2020 Symposium
Jan. 13–15
Lake Buena Vista, FL

LIVING to 100

SOCIETY OF ACTUARIES
INTERNATIONAL SYMPOSIUM

General Session IV – Panel: Mortality Projection from a Social Security Panel

SOA Antitrust Disclaimer
SOA Presentation Disclaimer

Mortality projections for Canadian social security programs

2020 Living to 100 Symposium
General Session IV - Panel: Mortality Projection from a Social Security Panel

Assia Billig, Chief Actuary, OCA, OSFI
Orlando, USA
**January 14, 2020**

Office of the Chief Actuary

- Mandate: conduct <u>statutory</u> actuarial valuations on
  - Canada Pension Plan (CPP) – **20M members**
  - Old Age Security Program (OAS) - **6M beneficiaries**
  - Federal public sector pension and insurance plans – **0.8M members**
  - Canada Student Loans Program – **0.5M loans**
  - Employment Insurance Program – **19M workers**
- The Chief Actuary is solely responsible for content and actuarial opinions in reports prepared by the OCA.
- Mortality projections are developed for CPP, OAS and large federal public sector pension plans.

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Life Expectancy at Age 65

Period Life Expectancy at Age 65 for Males
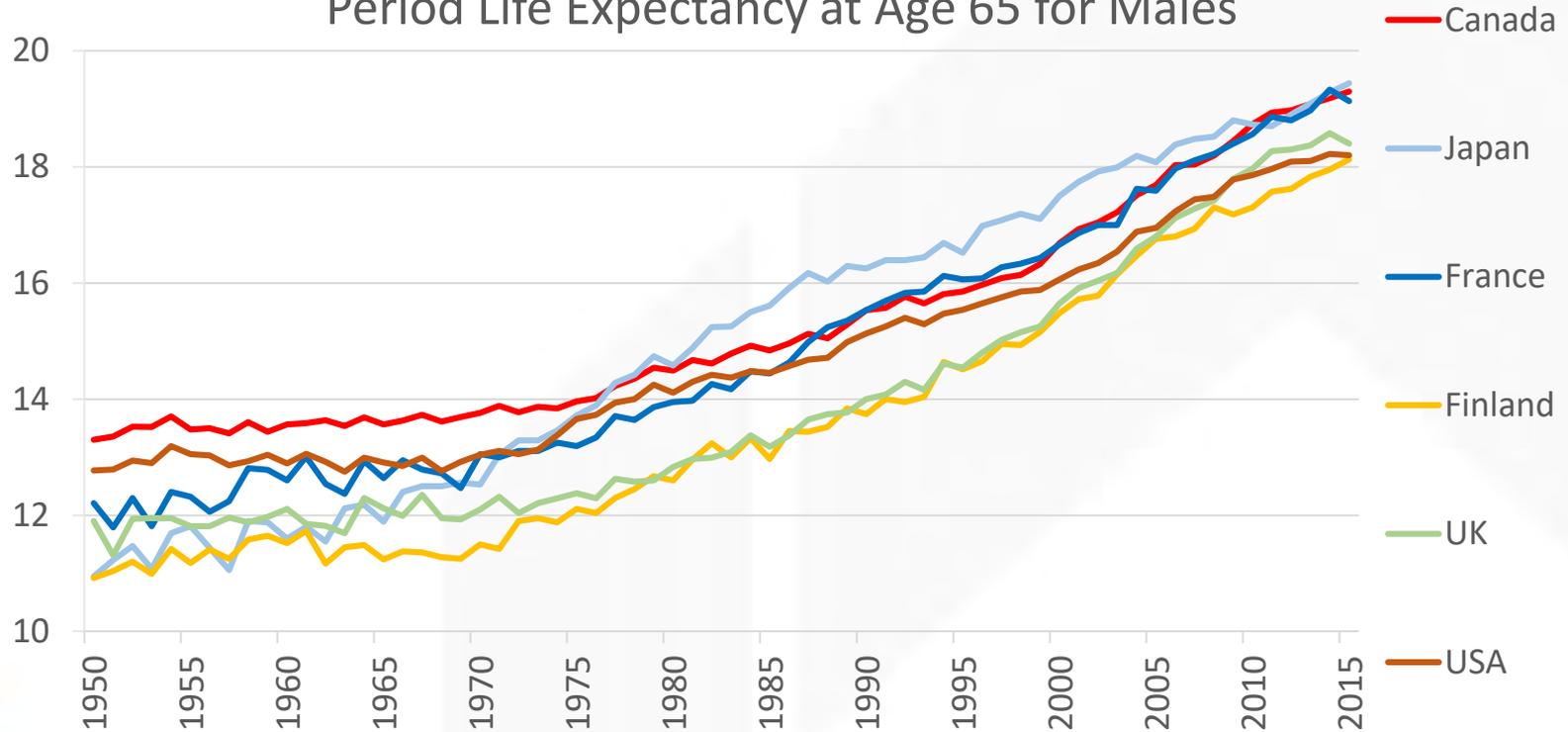
Source: Human Mortality Database
*Source for UK 2015+: Office for National Statistics, Past and projected expectations of life (ex) from the 2018-based life tables*

Life Expectancy at Age 65

Period Life Expectancy at Age 65 for Females
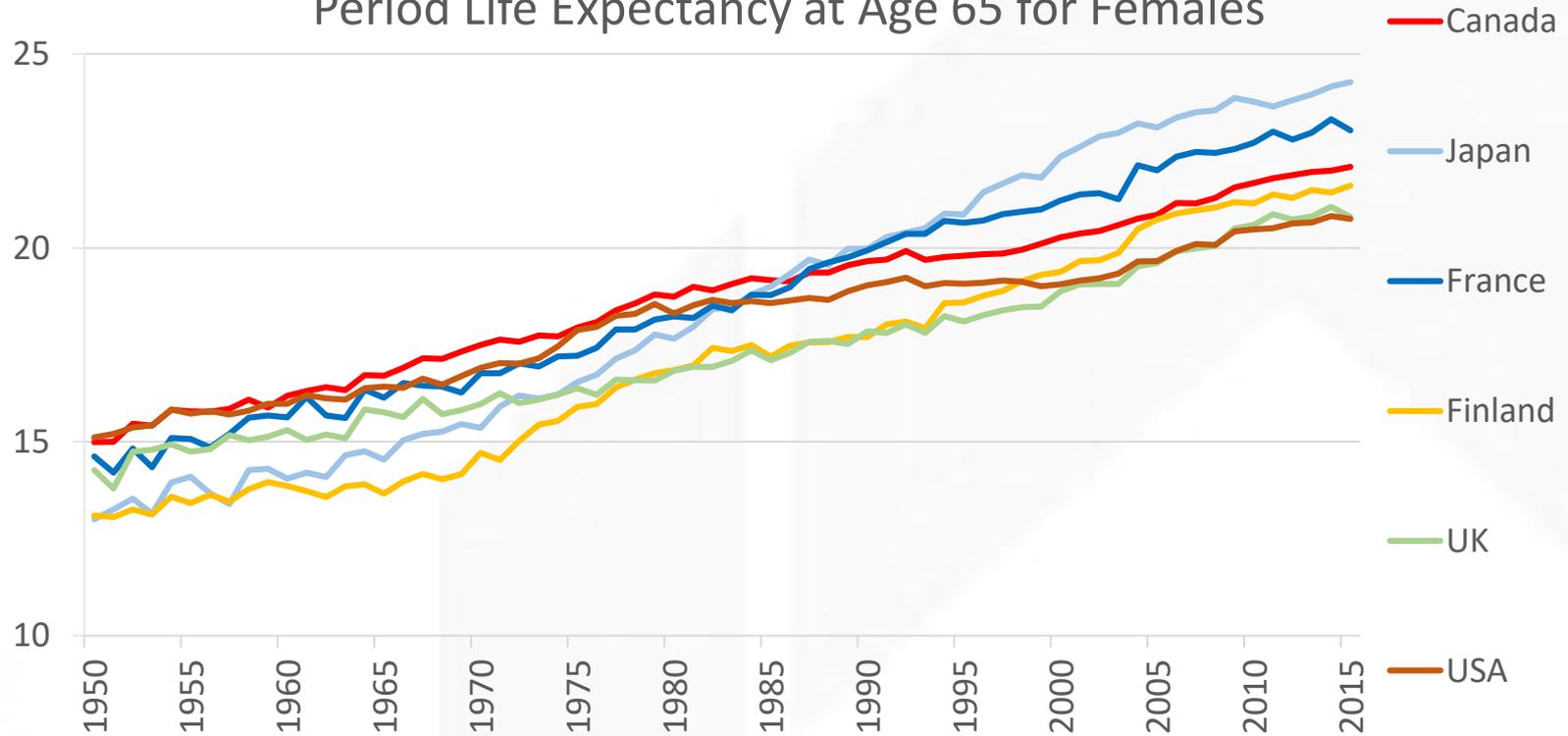
Source: Human Mortality Database
Source for UK 2015+: Office for National Statistics, Past and projected expectations of life (ex) from the 2018-based life tables

After age 85, Canada along with Japan and France have the lowest mortality rates

Number of deaths per 1,000 (2015, both sexes)

Source: Human Mortality Database
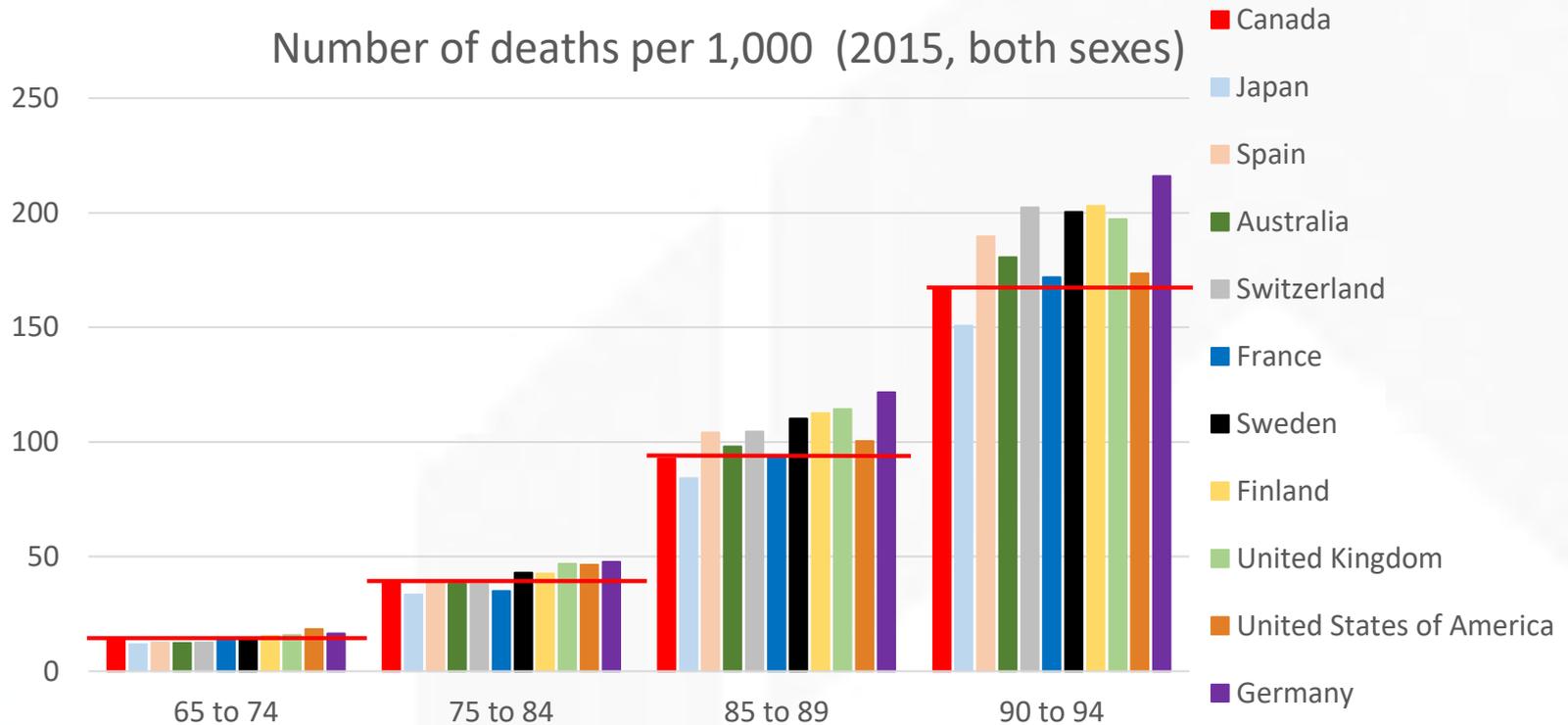
Cancer and Heart Diseases are the Leading Causes of Death in Most Countries


Mortality rates by cause, 75-84, both sexes, 2015
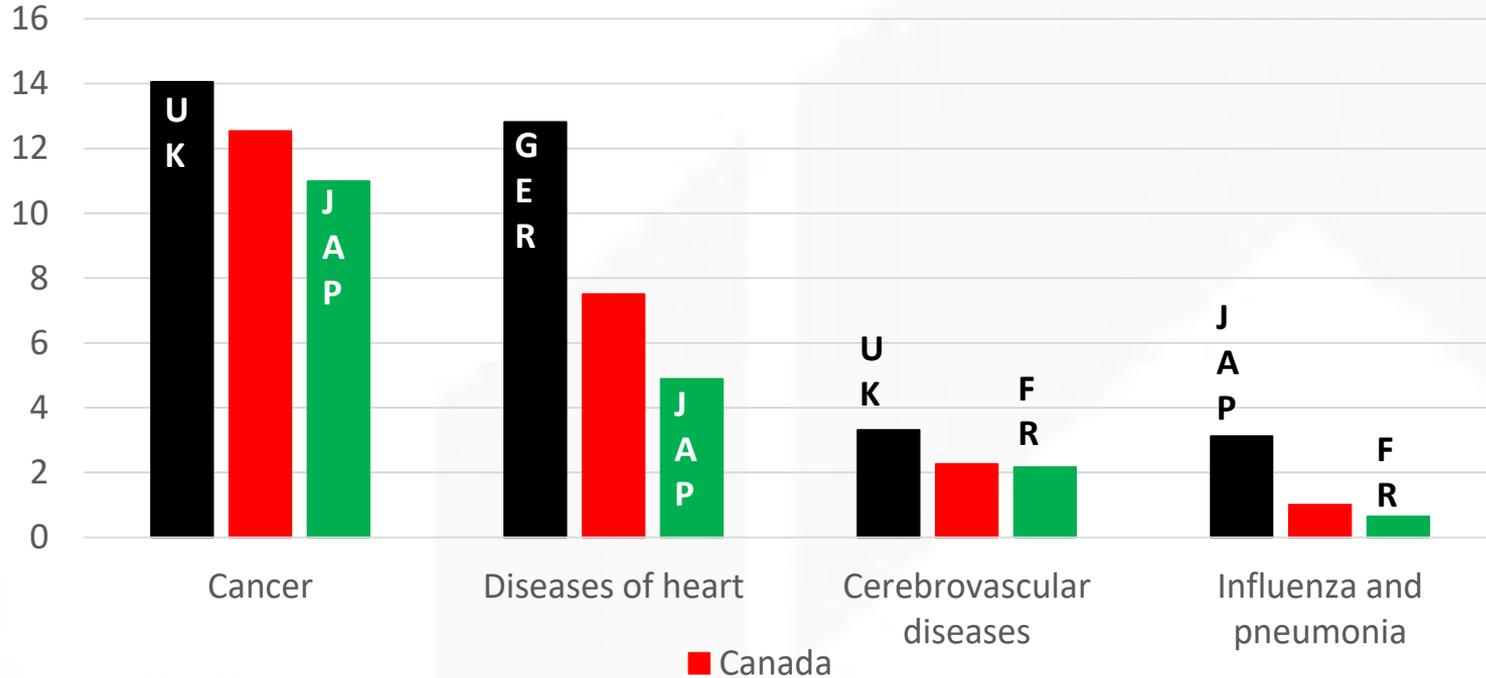
Source: World Health Organization

OSFI
BSIF

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Improvements in mortality related to heart diseases have been significant over the last decades
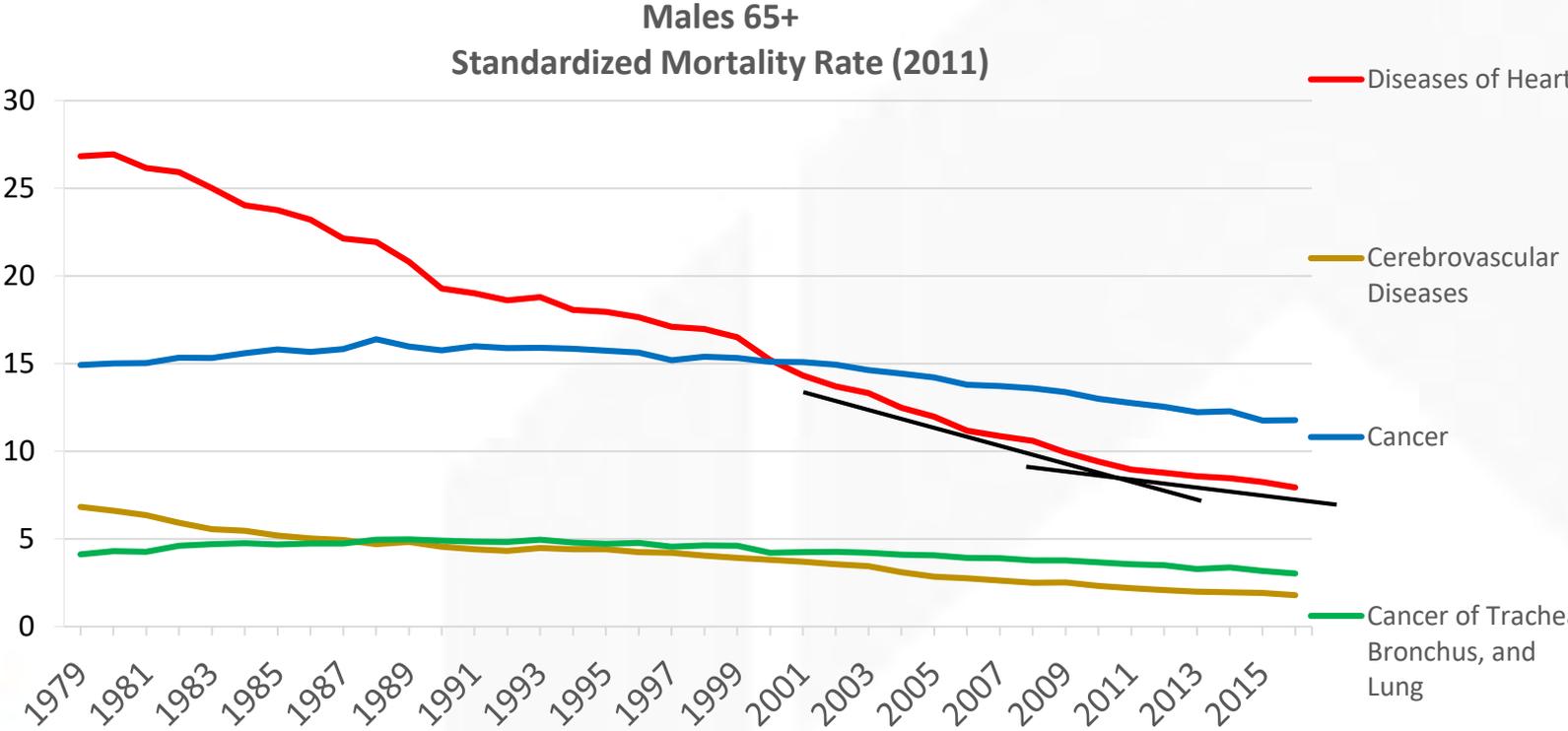
Males 65+
Standardized Mortality Rate (2011)

Legend:
- Diseases of Heart
- Cerebrovascular Diseases
- Cancer
- Cancer of Trachea, Bronchus, and Lung

*Source: Data from Statistics Canada, Health Division and OCA Calculations Standardized Using 2011 Canadian Population*

