	---	76.5	78.2	80.0	80.9	81.4	**80.7**	80.6	*80.9	25
Denmark	77.3	77.8	77.9	79.2	80.5	80.7	**80.6**	81.0	81.1	26
United States	**77.4**	**78.8**	**78.9**	**79.3**	**79.9**	**80.2**	**80.4**	**80.6**	**80.9**	**27**
Czech Republic[1]	74.0	75.5	76.8	78.5	79.2	79.9	**80.2**	80.5	80.5	28
Poland	74.4	75.2	76.4	78.0	79.4	79.6	**79.7**	80.0	80.0	29
Estonia	74.2	74.7	74.1	76.0	78.1	78.5	**78.7**	79.2	80.1	30
Slovak Republic[1]	74.3	75.4	76.3	77.4	77.9	78.2	**78.1**	78.7	78.7	31
Mexico	70.2	73.5	75.2	76.5	77.0	77.2	**77.4**	77.5	77.6	32
Hungary	72.7	73.7	74.5	75.9	76.9	77.4	**77.3**	77.8	77.9	33
Turkey	60.3	**69.5	71.3	73.1	75.0	75.3	**75.6**	75.8	76.1	34

Source: Centers for Disease Control and Prevention, National Center for Health Statistics, *Health, United States, 2011* , Table 21.

Life Expectancy at 65 Years of Age, 34 OECD countries: Males

Country	1980	1990	1995	2000	2005	2006	**2007**	2008	2009	**2007 Rank**
Japan	14.6	16.2	16.5	17.5	18.1	18.4	**18.6**	18.6	18.9	1
Switzerland	14.3	15.3	16.2	17.0	18.1	18.5	**18.6**	18.9	19.0	2
Australia	13.7	15.2	15.7	16.9	18.1	18.3	**18.5**	18.6	18.7	3
Iceland	15.8	16.2	16.2	18.1	18.0	18.3	**18.3**	18.2	18.3	4
Canada	**14.5**	**15.7**	**15.9**	**16.5**	**17.6**	**17.9**	**18.1**	**---**	**---**	**5**
France	13.6	15.5	16.1	16.7	17.7	18.0	**18.1**	18.2	---	6
Israel[3]	---	15.7	15.9	17.0	18.0	18.3	**18.1**	18.5	18.9	7
New Zealand	13.2	14.6	15.4	16.5	17.7	18.0	**18.1**	18.3	18.6	8
Italy	13.3	15.2	15.9	16.7	17.4	17.9	**18.0**	18.2	---	9
Spain	14.6	15.5	16.1	16.7	17.3	17.9	**17.8**	18.1	18.3	10
Sweden	14.3	15.3	16.0	16.7	17.4	17.6	**17.8**	17.9	18.2	11
United Kingdom	12.6	14.0	14.6	15.8	17.0	17.4	**17.6**	17.7	18.1	12
Austria	12.9	14.4	15.0	16.0	17.0	17.3	**17.5**	17.7	17.7	13
Germany[2]	12.8	14.0	14.8	15.8	16.9	17.2	**17.4**	17.5	17.6	14
Greece	15.2	15.7	15.9	16.1	17.1	17.5	**17.4**	17.8	18.1	15
Norway	14.3	14.6	15.1	16.1	17.2	17.7	**17.4**	17.6	18.0	16
Belgium	12.9	14.3	14.8	15.6	16.6	17.0	**17.3**	17.3	17.5	17
United States	**14.1**	**15.1**	**15.6**	**16.0**	**16.8**	**17.0**	**17.2**	**17.3**	**17.6**	**18**
Ireland	12.6	13.3	13.5	14.6	16.7	16.7	**17.1**	16.8	17.2	19
Finland	12.6	13.8	14.6	15.5	16.8	16.9	**17.0**	17.5	17.3	20
Netherlands	13.7	14.4	14.7	15.3	16.4	16.7	**17.0**	17.3	17.4	21
Mexico	15.4	16.0	16.1	16.5	16.8	16.8	**16.8**	16.8	16.8	22
Portugal	13.1	14.0	14.7	15.4	16.1	16.6	**16.8**	16.9	17.1	23
Denmark	13.6	14.0	14.1	15.2	16.1	16.2	**16.5**	16.6	16.8	24
Luxembourg	12.6	14.3	14.8	15.5	16.7	17.0	**16.4**	17.4	17.6	25
Republic of Korea	10.5	12.4	13.3	14.3	15.8	16.1	**16.3**	16.6	17.1	26
Chile	---	13.7	14.4	15.5	16.2	16.7	**16.2**	17.0	*16.8	27
Slovenia	---	13.2	13.5	14.1	15.5	16.1	**15.8**	16.3	16.3	28
Czech Republic[1]	11.2	11.7	12.7	13.8	14.4	14.8	**15.1**	15.3	15.2	29
Poland	12.0	12.4	12.9	13.6	14.4	14.5	**14.6**	14.7	14.7	30
Turkey	11.7	**12.8	13.1	13.4	13.9	13.9	**13.9**	14.0	14.0	31
Hungary	11.6	12.0	12.1	12.7	13.1	13.4	**13.4**	13.6	13.7	32
Slovak Republic[1]	12.3	12.2	12.7	12.9	13.2	13.3	**13.4**	13.8	13.9	33
Estonia	---	11.9	11.9	12.5	13.1	13.2	**13.2**	13.6	14.4	34