For women, mortality from cancer reduces slowly
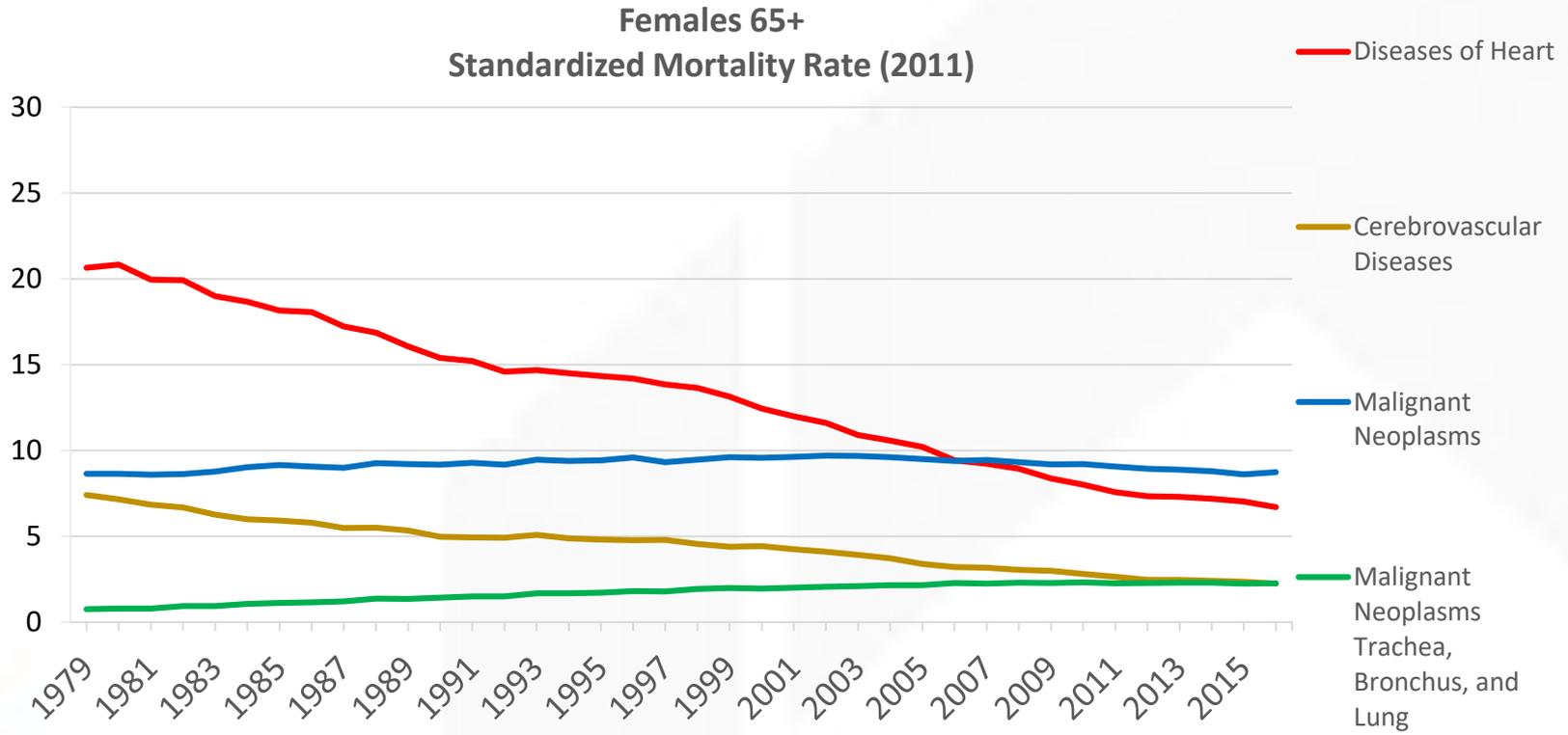
Females 65+
Standardized Mortality Rate (2011)

Source: Data from Statistics Canada, Health Division and OCA Calculations Standardized Using 2011 Canadian Population

Slowdown in mortality improvements in recent years: a blip or a new trend?
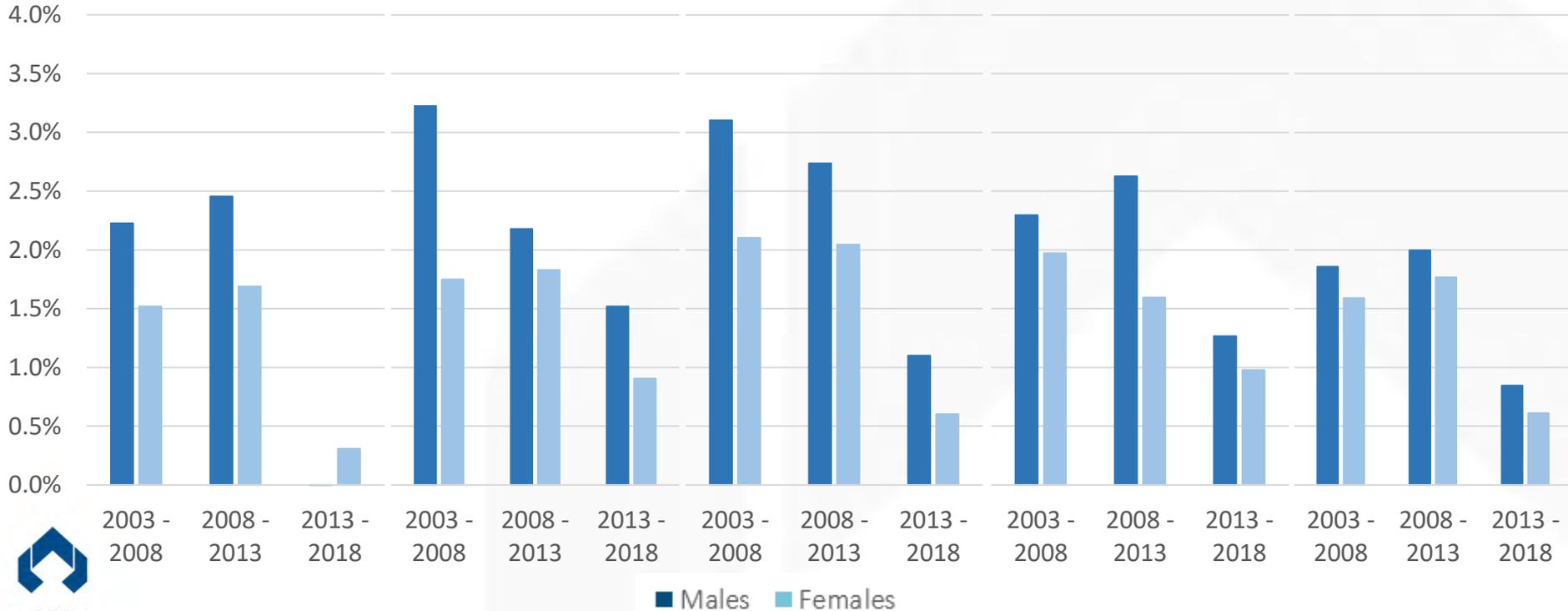
Source: OAS Mortality Fact Sheet – to be published in January 2020

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Future drivers of mortality are not easy to quantify

- "Easy" gains have been somewhat achieved:
  - Previous improvement in heart disease mortality will be tough to duplicate
  - Favorable effects of decreasing smoking prevalence should continue for awhile but will diminish in 20-30 years.

- Future drivers of mortality could be:

FAVORABLE
- ✓ Enhanced medical treatment
- ✓ Pharmaceuticals
- ✓ Technology Breakthroughs

UNFAVORABLE
- ✓ Pandemics
- ✓ Increasing drug resistance
- ✓ Natural and man-made disasters

Source: Longevity, The dark side, Sam Gutterman, Longevity 12, Chicago, Sept. 2016

- Other factors: obesity, opioids, income inequality, aging, marital status

By 2050, cost of obesity in Canada is projected to be 3 years of unrealized gains in life expectancy

The impact on life expectancy in years, average 2020-2050

Source: OECD (2019), The Heavy Burden of Obesity: The Economics of Prevention, OECD Health Policy Studies, OECD Publishing, Paris, https://doi.org/10.1787/67450d67-en.
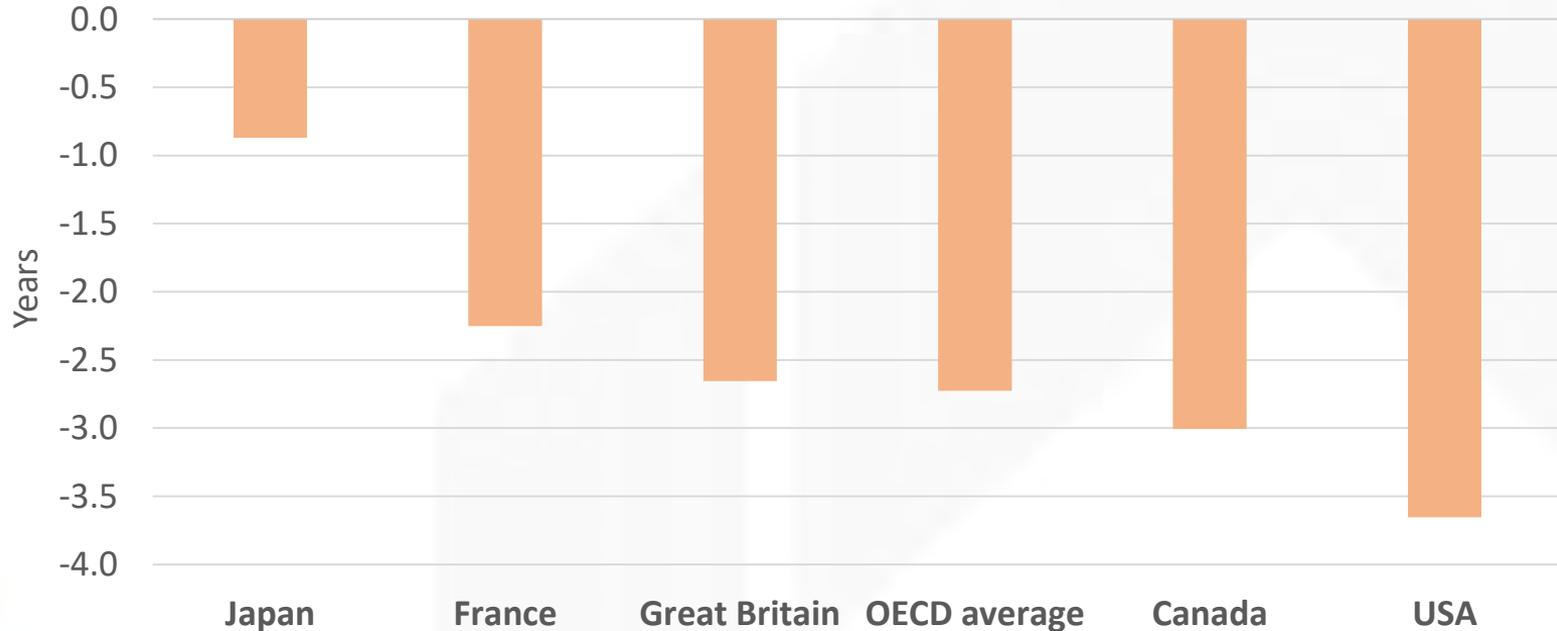
# In 2017, in Canada, death rates due to opioid overdose were 1.6 – 2.1 times higher than in 2015
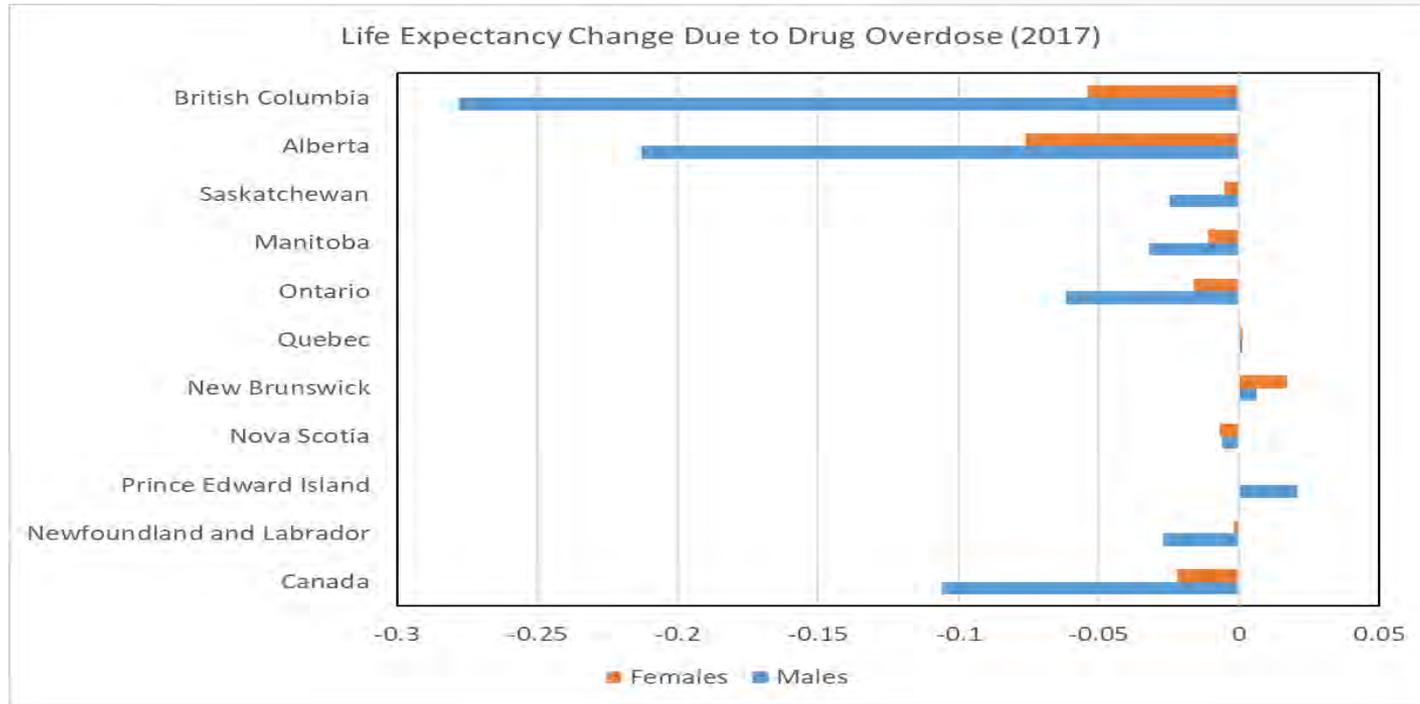
Mortality differences by socio-economic level diminish with age

Life Expectancies of CPP Retirement Beneficiaries by Level of Base CPP Pension (2019), without future improvements
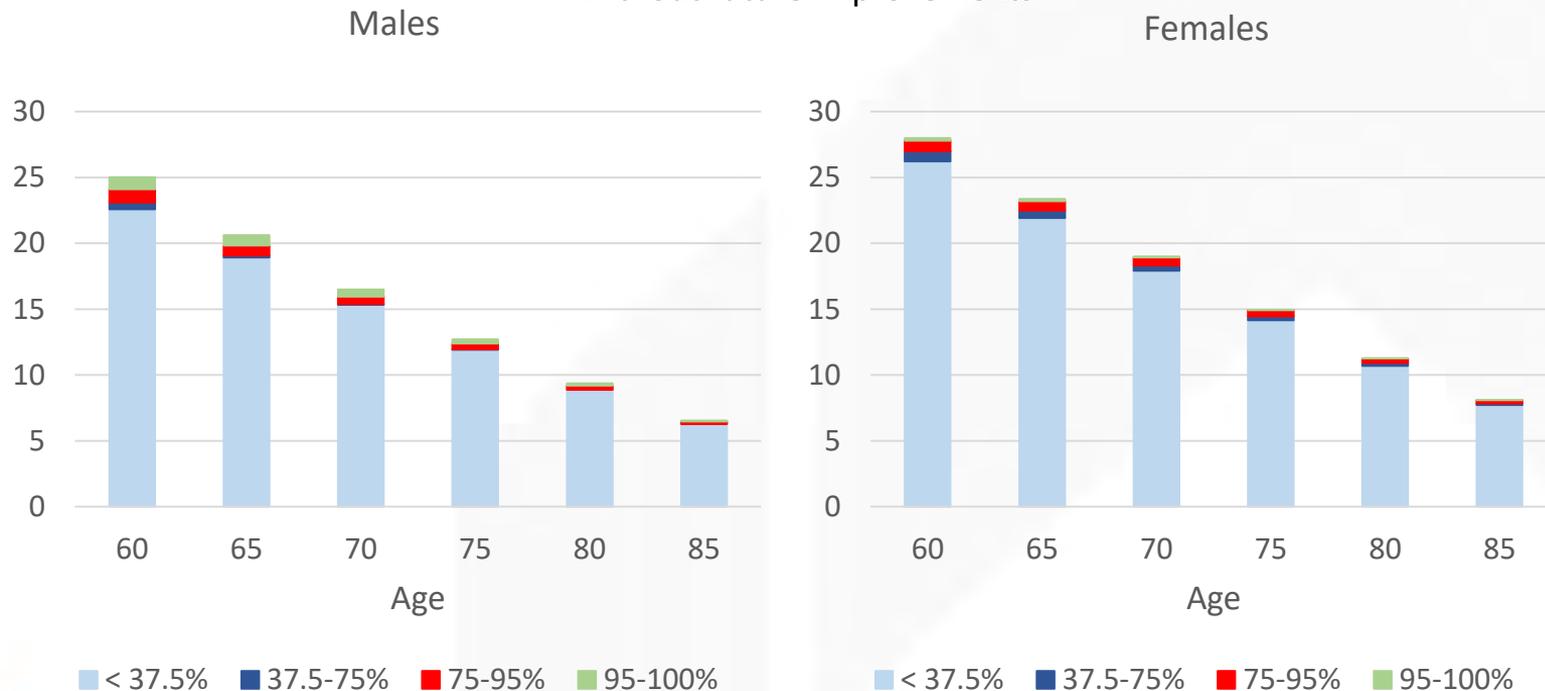
Source: OCA, 30th Actuarial Report on the Canada Pension Plan as at 31 December 2018

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The gap in life expectancy by benefit level is stable over time

Males Retirement Life Expectancy at Age 65 (High and Low Pension)


Legend: —— [0 - 37.5%] —— [100.00%]

Source: OCA, 30th Actuarial Report on the Canada Pension Plan as at 31 December 2018
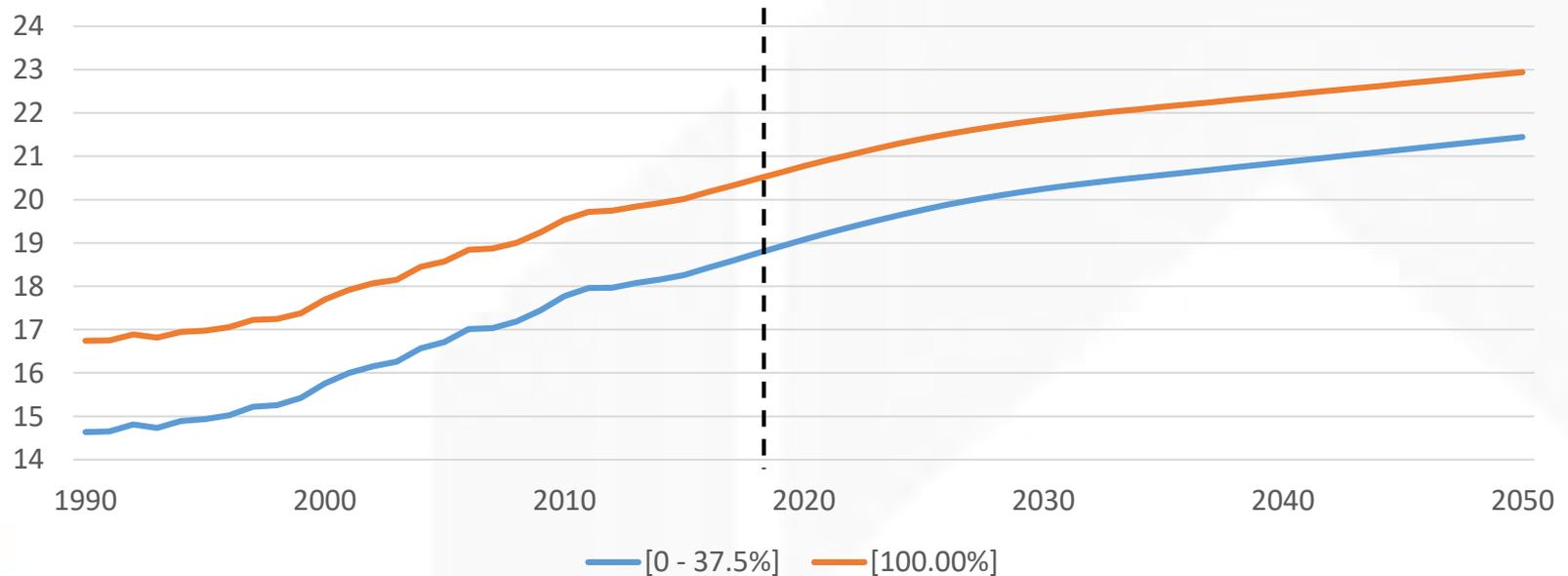
# Life expectancy is impacted marital status

Difference of life expectancy at age 65 (2013)

Source: OCA, AS No. 17 – OAS Program Mortality Experience
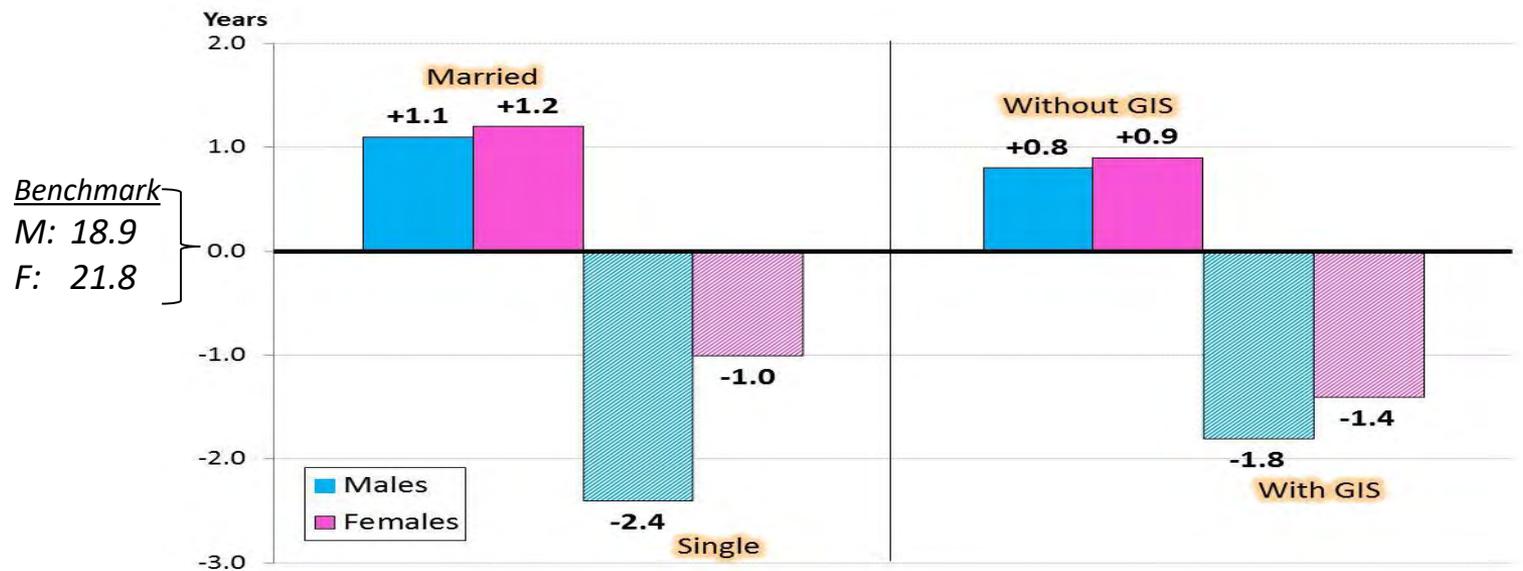
# Survivor Beneficiaries have a Much Higher Mortality than the Population

2015 Ratio of CPP Survivor Mortality to General Population

Source: OCA, Survivor Mortality Study 2018
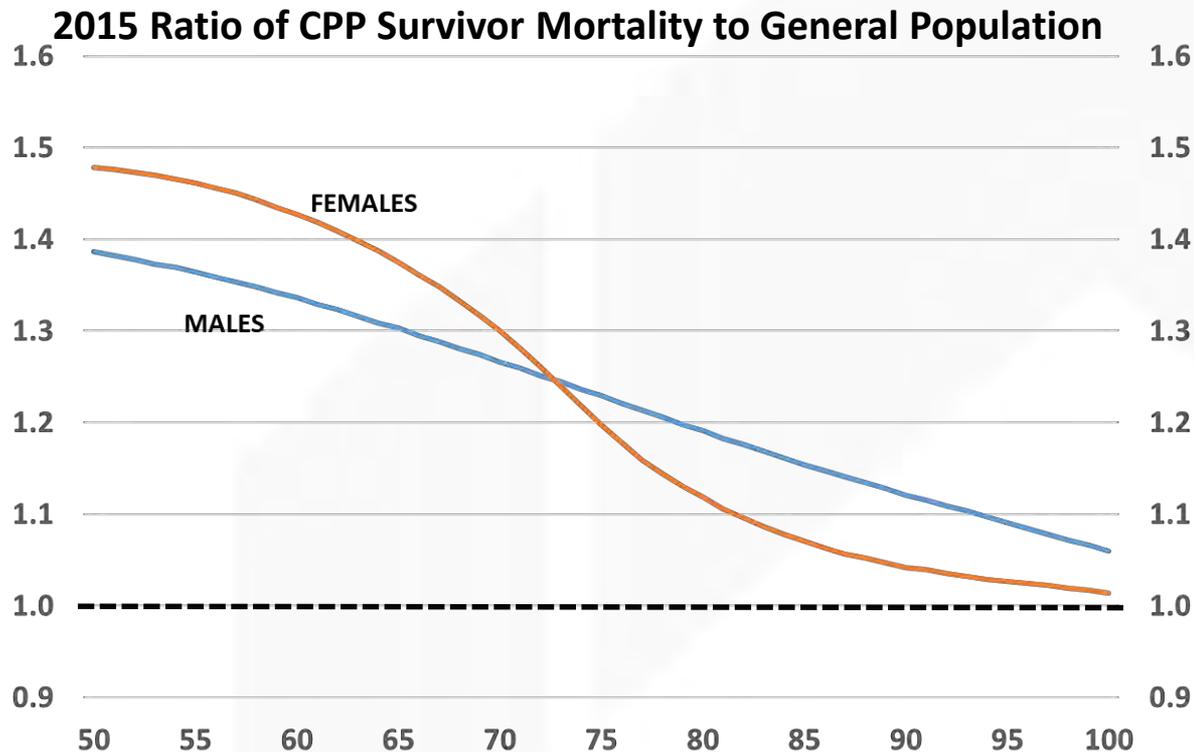
# CPP30 Assumes that Mortality will Continue to Improve but at a Slower Pace

CPP30 Assumed Annual Mortality Improvement Rates for Canada (65-74)
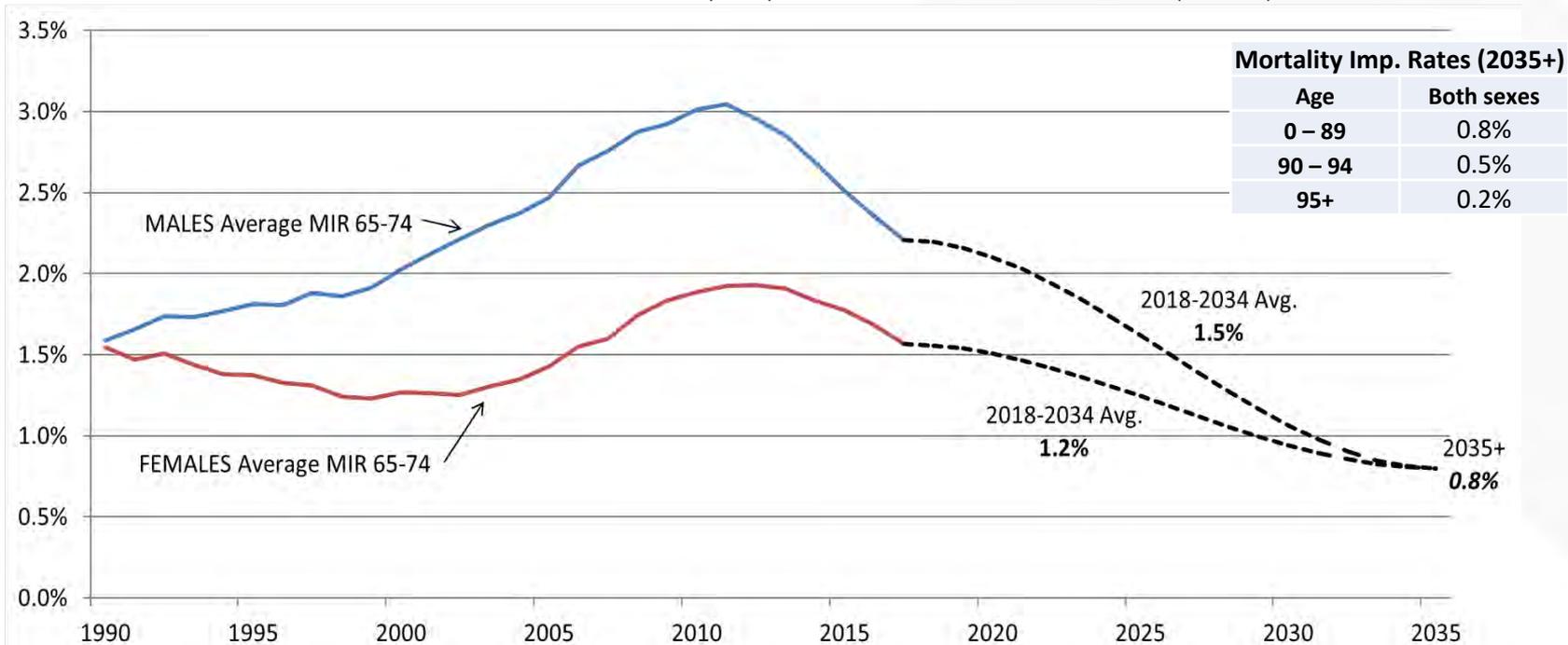
Mortality Imp. Rates (2035+)	
Age	Both sexes
0 − 89	0.8%
90 − 94	0.5%
95+	0.2%

MALES Average MIR 65-74

FEMALES Average MIR 65-74

2018-2034 Avg. **1.5%**

2018-2034 Avg. **1.2%**

2035+ *0.8%*

Source: OCA, 30th Actuarial Report on the Canada Pension Plan as at 31 December 2018

Evolution of CPP Mortality Projections over 7 Actuarial Reports

Projected LE for those Aged 65 - Male Canada
(with future mortality improvements)
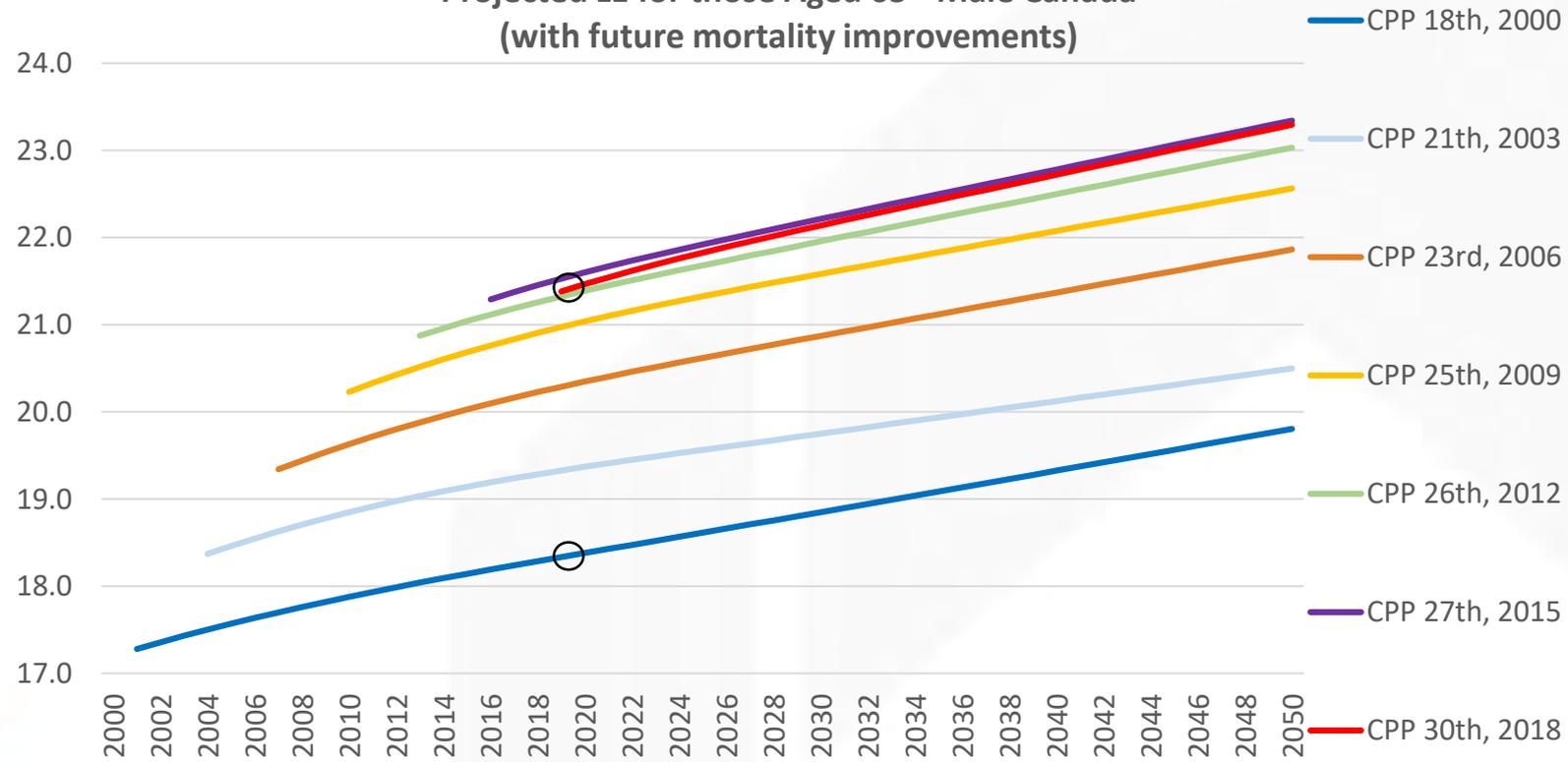
Legend:
- CPP 18th, 2000
- CPP 21th, 2003
- CPP 23rd, 2006
- CPP 25th, 2009
- CPP 26th, 2012
- CPP 27th, 2015
- CPP 30th, 2018

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Evolution of CPP Mortality Projections over 7 Actuarial Reports

Projected LE for those Aged 65 - Female Canada
(with future mortality improvements)
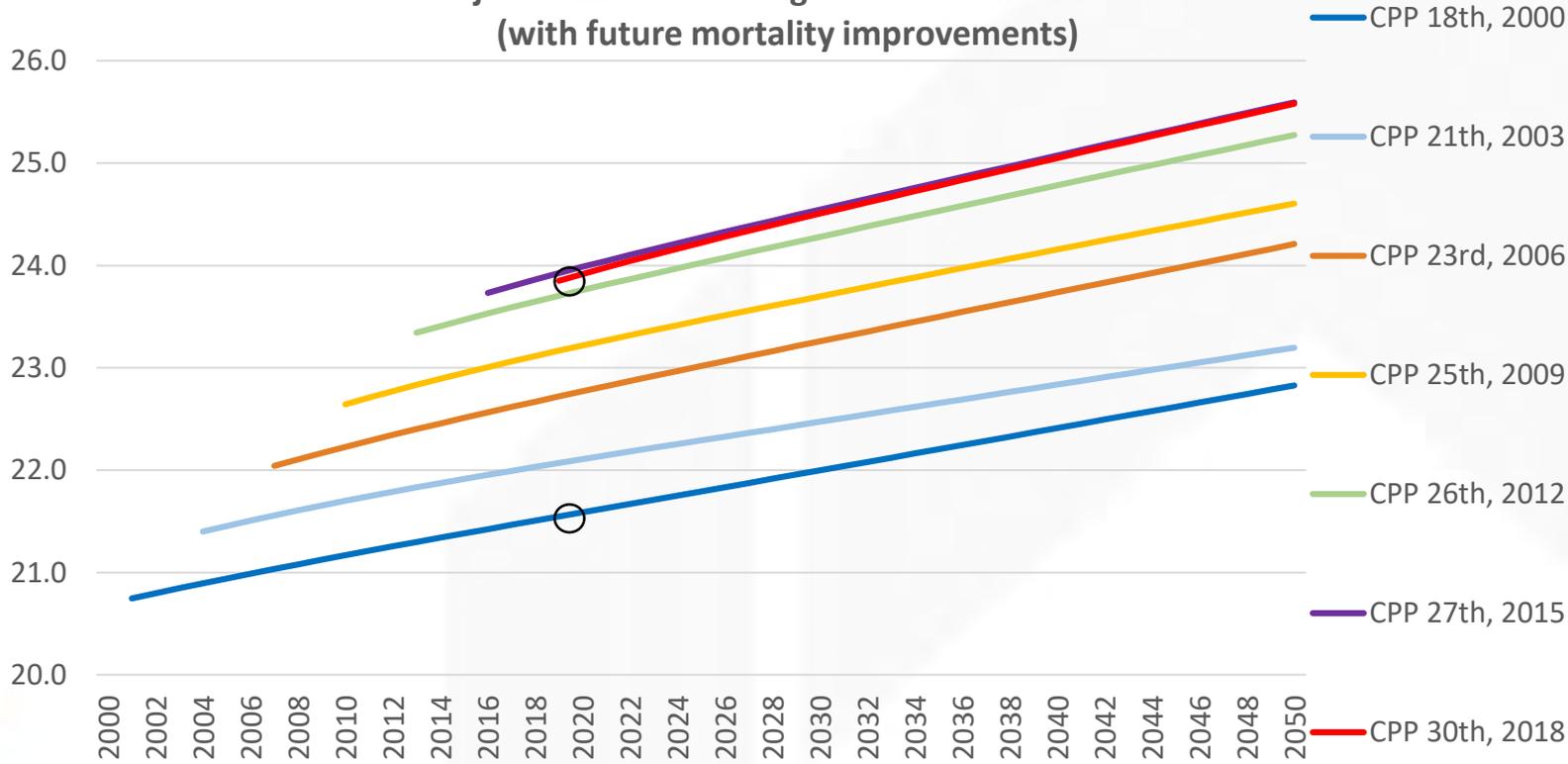
Relative impact of different mortality assumptions on the CPP contribution rates
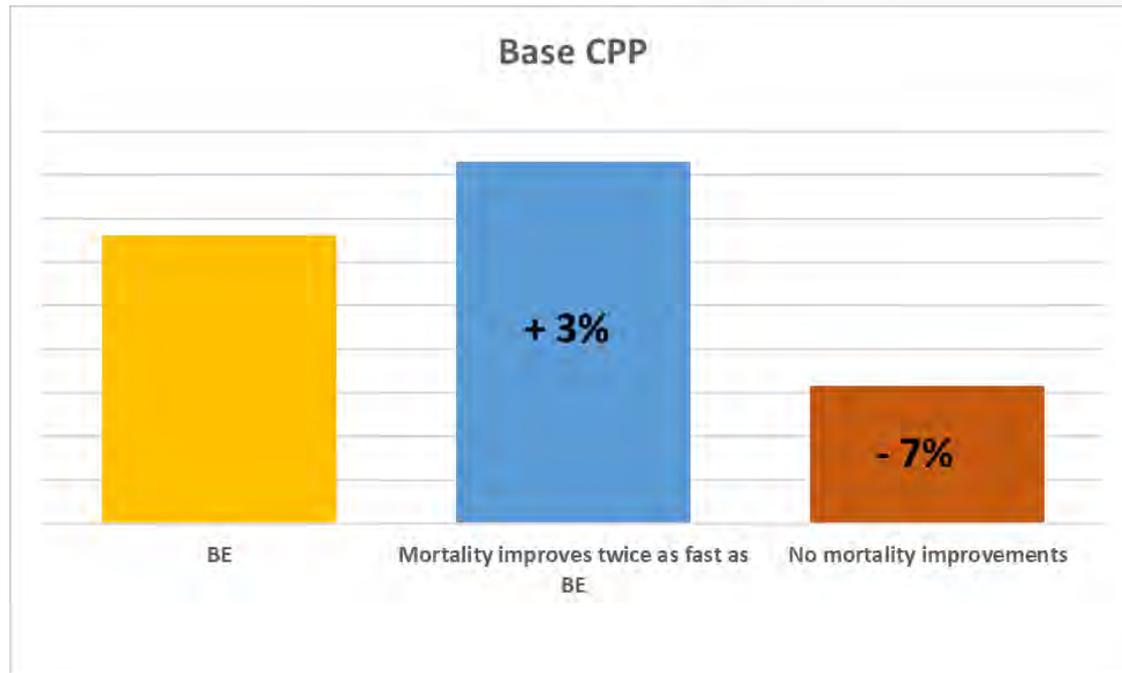
Can we live to 100?