Source: Centers for Disease Control and Prevention, National Center for Health Statistics, *Health, United States, 2011* , Table 21.

Life Expectancy at 65 Years of Age, 34 OECD countries: Females

Country	1980	1990	1995	2000	2005	2006	**2007**	2008	2009	**2007 Rank**
Japan	17.7	20.0	20.9	22.4	23.2	23.4	**23.6**	23.6	24.0	1
France	18.2	19.8	20.6	21.2	22.0	22.4	**22.5**	22.5	---	2
Switzerland	18.2	19.7	20.4	20.9	21.7	22.1	**22.2**	22.3	22.2	3
Spain	17.8	19.3	20.2	20.8	21.3	22.0	**21.9**	22.1	22.4	4
Italy	17.1	18.9	19.9	20.7	21.3	21.8	**21.8**	22.0	---	5
Australia	17.9	19.0	19.5	20.4	21.4	21.5	**21.6**	21.6	21.8	6
Canada	**18.9**	**19.9**	**19.9**	**20.2**	**20.9**	**21.1**	**21.3**	**---**	**---**	**7**
Finland	17.0	17.8	18.8	19.5	20.9	21.2	**21.2**	21.3	21.5	8
Austria	16.3	18.1	18.8	19.6	20.3	20.7	**21.0**	21.1	21.2	9
Belgium	16.8	18.8	19.3	19.7	20.2	20.6	**21.0**	20.9	21.1	10
Norway	18.2	18.7	19.3	19.9	20.9	20.8	**20.8**	21.0	21.1	11
Germany[2]	16.3	17.7	18.7	19.6	20.1	20.5	**20.7**	20.7	20.8	12
New Zealand	17.0	18.3	19.0	19.8	20.5	20.6	**20.7**	20.8	21.1	13
Sweden	17.9	19.0	19.6	20.0	20.6	20.8	**20.7**	20.8	21.0	14
Iceland	19.1	19.5	19.0	19.7	20.7	20.6	**20.6**	20.5	20.6	15
Netherlands	18.0	18.9	19.0	19.2	20.0	20.1	**20.5**	20.5	20.8	16
Republic of Korea	15.1	16.3	17.0	18.2	19.9	20.1	**20.5**	21.0	21.5	17
Luxembourg	16.5	18.5	19.7	20.1	20.4	20.3	**20.3**	21.0	21.4	18
Israel[3]	---	17.8	17.9	19.0	20.2	20.4	**20.2**	20.7	21.2	19
Portugal	16.1	17.1	18.1	18.9	19.4	20.2	**20.2**	20.3	20.5	20
United Kingdom	16.6	17.9	18.2	19.0	19.7	20.1	**20.2**	20.3	20.8	21
Ireland	15.7	17.0	17.2	18.0	19.8	20.2	**20.1**	20.3	20.6	22
Slovenia	---	16.7	17.1	17.9	19.9	20.1	**19.9**	20.2	20.1	23
United States	**18.3**	**18.9**	**18.9**	**19.0**	**19.5**	**19.7**	**19.9**	**20.0**	**20.3**	**24**
Chile	---	17.2	18.2	19.3	19.7	20.2	**19.5**	20.4	*19.9	25
Greece	17.0	18.0	18.2	18.4	19.2	19.4	**19.4**	19.8	20.2	26
Denmark	17.6	17.9	17.6	18.3	19.1	19.2	**19.2**	19.5	19.5	27
Poland	15.5	16.1	16.6	17.5	18.6	18.8	**18.9**	19.0	19.1	28
Czech Republic[1]	14.4	15.3	16.2	17.3	17.7	18.3	**18.5**	18.8	18.8	29
Estonia	---	15.5	16.0	16.8	18.1	18.2	**18.5**	18.6	18.3	30
Mexico	17.0	17.8	17.8	18.1	18.2	18.2	**18.2**	18.3	18.3	31
Hungary	14.6	15.3	15.8	16.5	16.9	17.2	**17.3**	17.5	17.6	32
Slovak Republic[1]	15.4	15.7	16.1	16.5	16.9	17.1	**17.1**	17.5	17.6	33
Turkey	12.8	**14.3	14.7	15.1	15.6	15.7	**15.8**	15.8	15.9	34