"Living to be 100 was easy. Thirty years ago I took out a restraining order against the Grim Reaper!"

To live beyond 100…

- A calendar year life expectancy at birth of ***100*** in 2015 is achievable if:

    - Mortality rate at each age are reduced by 86% for males (82% for females).

    - Mortality below age 97 is zero, then current mortality for ages 97 to 120.

    - The maximum life span increases to 138 years for males (131 years for females) and mortality rates are changed accordingly.

Conclusion

- There is a lot of uncertainty related to future mortality
- Understanding past is important but we need to look into future
- Increasing longevity at older ages is expected to continue to put financial pressure of programs targeted to older population.

Appendix

Life Expectancy at Birth

Period Life Expectancy at Birth for Males
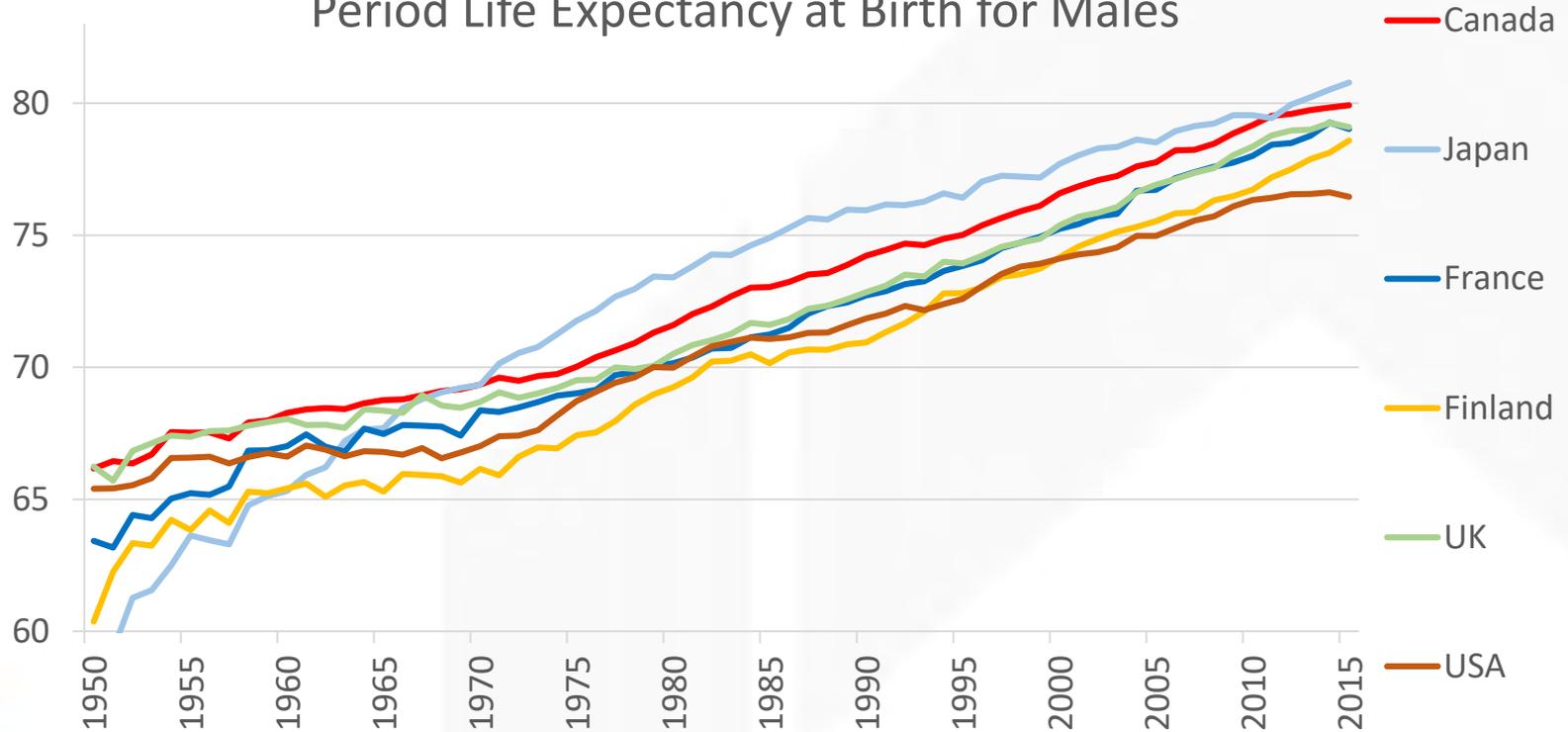
Source: Human Mortality Database
Source for UK 2015+: Office for National Statistics, Past and projected expectations of life (ex) from the 2018-based life tables

Life Expectancy at Birth

Period Life Expectancy at Birth for Females
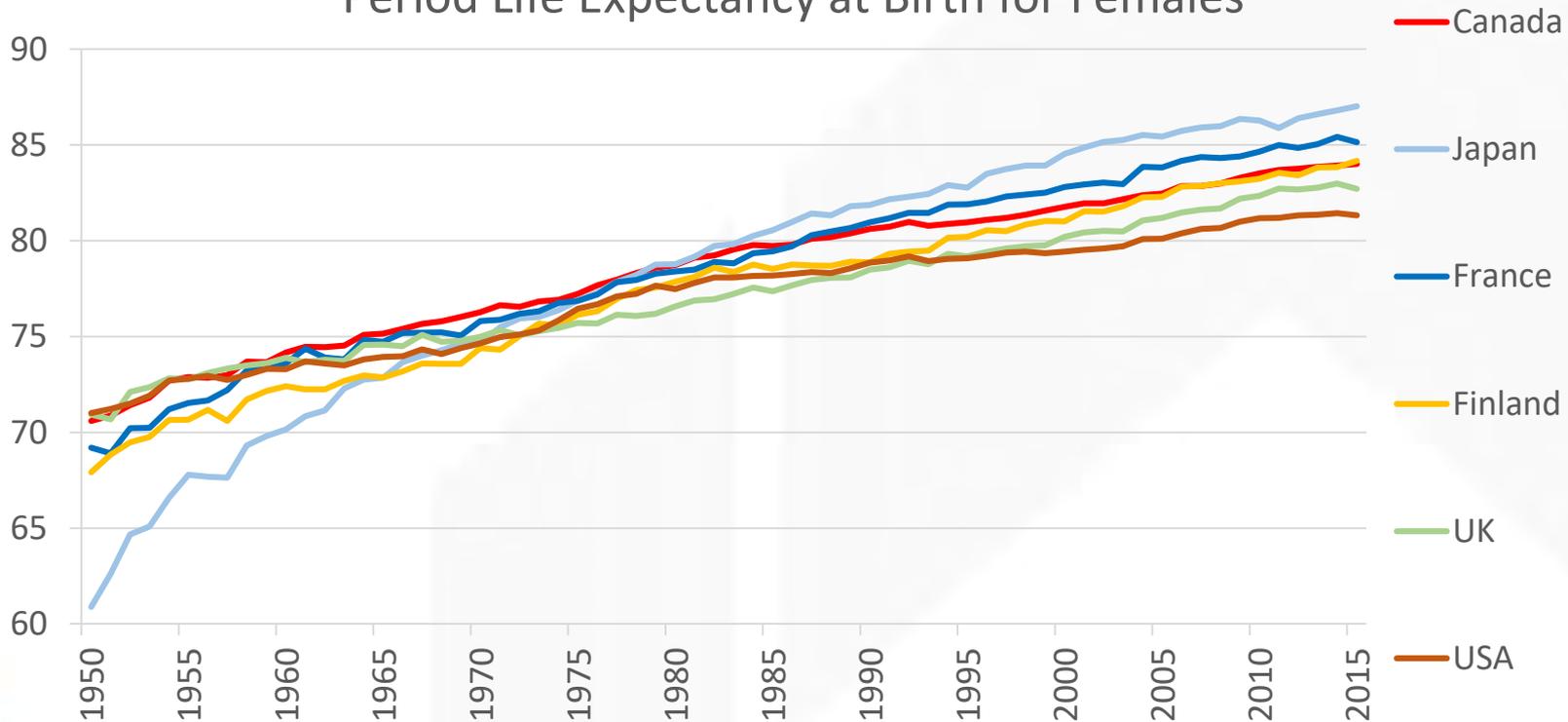
Females Retirement Life Expectancy at Age 65 (High and Low Pension)

Source: OCA, AS No. 16 – CPP Retirement, Survivor and Disability Beneficiaries Mortality Study

Mortality in the United Kingdom

Living to 100 Symposium
14 January 2020
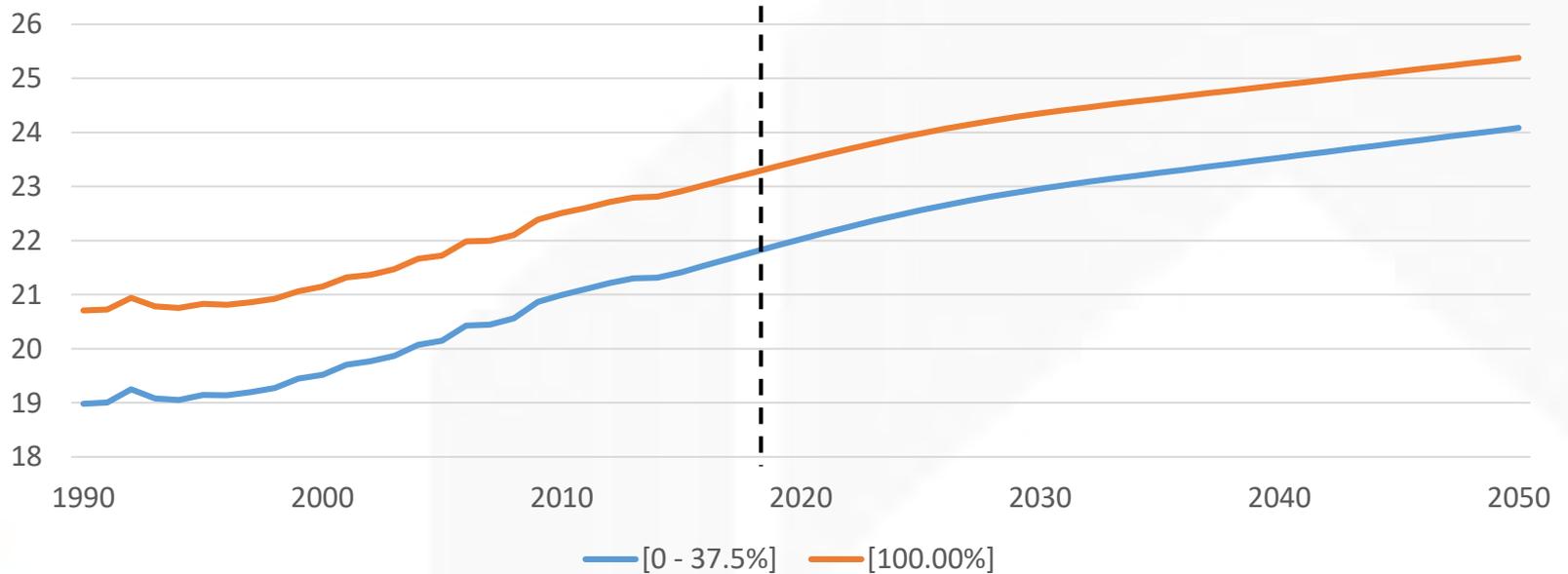
Adrian Gallop

UK Government Actuary's Department

UK Office for National Statistics

Presentation outline

- Projections methodology
- Historical trends
- Mortality 2018-based projection results
- Mortality by deprivation, area, socio-economic category and insured/retired

Projected period life expectancy for UK

	2018	2028	2043	2053
Expectation of life at birth				
Males	79.6 (79.9)	80.9 (81.7)	82.6 (83.7)	83.8 (84.9)
Females	83.2 (83.4)	84.1 (84.7)	85.5 (86.4)	86.5 (87.5)
Expectation of life at age 65				
Males	18.8 (19.0)	19.6 (20.2)	20.8 (21.7)	21.7 (22.7)
Females	21.1 (21.3)	21.7 (22.3)	22.8 (23.6)	23.6 (24.5)

2016-based principal projection figures in brackets

Method for setting the mortality assumptions

UK Population Mortality Projections

Methodology

- Estimate 2017-18 mortality improvement rates by age and gender

- Set target rates of mortality improvement for 25th year 2043 (the target year)

- Make assumptions on method and speed of convergence of current improvement rates to target rates and how improvement rates change thereafter

- Apply successively to assumed base mortality rates

- Improvement rates and base mortality rates country specific – set considering recent experience v UK

- Adjustment in 2018-19 for known deaths data

Step 1: Estimate mortality rates and improvements for the base year

- Use UK population estimates and deaths registrations from 1961 to base year – 1
- Produce smooth mortality rates by age and sex
- Project forward annual improvement rates in the base year – 3 to the base year
- Use to derive UK mortality rates for the base year

	2014-15	2015-16	2016-17	2017-18
Age 0	a%	a%	a%	a%
Age 1	b%	b%	b%	b%
…				
Age 65	w%			
Age 66	x%	w%		
Age 67	y%	x%	w%	
Age 68	z%	y%	x%	w%

Step 2: Set target rates of mortality improvement for the future

- Set annual % rates of mortality improvement by age and sex assumed for the 25th year of the projection

- Set method and speed of convergence from base year to target year rates.

- Decide how mortality improvements persist after the target year

# Step 3: Project from the base year to the 25th year and beyond

- Apply convergence factor successively

- Improvements projected by age for those born after 1960

- Improvements projected by cohort for those born before 1960

	2019	2020	2021	2022
Age 0				
Age 1				
Age 2				
Age 65				
Age 66				
Age 67				
Age 68				

Long term improvements beyond 2043

	2043	2044	2045	2046
Age 0				
Age 1				
Age 2				
Age 65				
Age 66				
Age 67				
Age 68				

Step 4: Projecting for the UK countries

Base year mortality rates

• UK base year rates multiplied by country specific factors derived from National life tables

Base year mortality improvement rates

• Adjust UK base improvement rates for Scotland

• Adjust UK to UK excluding Scotland and assume these improvements for England, Wales and Northern Ireland.