Source: Centers for Disease Control and Prevention, National Center for Health Statistics, *Health, United States, 2011* , Table 21.

Age-Standardized Death Rate at Age 65 and Older

$$\mathrm{ASDR}_y(\{N_x\}) = \sum_{x=65}^{\omega} N_x \cdot m_{x,y} \Big/ \sum_{x=65}^{\omega} N_x$$

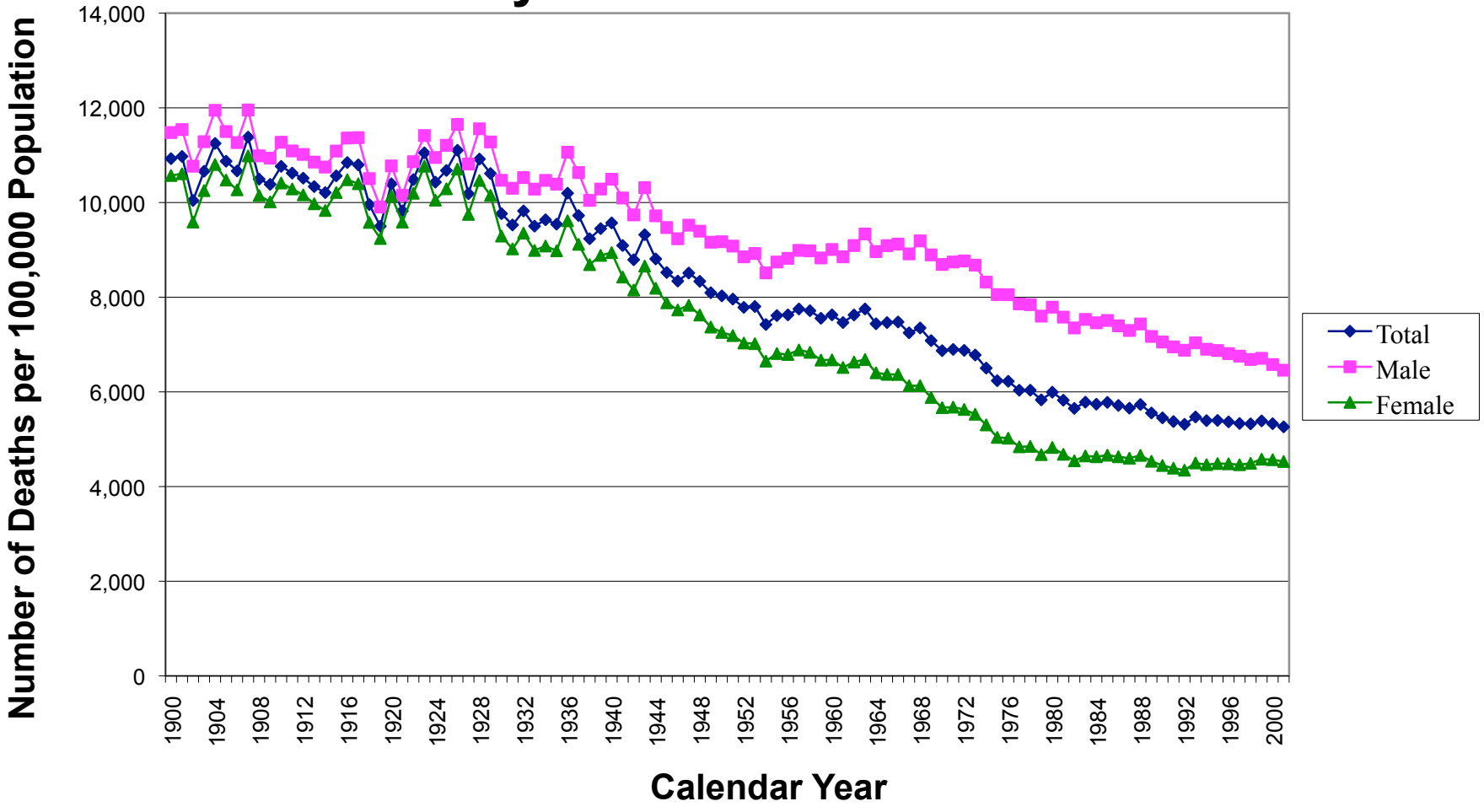
where

N_x = Standard (mid-year) population at age x

and

$m_{x,y}$ = Death rate at age x in year y

Age-Standardized Death Rates at Age 65 and Over by Sex and Calendar Year



Source : *2007 Technical Panel on Assumptions and Methods: Report to the Social Security Advisory Board*. Social Security Advisory Board, Washington, DC. 2007.

Age-Standardized Death Rates by Sex, Under Age 65, Age 65 and Over and Calendar Year

(Per hundred thousand)

Calendar Year	Total			Male			Female		
	Total	Under 65	65 and Over	Total	Under 65	65 and Over	Total	Under 65	65 and Over
1980	1,035.9	331.9	5,993.6	1,352.9	439.0	7,789.5	800.4	228.8	4,826.2
1981	1,007.2	323.2	5,823.9	1,315.6	426.3	7,579.0	778.3	224.0	4,681.9
1982	975.8	312.0	5,650.9	1,273.5	410.5	7,351.2	755.3	217.3	4,544.2
1983	987.7	306.9	5,782.6	1,288.3	401.9	7,531.2	766.5	215.5	4,647.1
1984	980.1	304.2	5,740.0	1,276.4	398.4	7,459.8	762.8	213.7	4,630.1
1985	984.2	303.6	5,777.6	1,282.5	398.5	7,508.3	765.5	212.2	4,662.4
1986	975.3	302.5	5,713.8	1,267.7	397.6	7,395.5	760.2	210.7	4,630.0
1987	965.6	299.6	5,655.6	1,251.8	393.5	7,297.3	754.9	209.1	4,598.2
1988	974.9	299.3	5,733.2	1,268.2	392.7	7,434.1	762.4	209.1	4,658.8
1989	948.8	294.9	5,553.9	1,231.2	387.9	7,170.3	743.3	205.0	4,533.8
1990	931.2	289.4	5,451.1	1,210.6	381.0	7,053.4	728.5	200.8	4,444.8
1991	918.8	286.2	5,373.5	1,193.7	376.3	6,950.7	719.9	199.1	4,388.2
1992	906.2	280.2	5,315.3	1,178.2	368.6	6,880.0	710.7	194.5	4,345.5
1993	928.0	283.1	5,470.0	1,200.5	372.0	7,035.6	731.8	197.0	4,498.0
1994	916.2	280.5	5,392.7	1,180.8	368.6	6,900.9	725.8	195.2	4,462.8
1995	913.9	277.3	5,397.5	1,172.3	362.7	6,873.8	728.2	194.5	4,486.9
1996	900.4	266.1	5,367.2	1,148.1	344.3	6,808.8	723.9	190.5	4,480.5
1997	885.1	253.6	5,332.5	1,123.5	324.0	6,754.5	717.4	185.7	4,461.4
1998	878.3	246.9	5,325.2	1,106.4	314.4	6,684.6	717.6	181.7	4,491.5
1999	884.3	245.0	5,386.6	1,106.3	310.9	6,708.7	728.1	181.5	4,578.0
2000	875.7	243.4	5,328.3	1,087.9	308.5	6,577.0	726.0	180.6	4,567.4
2001	867.4	243.6	5,260.7	1,072.7	308.1	6,457.9	721.8	181.2	4,529.5
2002	863.6	242.7	5,236.6	1,067.4	307.6	6,418.6	719.7	180.0	4,521.0
2003	851.3	241.2	5,148.2	1,046.7	305.3	6,268.0	712.3	179.2	4,467.2
2004	852.2	232.8	5,214.4	1,041.2	291.9	6,318.3	719.2	175.6	4,546.9
2005	847.8	230.0	5,199.0	1,032.5	287.8	6,277.6	718.1	174.1	4,549.4
2006	843.7	227.2	5,185.2	1,024.1	283.7	6,238.7	717.3	172.6	4,553.2