Recent and historic trends in mortality

# Period expectation of life at birth, England & Wales, 1841-2017
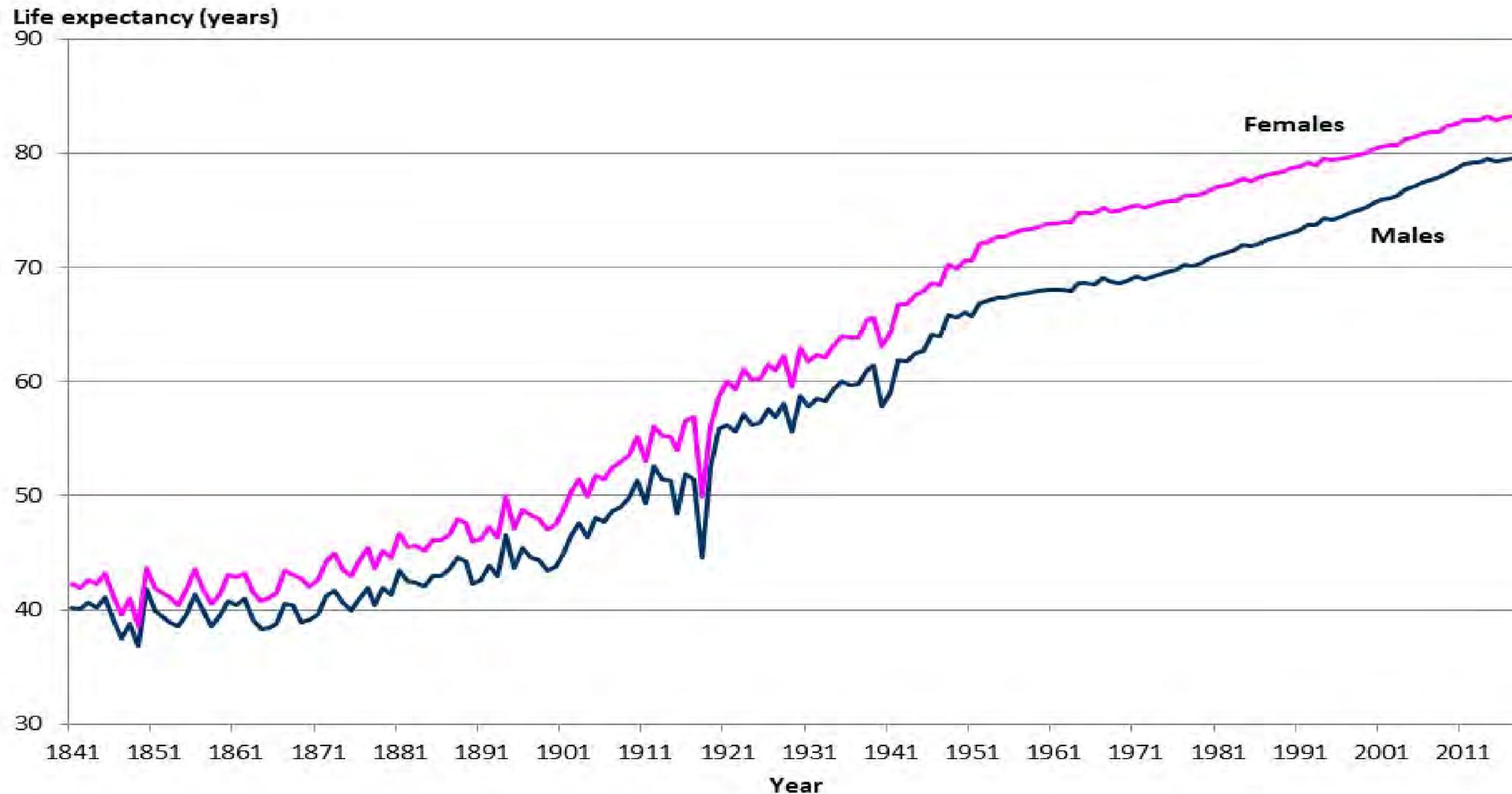
# Period expectation of life at age 65, England & Wales, 1841-2017
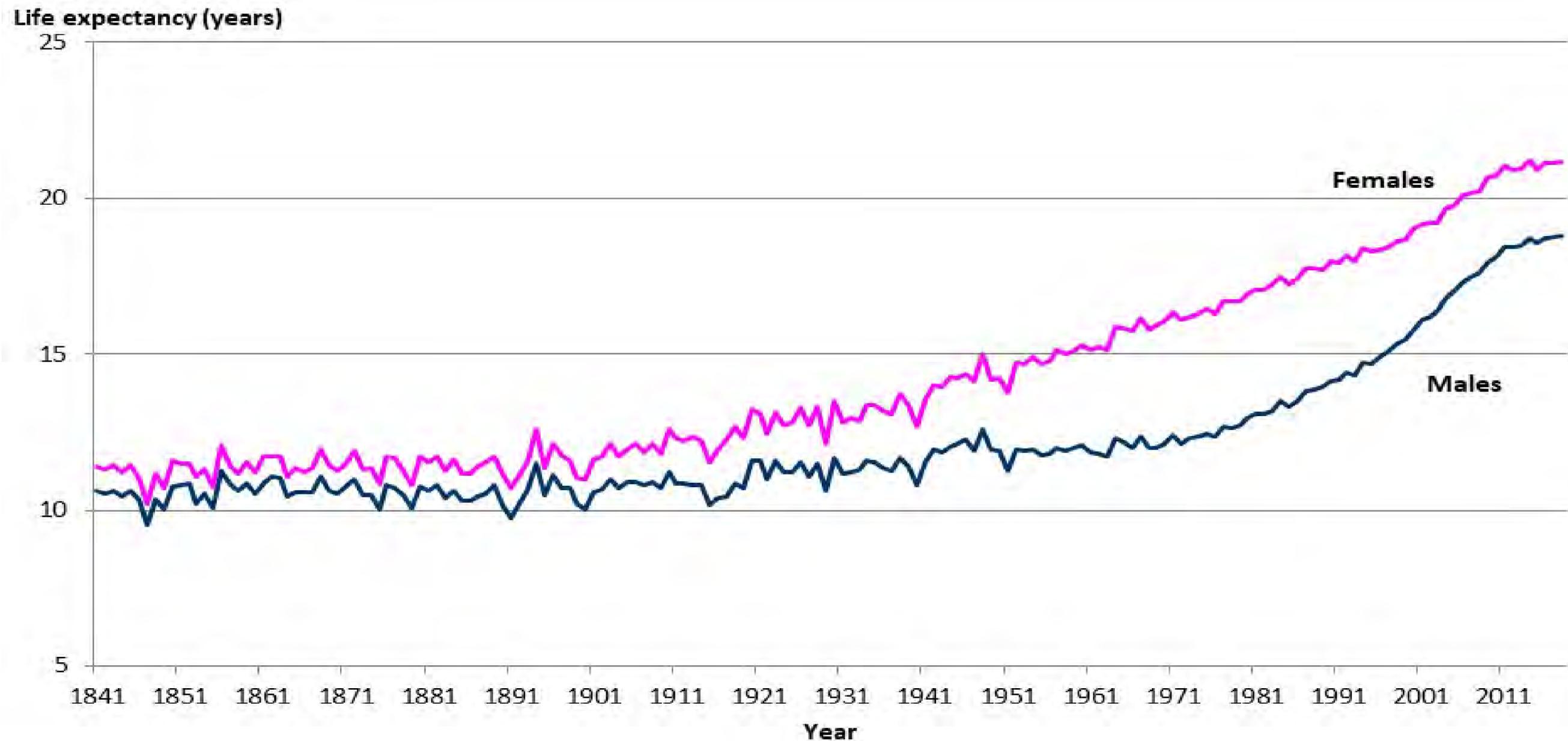
Annualised rates of mortality improvement Males, E&W
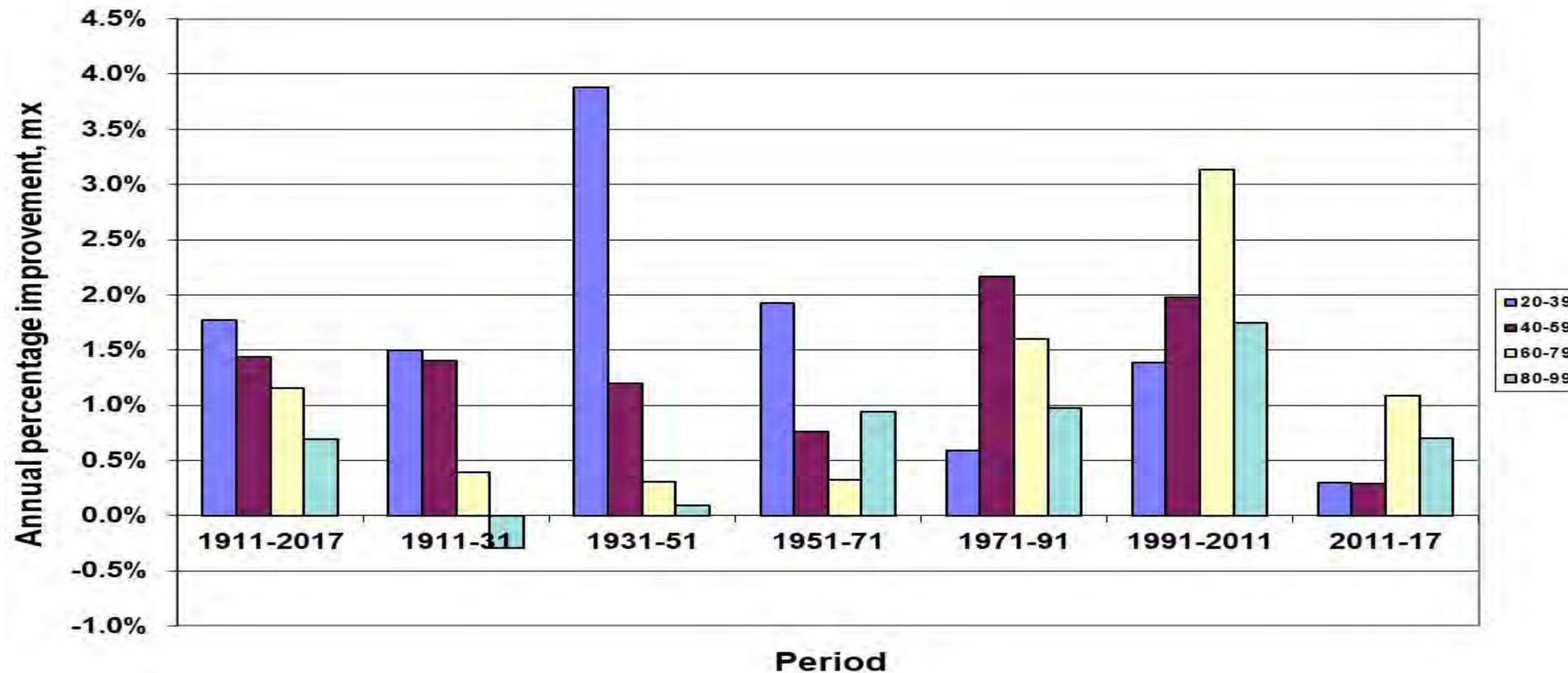
# Annualised rates of mortality improvement Females, E&W
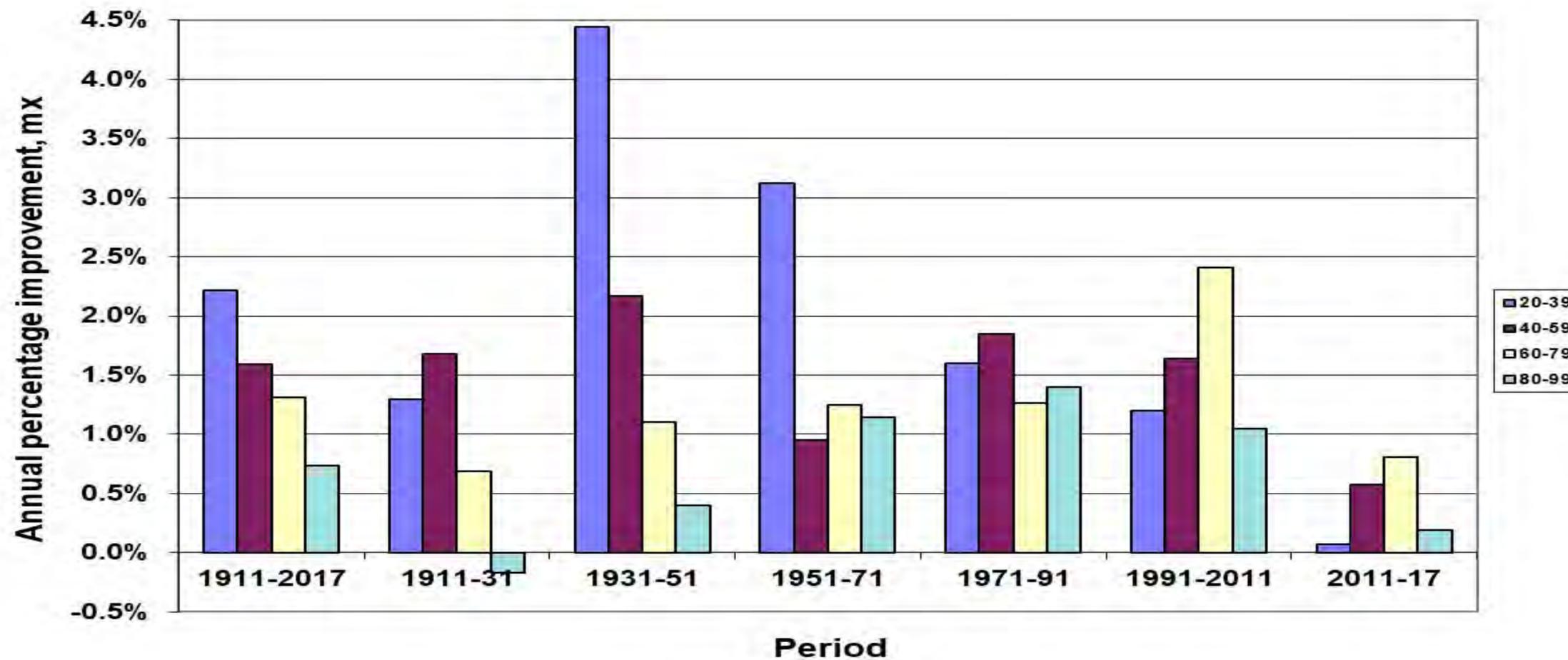
Age-standardised mortality rate per 100,000, United Kingdom, 2001 to 2017
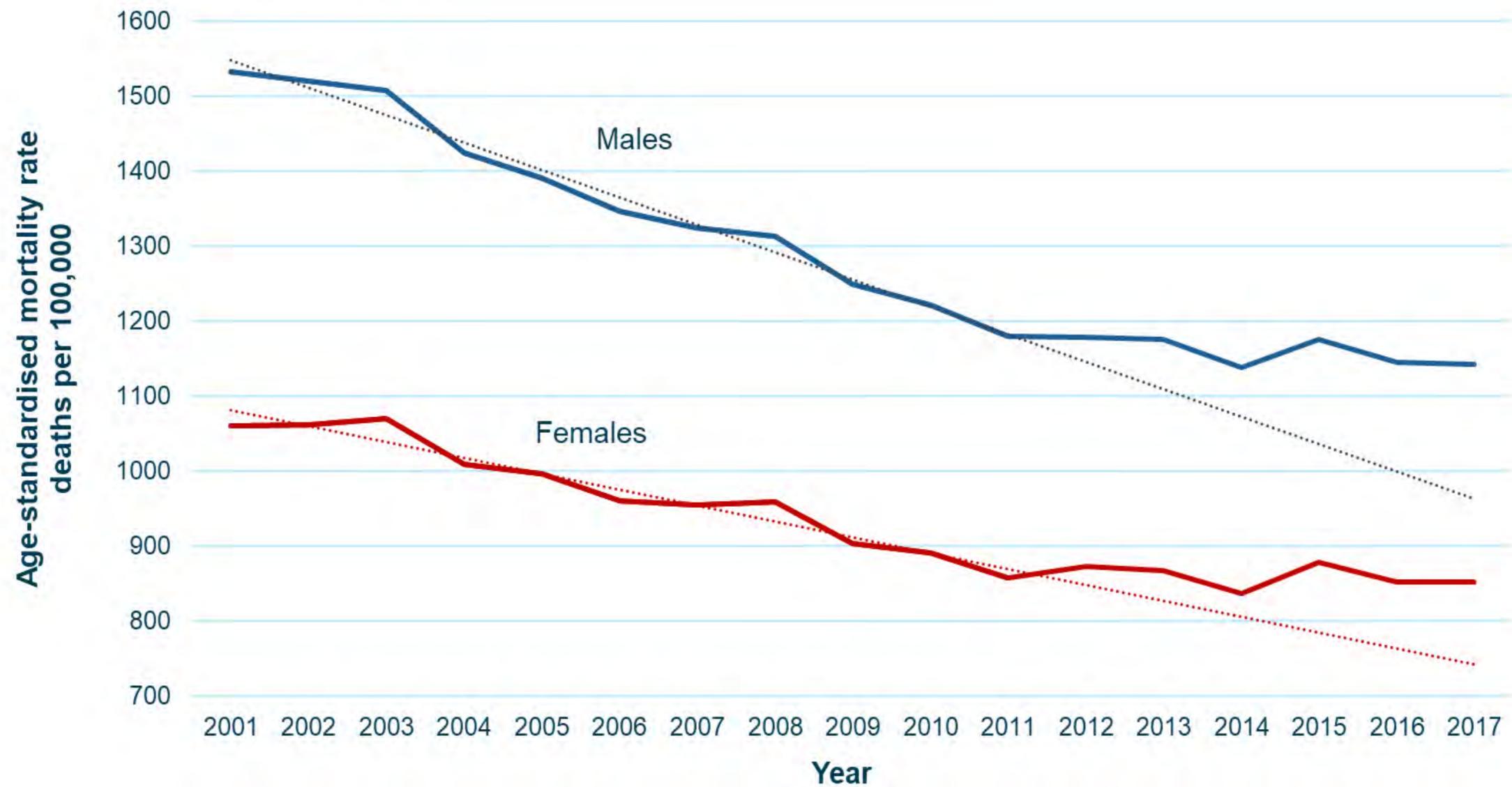
Male age-standardised mortality rates for top five leading causes of death, 2001 to 2017, E&W

Age standardised mortality rates for selected broad disease groups

Legend:
- Dementia and Alzheimers (F01, F03, G30)
- Ischaemic heart disease (I20-I25)
- Cerebrovascular disease (I60-I89)
- Chronic lower respiratory disease (J40-J44)
- Lung cancer (C33, C34)
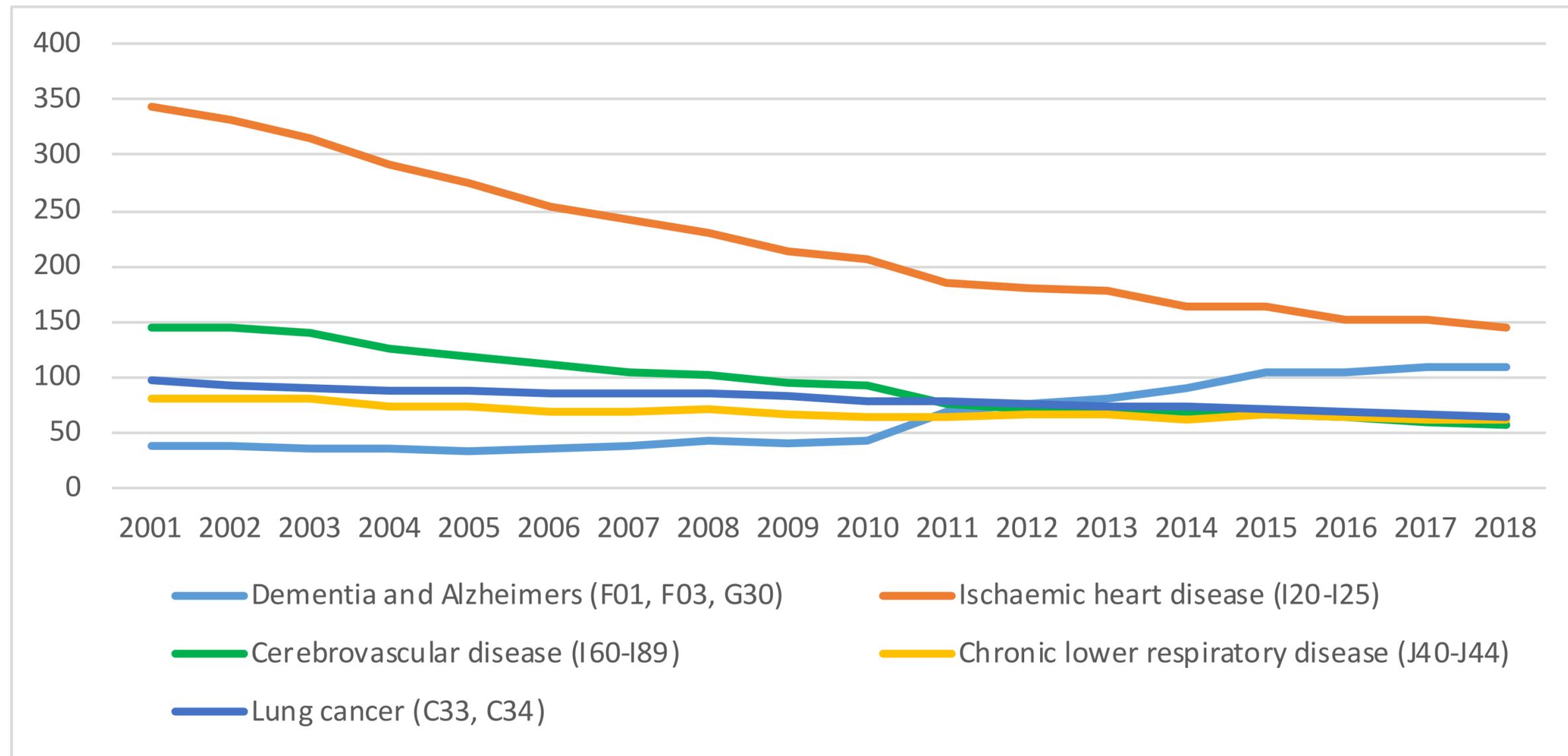
Source: ONS

Female age-standardised mortality rates for top five leading causes of death, 2001 to 2017, E&W

Age standardised mortality rates for selected broad disease groups
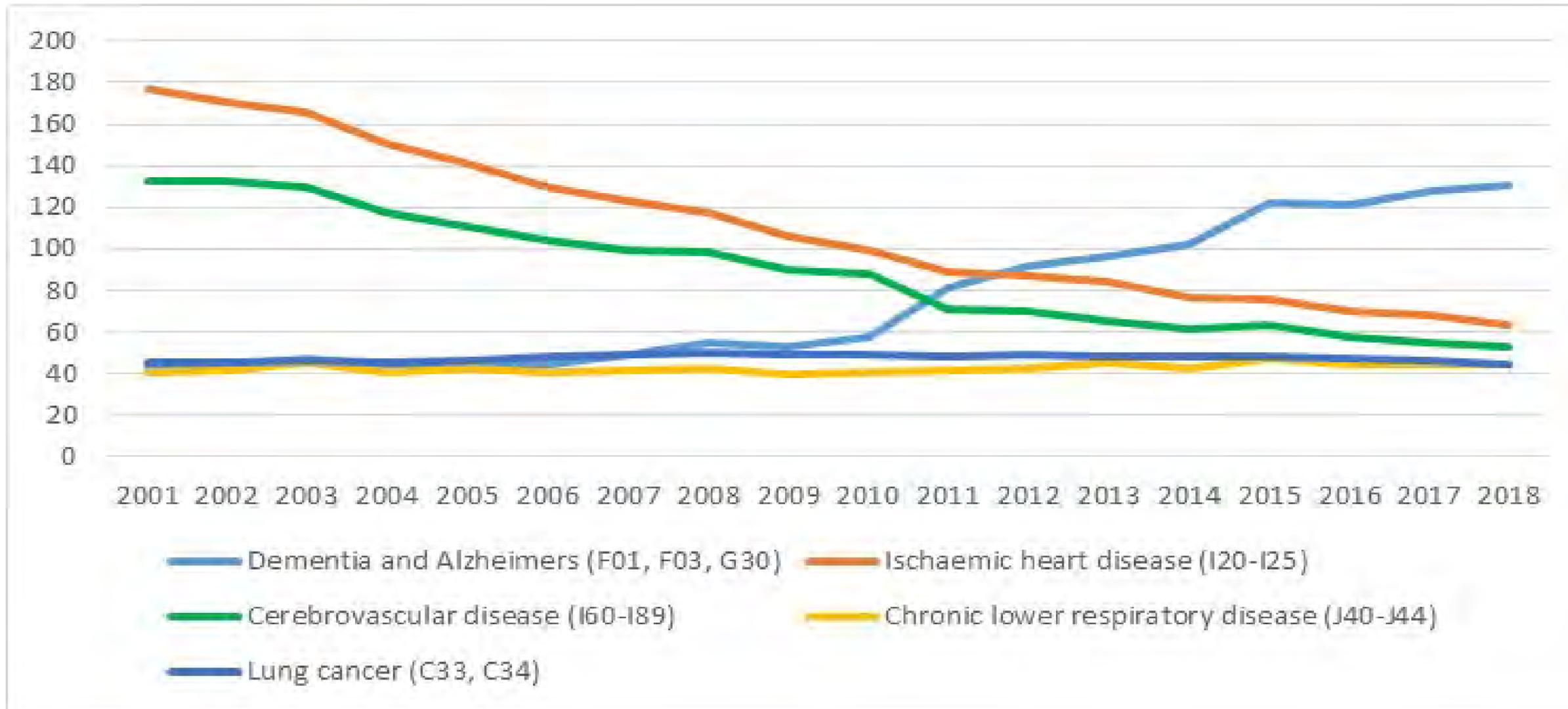
Source: ONS

Obesity prevalence in England, Ages 16+, 1993-2018
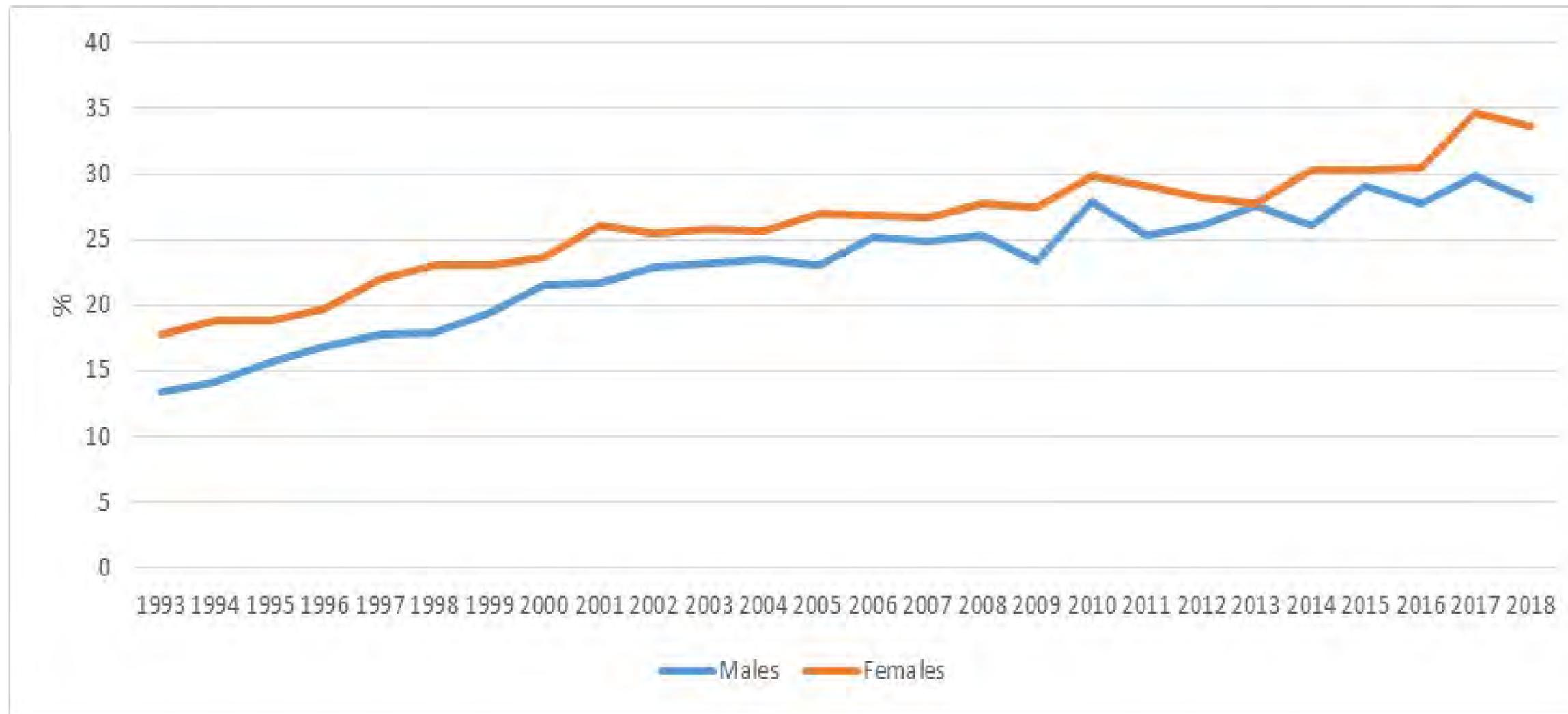
Source: Health Survey for England 2018,
NHS digital

2018-based assumptions

Mortality: Assumptions

- Annual improvement in mortality rates in 25 years time 2043) of 1.2% up to age 90, males and females

- Reducing linearly to 0% over age range 90 to 110

- Rates of improvement remain constant beyond 2043

- Broadly same long-term assumptions as for 2016-based projections up to age 90, lower at oldest ages

- Different short term assumptions

Choice of target rates

- Rates of improvement at older ages most important

- Standardised average rate of improvement since 1911 ≈ 1.2% pa

- Views of Expert Panel

- Cohorts exhibiting greatest improvements in the past now showed little or no relative advantage

- Debate as to whether future technical, medical and environmental changes will have greater or lesser impact than in the past

Views of the expert panel

Projections should not be disproportionately influenced by the recent slowdown in life expectancy improvements since 2011

Most improvement from changes in smoking patterns have now been realised so relatively little influence in future

Effects of obesity more difficult to predict

The increase in deaths from Alzheimer's and dementia was thought to be partly a reporting issue, with deaths that would have been reported under other causes such as respiratory diseases in the past now being reported as Alzheimer's or dementia

Same long-term rates for males and females

    but vary by age with average target rates of 1.7% for age 0 to 19

    reducing to 1.0% for those aged 80 and over

Variant projections

High life expectancy (HLE) – target rate plus 0.7%

Low life expectancy (LLE) – target rate minus 1.2% (with min 0%)

Additional plus or minus 2.0% on improvement rate in 2019

Assumed smooth percentage change in death rates 2017-18 and 2042-43 by age, UK
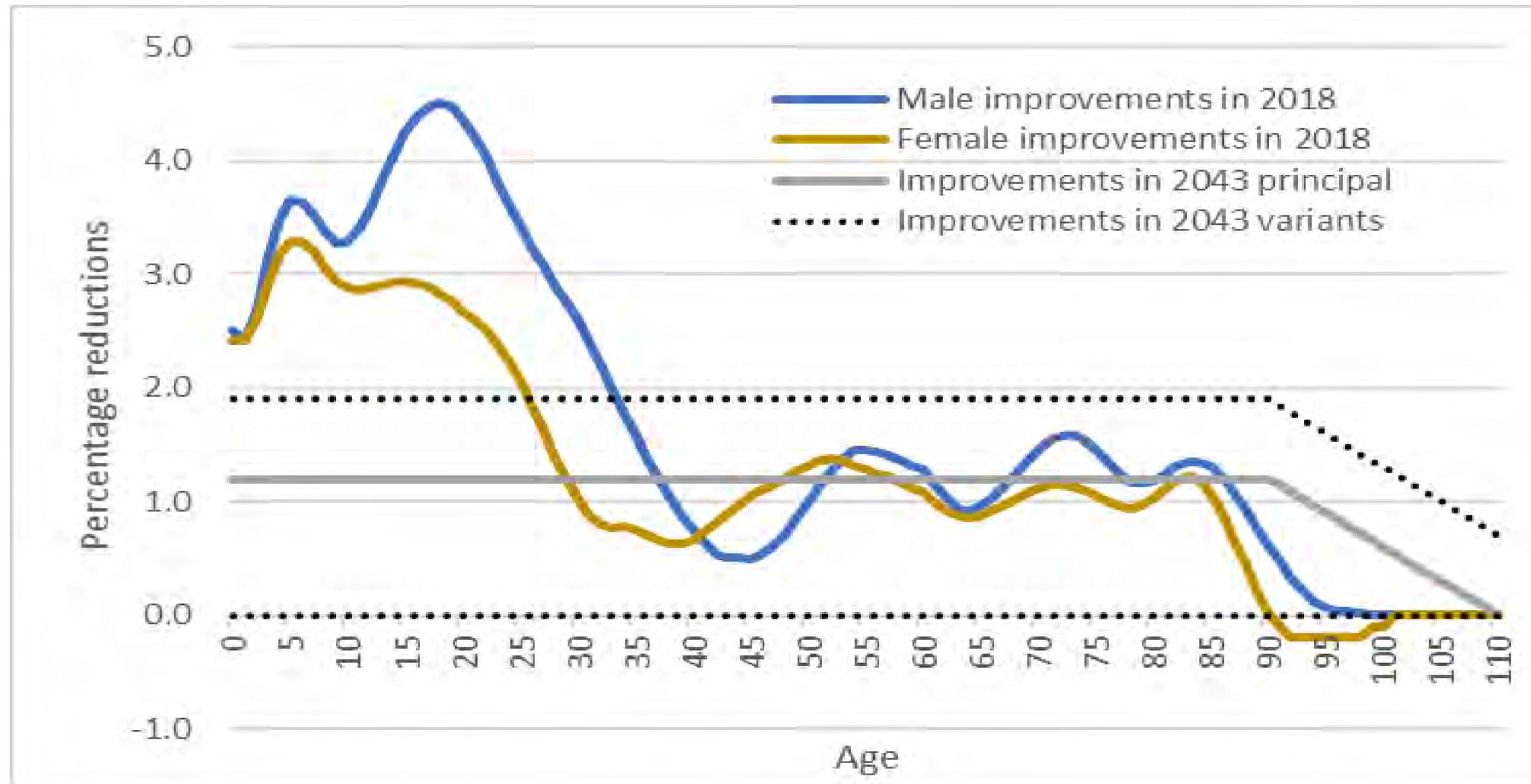
2018-based annual improvement in smoothed mortality rates, UK males 1961/2 – 2042/43


UK males: Percentage improvements in mortality rates for males, 1962 - 2043
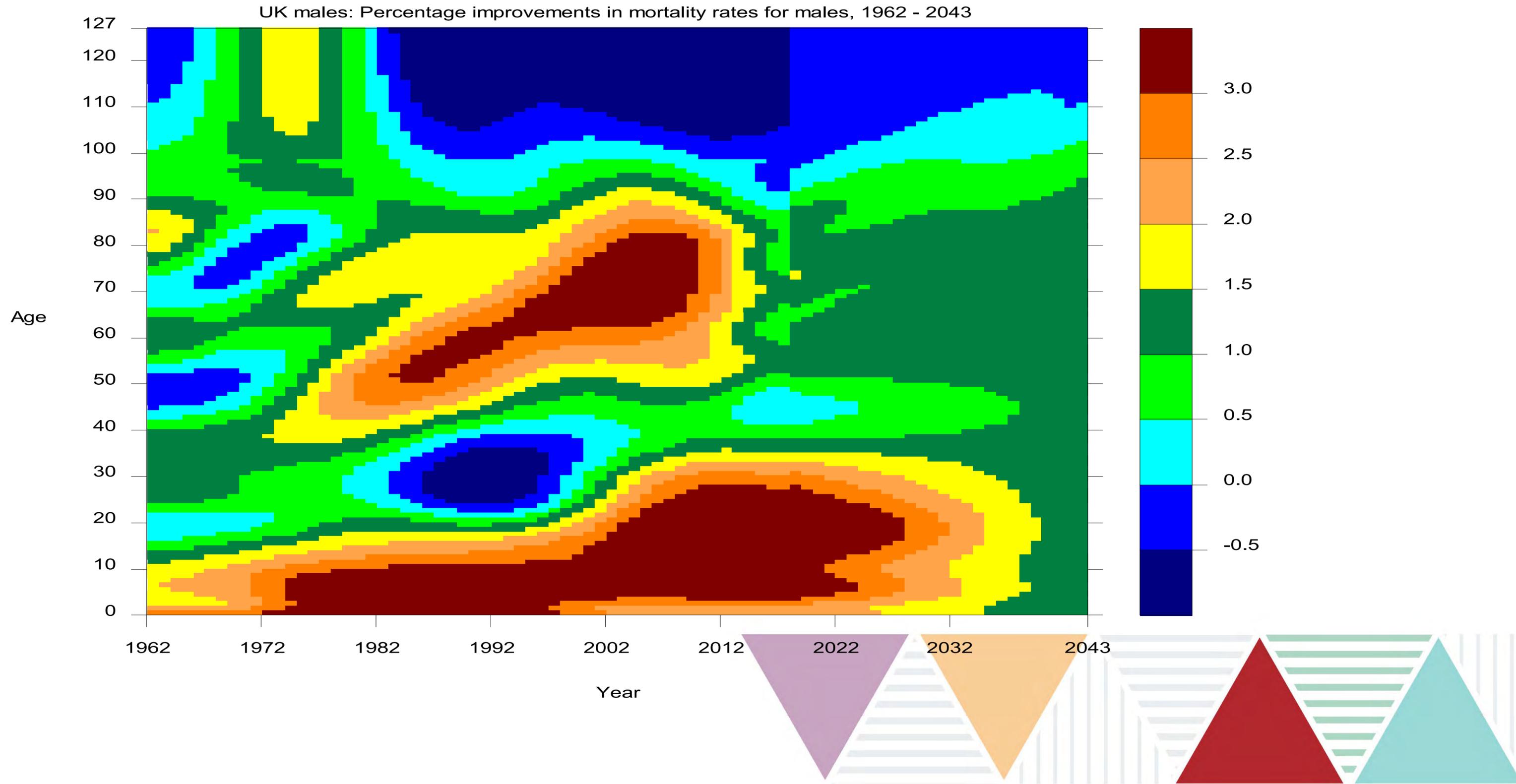
2018-based annual improvement in smoothed mortality rates, UK females 1961/2 – 2042/3

UK females: Percentage improvements in mortality rates for females, 1962 - 2043
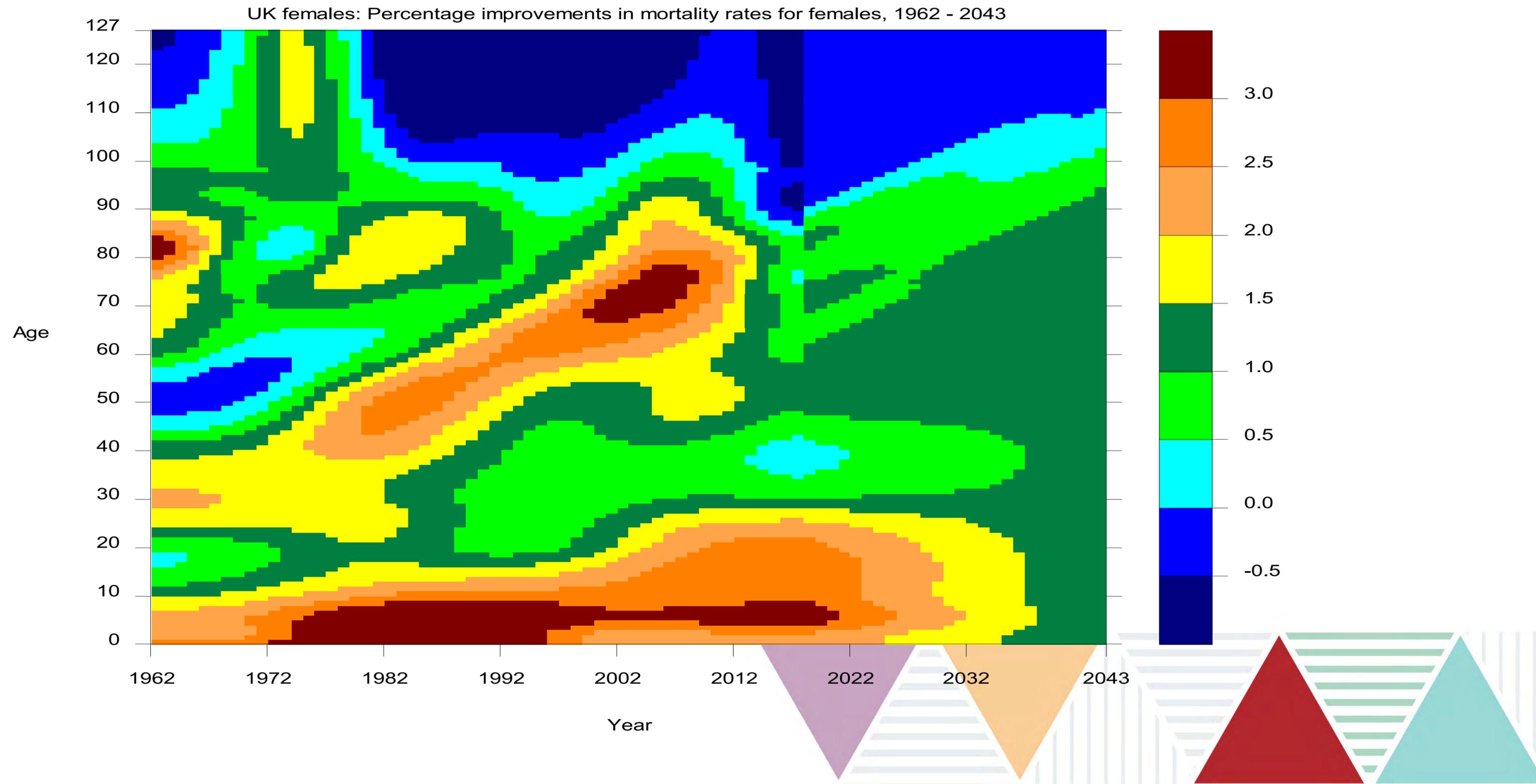
Period expectations of life at birth in 2017

| Country	Males	Females
UK	79.3	83.0
The Netherlands	80.1	83.3
Sweden	80.7	84.1
Denmark (2017-18)	79.0	82.9
France (provisional 2017)	79.4	85.3
Germany (2016-18)	78.5	83.3
Canada (2015-17)	79.9	84.0
USA (SSA)	76.4	81.1
Australia (2016-18)	80.7	84.9
Japan	81.1	87.3

Source: published life expectancy from country's national statistics website November 2019

Projected period expectations of life at birth in 2060

Country	Males	Females
UK	**84.5**	**87.2**
The Netherlands	86.5	89.9
Sweden	86.2	88.5
Denmark (2059)	86.6	88.9
France	86.0	91.1
Germany	84.4	88.1
Canada (2062/3)	86.4	89.6
USA (SSA)	81.1	85.0
Australia (medium 2065/6)	83.0	86.0
Japan	84.7	91.1

Source: latest published projections from country's national statistics website November 2019