Source: Social Security Administration, Office of the Chief Actuary, August 16, 2007.

Age-Standardized Disability Prevalence Rate at Age 65 and Older

$$\mathrm{ASDR}_y(\{N_x\}) = \sum_{x=65}^{\omega} N_x \cdot \pi_{x,y} \Big/ \sum_{x=65}^{\omega} N_x$$

where

N_x = Standard (mid-year) population at age x

and

$\pi_{x,y}$ = Disability prevalence rate at age x in year y

ADLs in the U.S. National Long Term Care Survey (NLTCS)

1. Bathing
2. Continence
3. Dressing
4. Eating
5. Transferring (in/out bed)
6. Toileting
7. Inside mobility
   - not included in the **HIPAA ADL Trigger**

ADL Disability Thresholds

0. Performs ADL
1. Needs, but does not receive, help with ADL
2. Performs ADL with special equipment
3. Standby help with/without special equipment
4. Active help, with/without special equipment
5. Unable to perform ADL

Two or more ADLs at levels 3–5 are required to meet the **HIPAA ADL Trigger**.

The traditional NLTCS triggers count the ADLs at levels 2–5.

Percent of Population Meeting HIPAA ADL Trigger, United States 1984 and 2004, Males, Age 65 and Above, by Age and Totalled Over Age, with Two Modes of Age Standardization

Age	1984	2004	% Change	Annual Rate of Decline; 20 yr.
65-69	3.1	2.1	-32.0	1.91%
70-74	5.5	3.7	-33.0	1.98%
75-79	8.6	5.9	-30.6	1.81%
80-84	13.5	8.7	-35.2	2.15%
85-89	21.9	11.8	-46.1	3.04%
90-94	37.3	21.7	-41.8	2.67%
95+	54.2	31.4	-42.1	2.69%
Total	7.5	5.8	-22.0	1.23%
1984 ASDR	7.5	4.8	-35.4	2.16%
2004 ASDR	9.2	5.8	-36.7	2.26%

NOTE: ASDR denotes age-standardized disability rate; the 1984 and 2004 results were separately age-standardized to the 1984 and 2004 NLTCS weighted male population.

Source: Authors' calculations based on the 1984 and 2004 NLTCS.

Percent of Population Meeting HIPAA ADL Trigger, United States 1984 and 2004, Females, Age 65 and Above, by Age and Totalled Over Age, with Two Modes of Age Standardization

Age	1984	2004	% Change	Annual Rate of Decline; 20 yr.
65-69	3.5	2.3	-35.0	2.13%
70-74	4.9	3.9	-20.2	1.12%
75-79	9.0	6.7	-26.0	1.50%
80-84	17.2	11.8	-31.5	1.87%
85-89	30.1	23.3	-22.7	1.28%
90-94	49.8	31.4	-37.0	2.28%
95+	70.1	56.1	-20.0	1.11%
Total	11.0	9.8	-10.2	0.54%
1984 ASDR	11.0	7.9	-27.7	1.61%
2004 ASDR	13.6	9.8	-27.9	1.62%

NOTE: ASDR denotes age-standardized disability rate; the 1984 and 2004 results were separately age-standardized to the 1984 and 2004 NLTCS weighted female population.