Projected mortality improvement rates for 2017/18 by age in successive projections, UK, Males
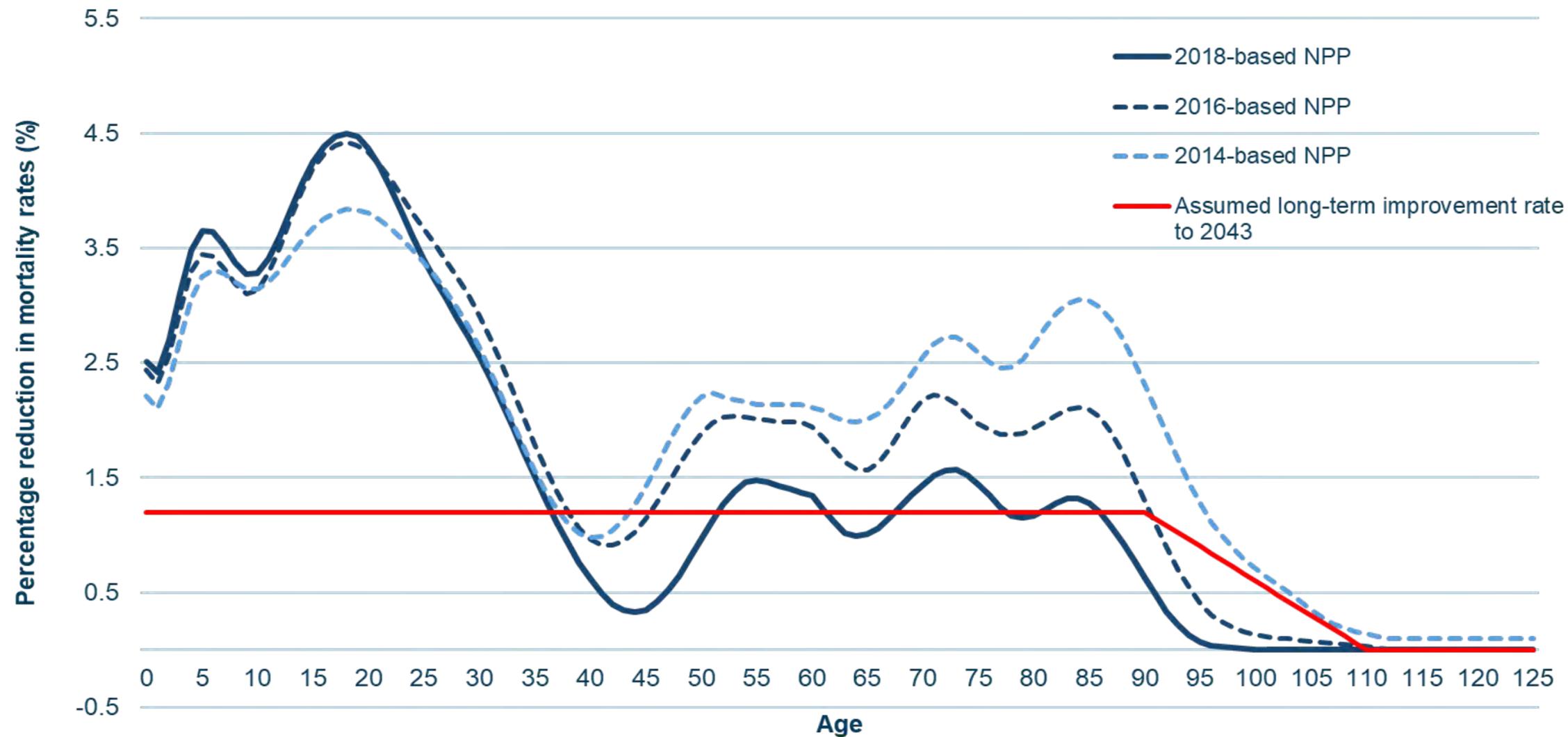
Projected mortality improvement rates for 2017/18 by age in successive projections, UK, Females
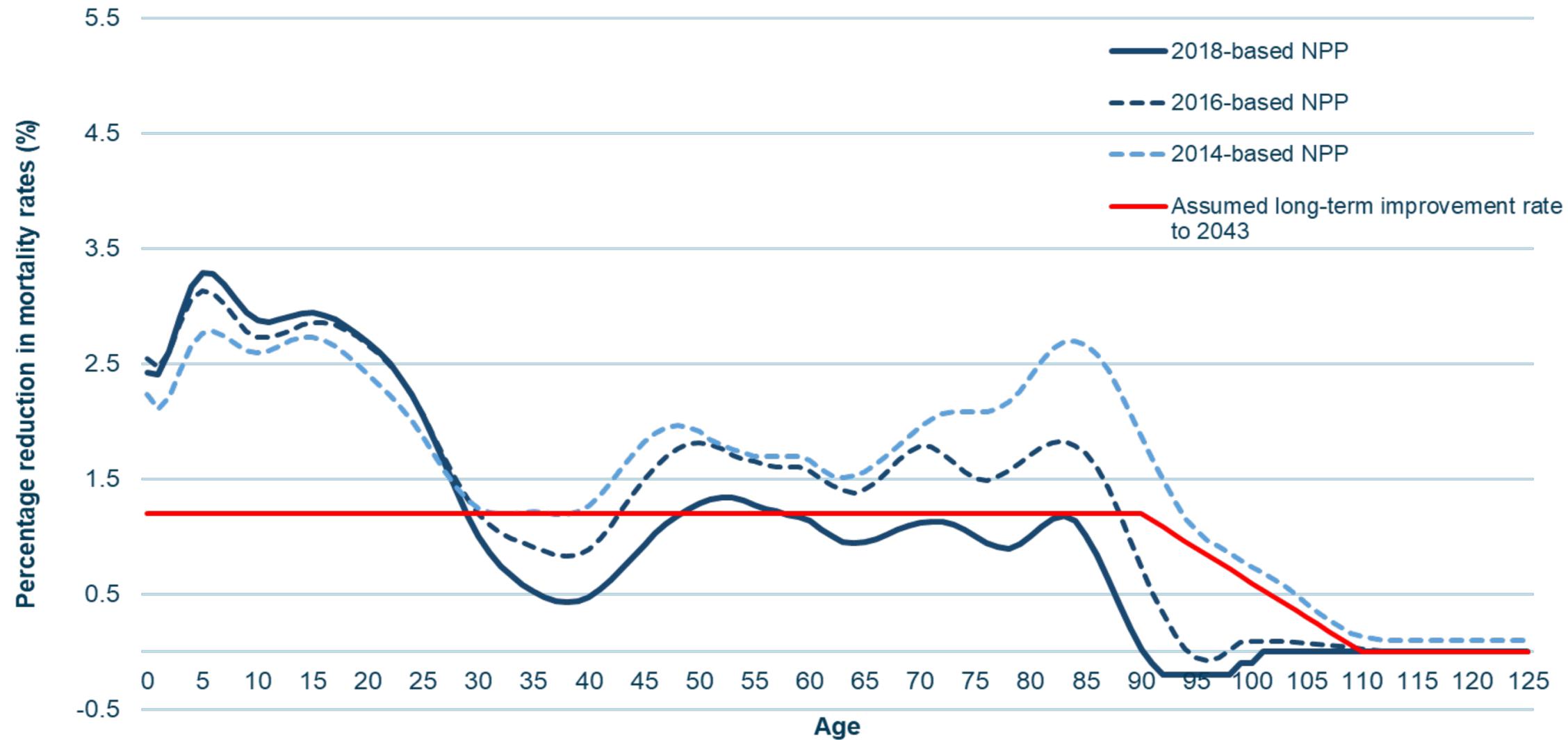
Ratio of base mortality rates for 2018 to those projected for 2018 in the 2016-based projections, UK
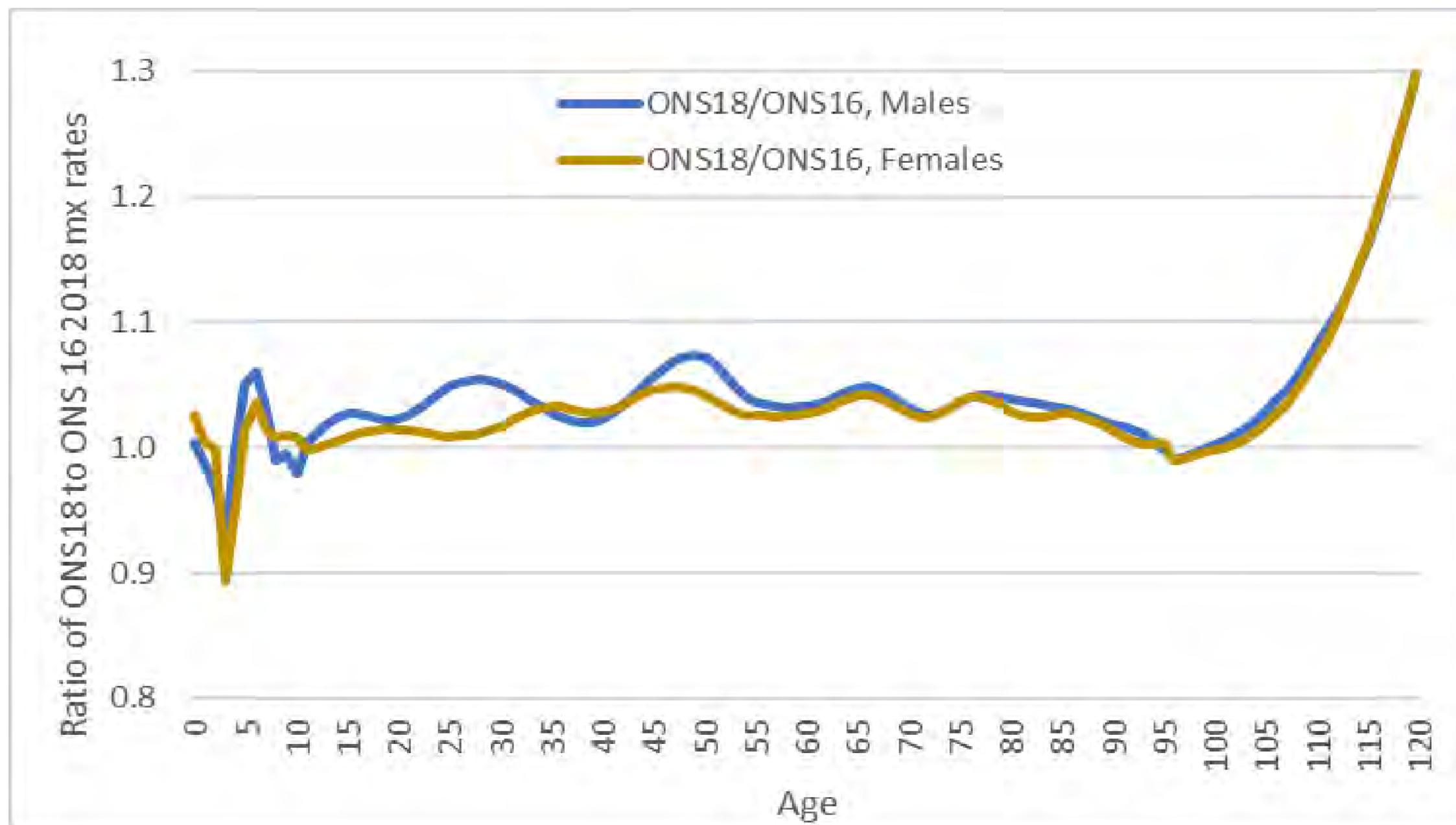
Principal period life expectancy at birth projection for base years 2010 – 2018, United Kingdom
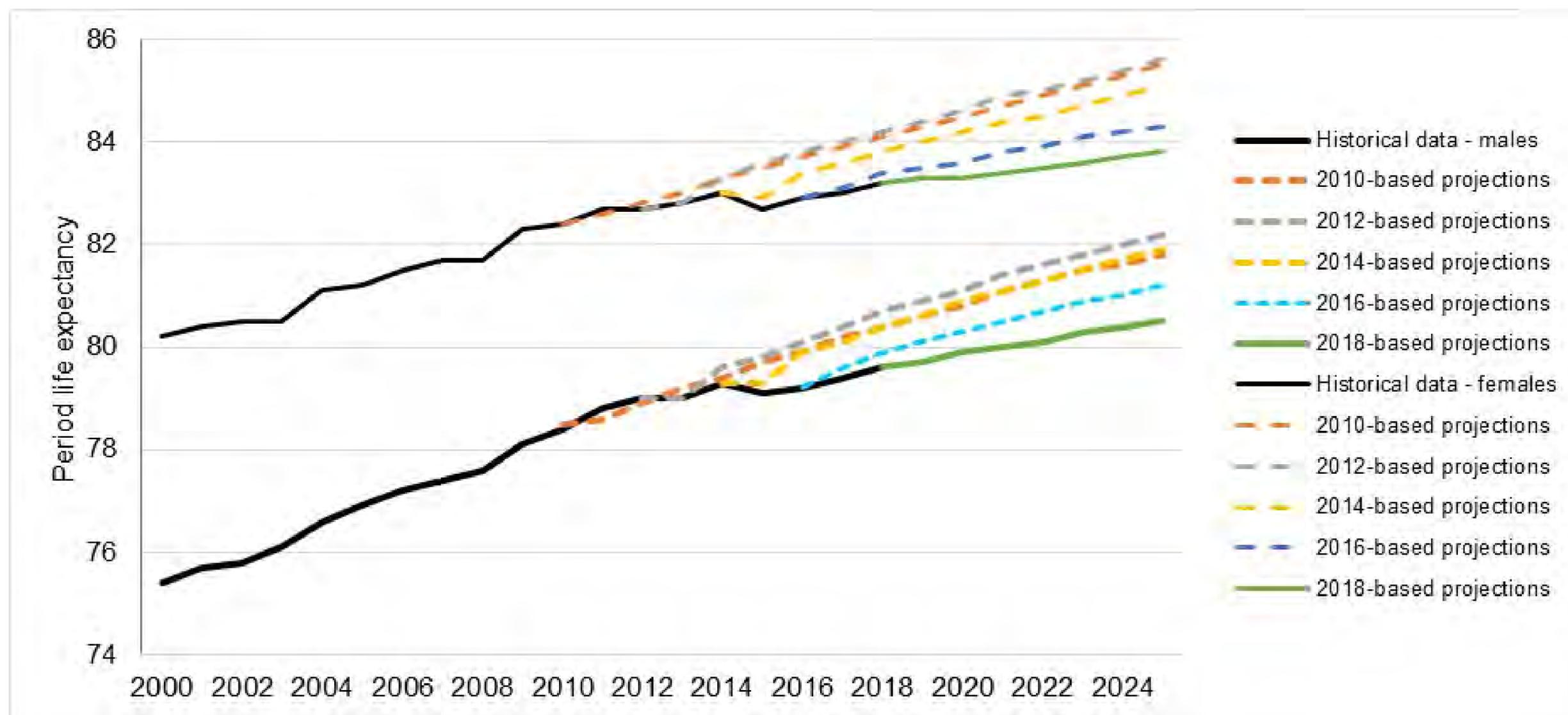
Mortality by region and deprivation

Period life expectancy at birth by region, Females, 2015-17

81.1

81.6

82.3

81.8   82.4

82.9

82.3   82.7

83.7

84.0 84.3

83.7
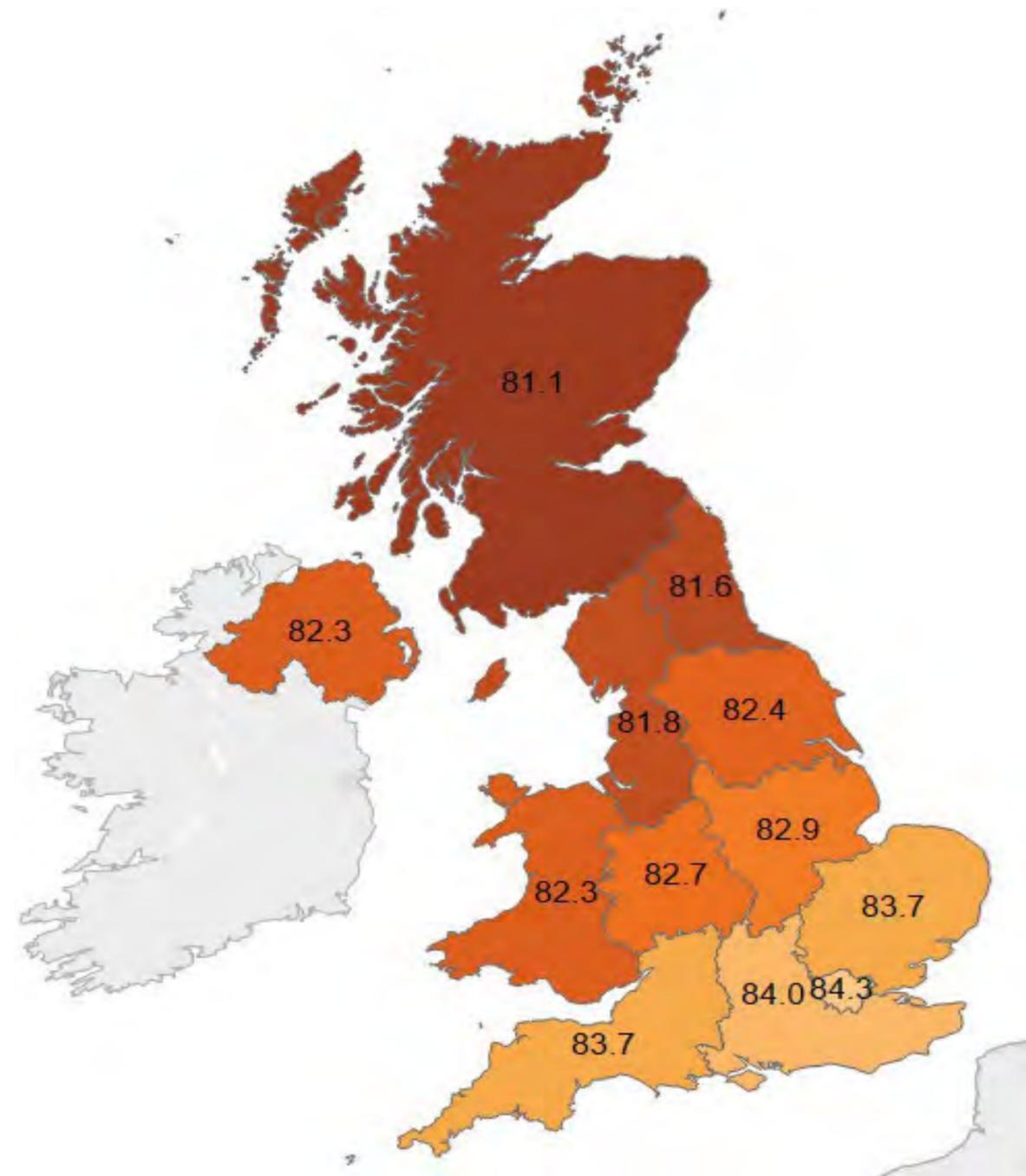
Source: ONS

Male period life expectancy at birth by national deprivation decile, England, 2015-17
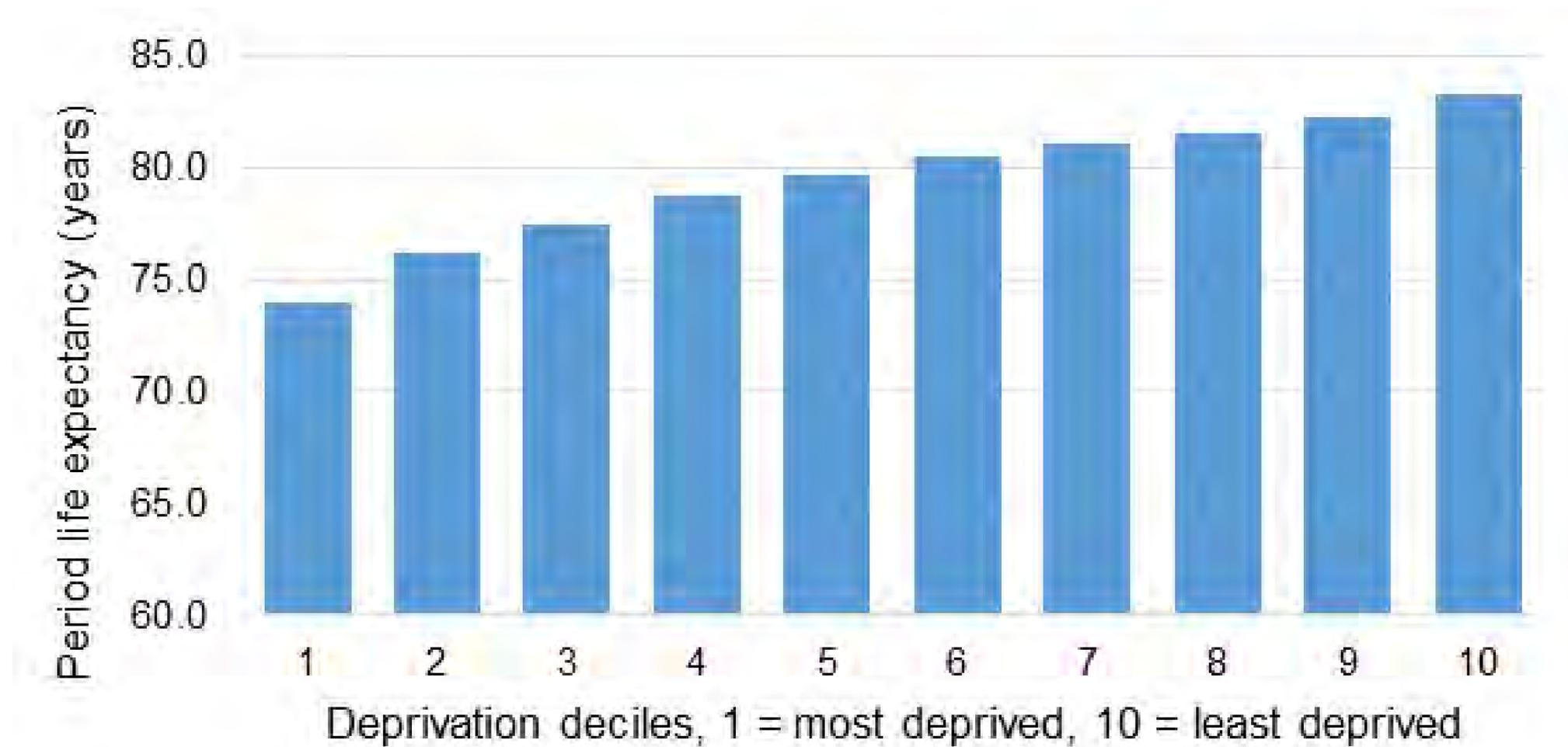
Source: ONS