Source: Authors' calculations based on the 1984 and 2004 NLTCS.

Disabled Life Expectancy at and beyond Age x in Year y (Sullivan, 1971)

$$e_{D\,x,y} = \int_0^{\infty} {}_t p_{x,y}\ \pi_{x+t,y}\ dt$$

where

$${}_t p_{x,y} = l_{x+t,y} \Big/ l_{x,y}$$

and

$\pi_{x+t,y}$ = disability prevalence at age $x + t$

Sullivan DF. 1971. "A single index of mortality and morbidity." *HSMHA Reports* 86(4): 347-354.

Life Expectancy and HIPAA ADL Expectancy (in Years at Age 65), United States 1984 and 2004, by Sex

	Males				Females			
	1984	2004	Change	Relative Change	1984	2004	Change	Relative Change
Life Expectancy	14.46	16.67	2.21	15.3%	18.64	19.50	0.85	4.6%
ADL Expectancy	1.23	0.98	-0.25	-20.1%	2.41	1.88	-0.53	-22.0%

Source: Authors' calculations based on 1984 and 2004 NLTCS, 1984 life tables interpolated from 1980 and 1990 life tables in Bell and Miller (2005), and 2004 life tables from Social Security Online.

Change from Year y_0 to Year y in Disabled Life Expectancy at and beyond Age x

$$e_{Dx,y} - e_{Dx,y_0} = \int_0^\infty \left({}_t p_{x,y} \ \pi_{x+t,y} - {}_t p_{x,y_0} \ \pi_{x+t,y_0} \right) dt$$

$$= \int_0^\infty \left({}_t p_{x,y} - {}_t p_{x,y_0} \right) \pi_{x+t,y_0} \ dt \qquad \text{Survival Increment}$$

$$- \int_0^\infty {}_t p_{x,y} \left(\pi_{x+t,y_0} - \pi_{x+t,y} \right) dt \quad \text{Morbidity Decrement}$$

Components of Change in Male Life Expectancy and HIPAA ADL Expectancy (in Years at Age 65), United States 1984 and 2004

	Year				
At Age 65	1984	2004	Change	Survival Increment	Morbidity Decrement
Life Expectancy	14.46	16.67	2.208	2.208	—
HIPAA ADL Expectancy	1.23	0.98	-0.247	0.328	0.575

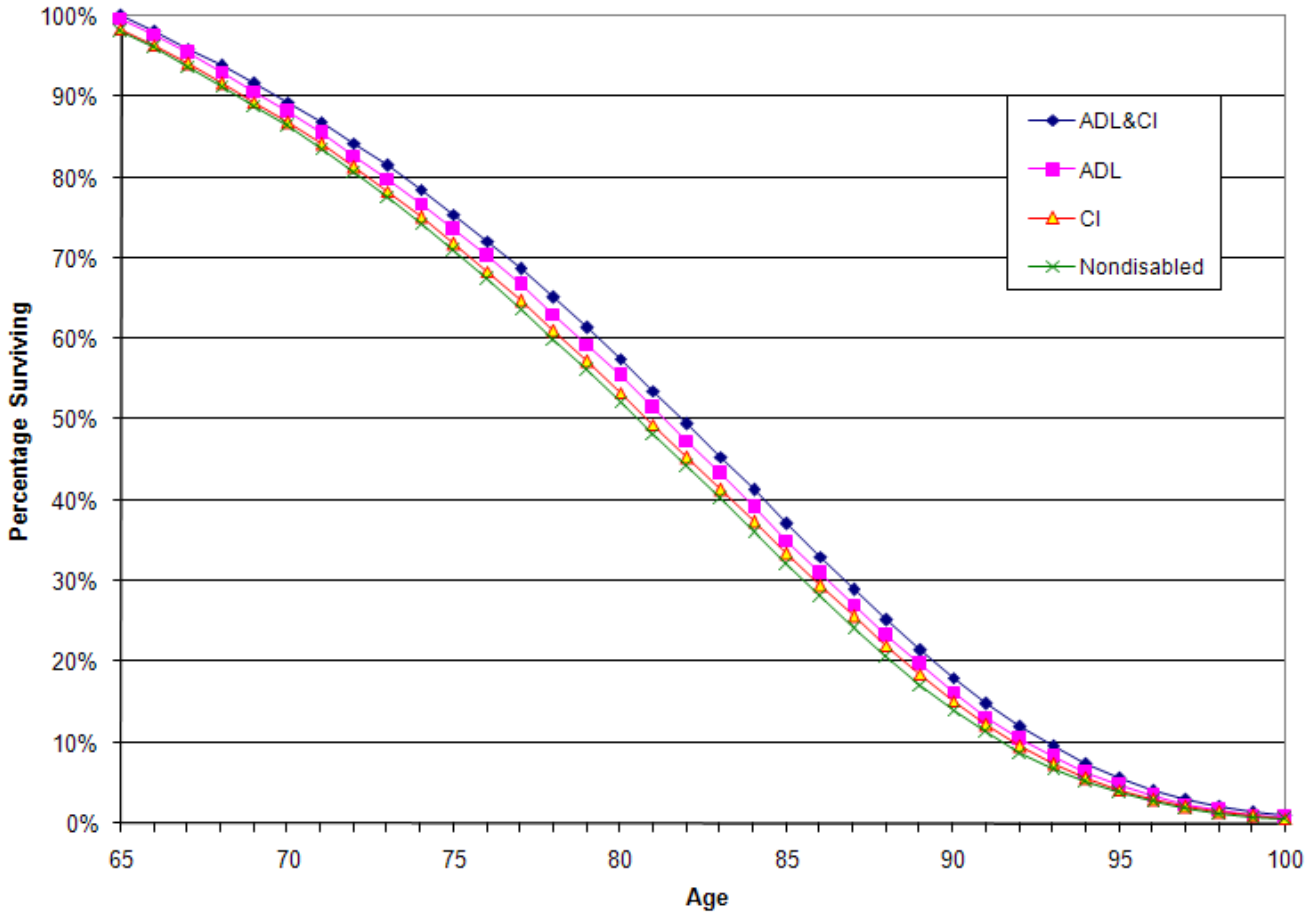
Source: Author's calculations.

Components of Change in Female Life Expectancy and HIPAA ADL Expectancy (in Years at Age 65), United States 1984 and 2004

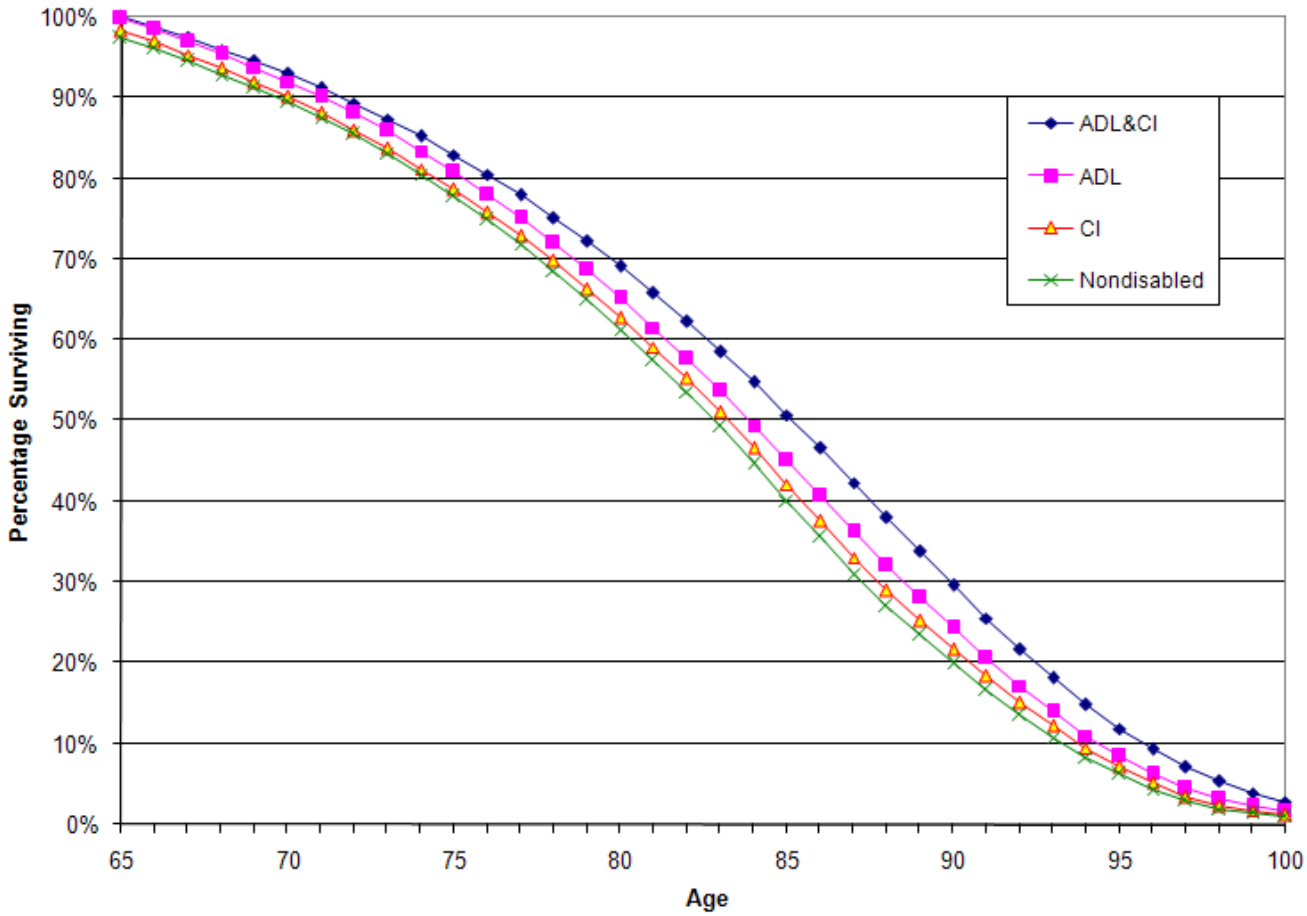
	Year				
At Age 65	1984	2004	Change	Survival Increment	Morbidity Decrement
Life Expectancy	18.64	19.50	0.853	0.853	—
HIPAA ADL Expectancy	2.41	1.88	-0.531	0.200	0.731

Source: Author's calculations.

Joint Relative Survival at Ages 65+, Meets Any HIPAA Trigger, United States 2004, Males



Joint Relative Survival at Ages 65+, Meets Any HIPAA Trigger, United States 2004, Females



Summary

Mortality Compression = Rectangularization of Survival Function

Big effects over entire 20th century at age 0+.

Lesser effects recently and at age 10+.

Theoretical limits on variances will constrain future effects to approximately parallel shifts of survival functions at age 65+.

Average ages at death (LE's) will continue to increase.

U.S. LE rankings at birth (#25, #24) and age 65 (#18, #24) indicate large potentials for LE gains, without any effective biological constraints.

Summary

Morbidity Compression = Reduction in Lifetime ADL Disability Days

Big declines over measurement period 1984-2004 at age 65+.

Start and end rates differed substantially between males and females.

Relative rates of decline (20%, 22%) in ADL expectancies were similar and very substantial for both males and females.

Age-standardization is important for correct comparisons of populations with changing age structure.

Separate or Related?

Mortality improvement, with static morbidity rates, would lead to increased morbidity (the **survival increment**; e.g., 0.33 yr., 0.20 yr.).

Actual mortality improvement, without compression, has been counterbalanced by an even greater reduction in morbidity (the **morbidity decrement**; e.g., 0.58 yr., 0.73 yr.).

Conclusion: Mortality compression is not necessary for morbidity compression.

Open question: Will morbidity compression reach an actual or theoretical lower limit, at which time survival increments and morbidity decrements are in balance?

Acknowledgements

Analysis of the NLTCS was funded by the ILTCI Conference Board and SOA LTCI Section and Special Research Fund through a joint grant to Duke University; and by the National Institute on Aging through Grants R01AG028259, R01AG030612, R01AG032319, and R01AG030198-01A2.

Funding for the NLTCS data collection was provided by the National Institute on Aging, most recently through Grant U01-AG07198 to Duke University.