Male healthy life expectancy at birth and years lived in poorer states of health by national deprivation decile, England, 2015-17
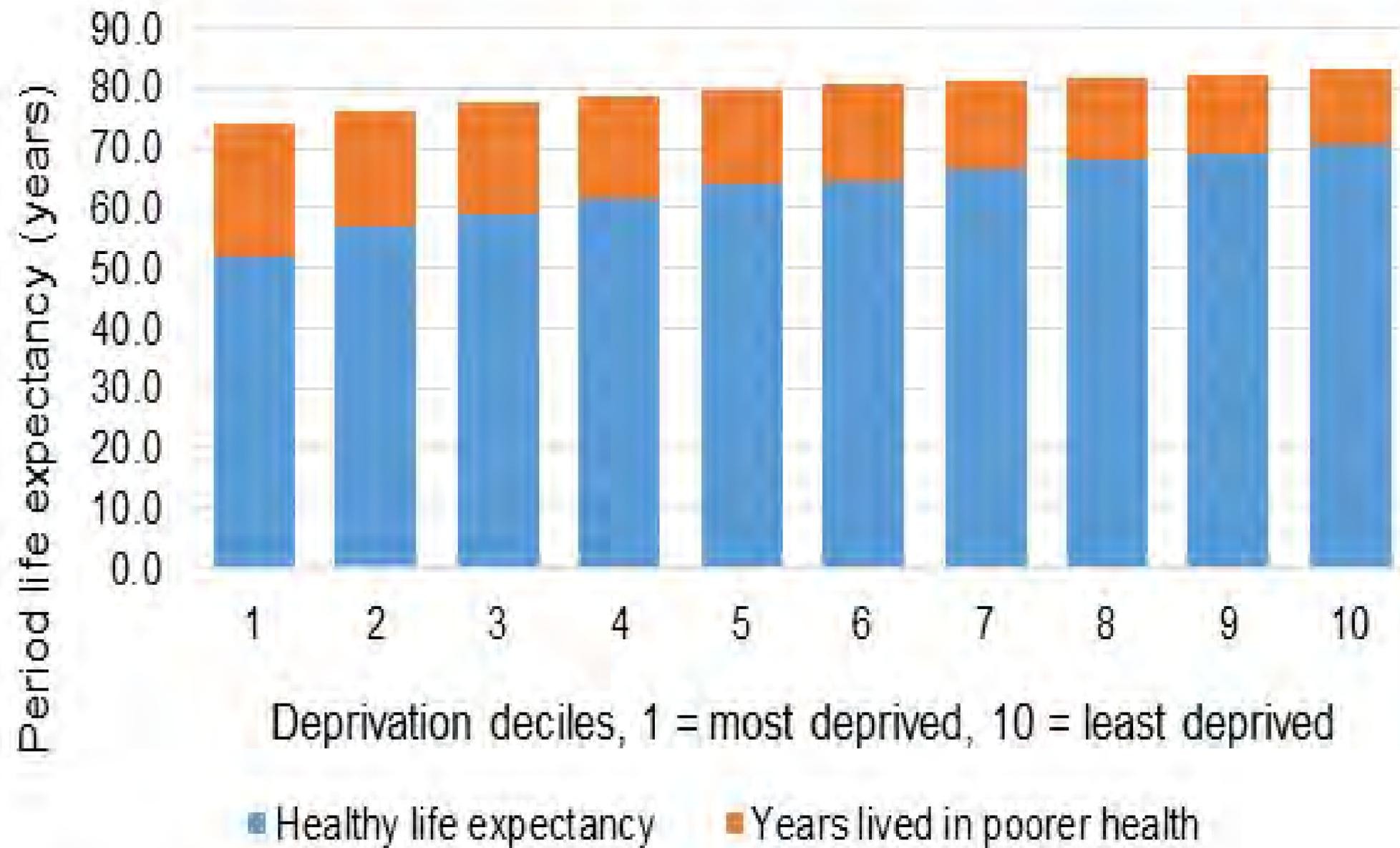

Source: ONS

Period life expectancy by IMD – Males, England
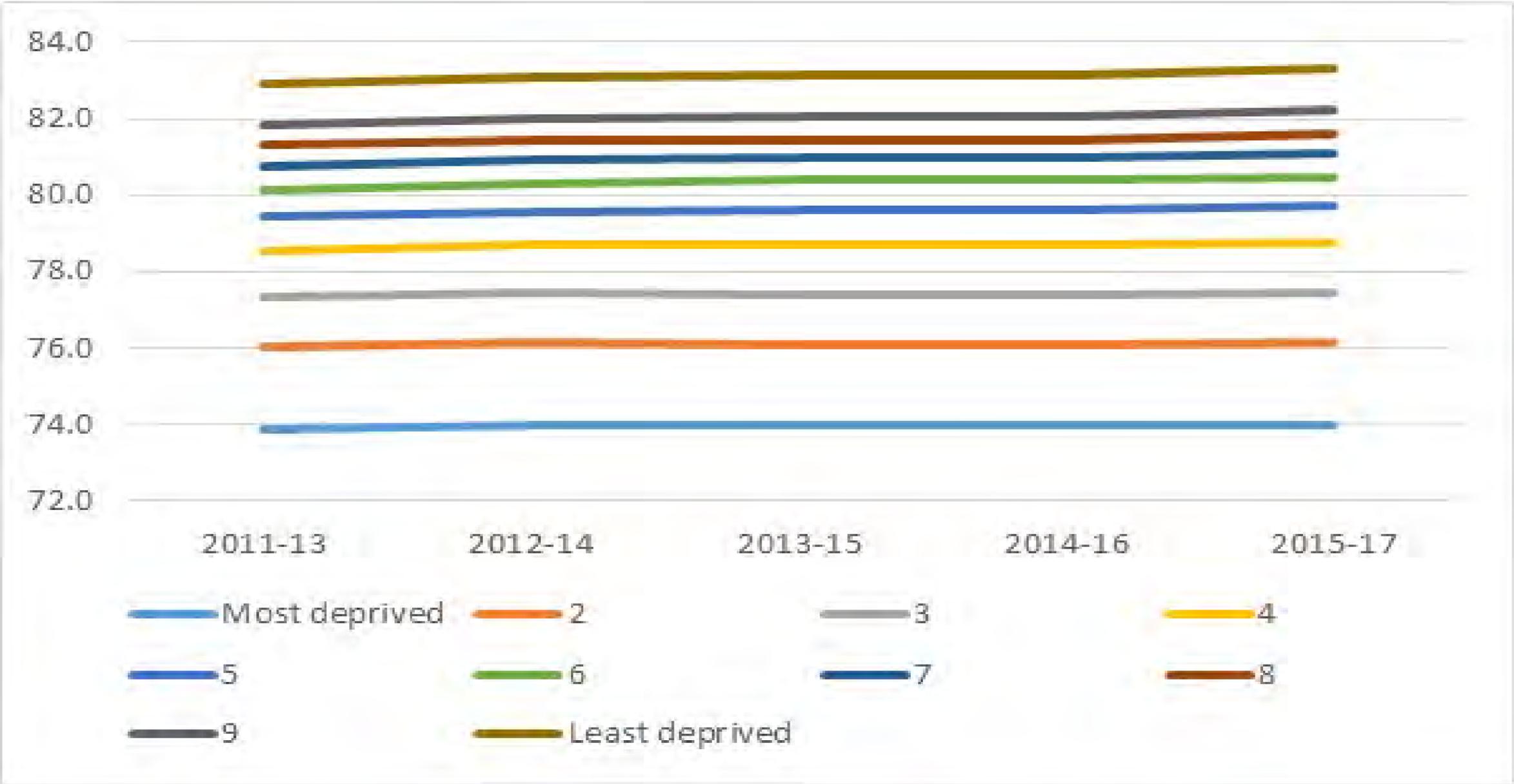
Source: ONS

Period life expectancy by IMD – Females, England
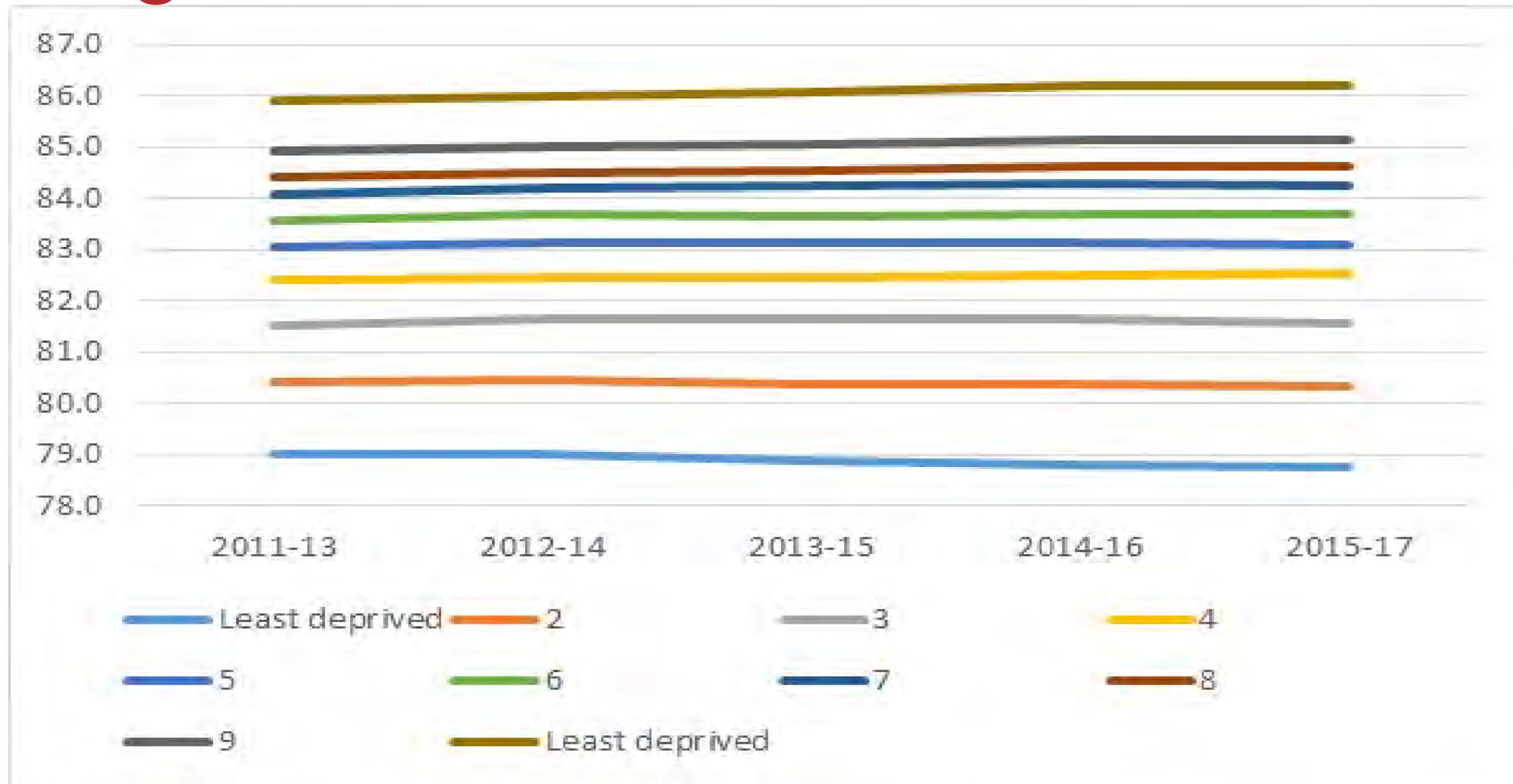
Change in life expectancy in days between 2012-14 and 2015-17, by sex and decile, England

Figure 2: Change in life expectancy in days between 2012 to 2014 and 2015 to 2017: by sex and decile, England

Life expectancy (days)

Deprivation deciles - 1 = most deprived, 10 = least deprived

● male   ● female
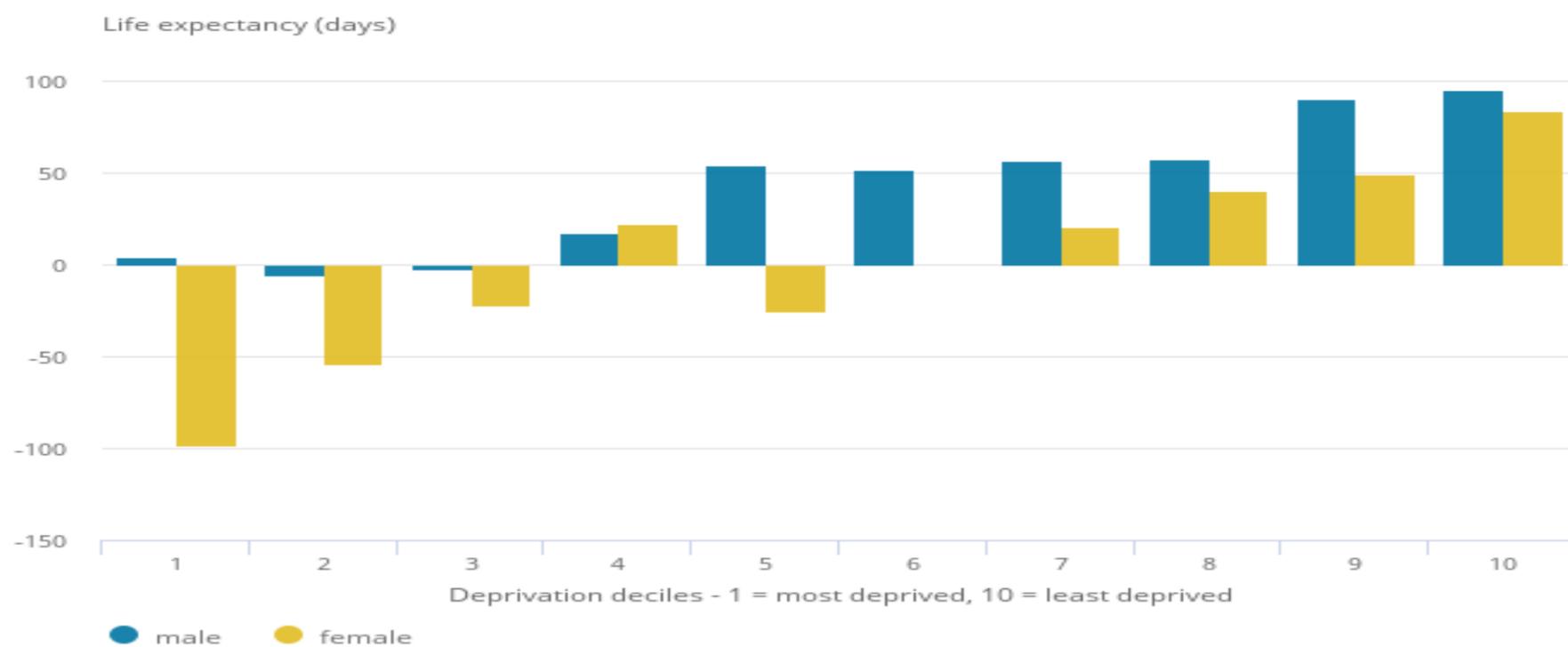
Source: Office for National Statistics

England, Males 40-89, ASMR and ADSMR Inequality
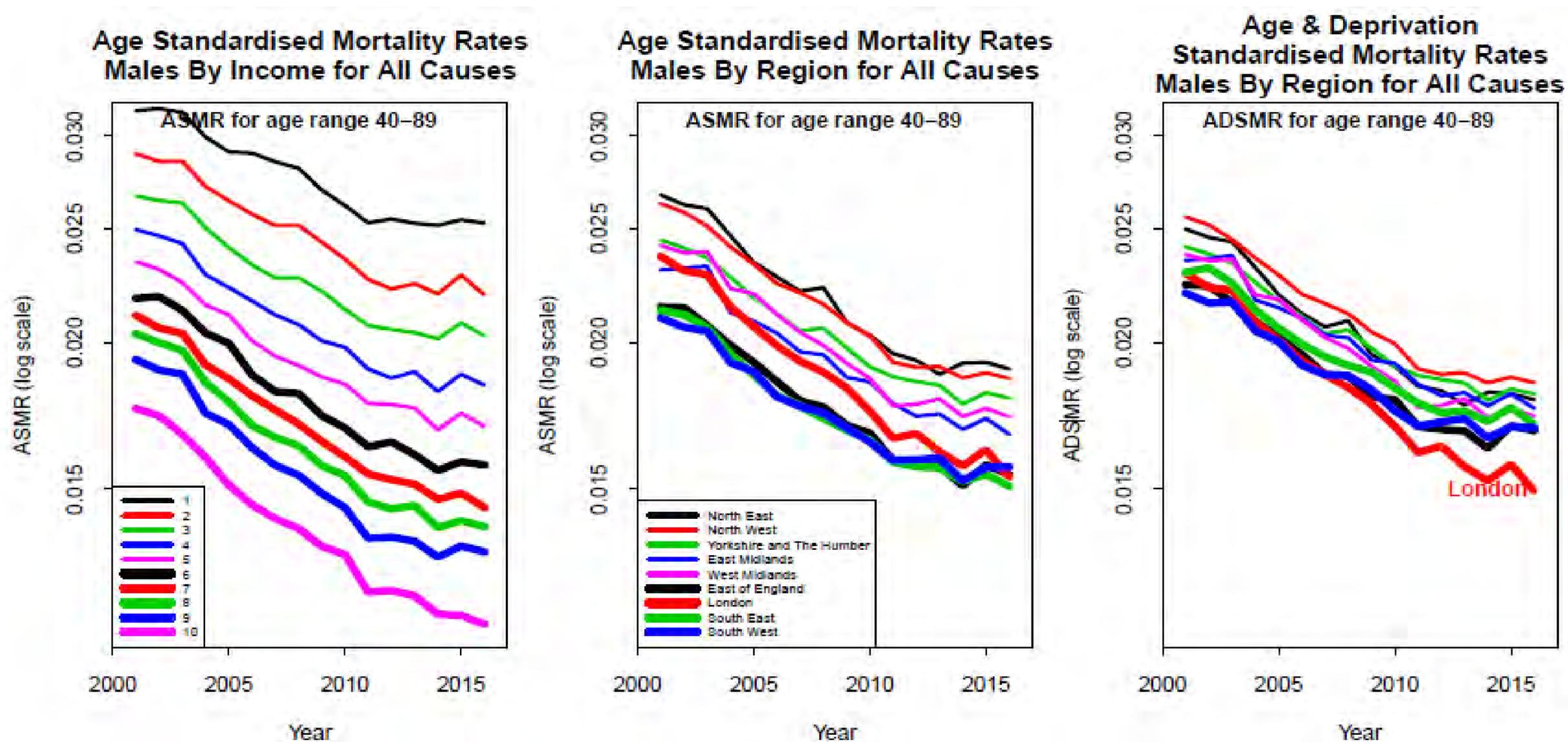
Source: Trends in Mortality by Socio-Economic Group and Cause of Death, Andrew Cairns, ARC

Recent ARC research on mortality data by socio-economic group, region and cause of death

What are the key drivers of all-cause mortality?

How are the key drivers changing over time?

Which causes of death have high levels of inequality?

Can we point to specific causes of death as responsible for growing inequality?

Leading to: insight into mortality underpinning life insurance and pensions

Which causes of death exhibit growing inequality

Ischaemic heart disease

Diabetes

Cerebrovascular

Circulatory

Respiratory diseases

Mental illnesses (females)

Lung cancer

⇒ a widening gap in the prevalence of controllable risk factors: smoking, diet, exercise, alcohol etc.

No significant causes of death with narrowing inequality gap

Contributors to the slowdown since 2011

Main contributors seem to be:

- Heart diseases (but less so for the least deprived)
- Dementias and Alzheimer's
- Possibly respiratory diseases
- Possibly diabetes

ARC Research - summary

Causes of death with associated controllable risk factors

⇒ mortality inequality

Significant levels of inequality for most of the big CoD's

Regional differences remain even after adjusting for deprivation

Causes of death with no controllable risk factors

⇒ little or no inequality

Mortality inequalities have widened since 2001

Link to multiple controllable risk factors

Slowdown since 2011 + ischaemic heart disease

NO slowdown in the least deprived group

Thank you
Questions?

Declining Mortality (Increasing Longevity): At What Rate? At What Ages?

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US Social Security Administration

2020 Living to 100 Symposium
General Session IV - Mortality Projection from a Social Security Panel
January 14, 2020

Perspective: "Aging" Not Mainly from Mortality

Aging (change in age distribution) mainly due to drop in birth rates

Aged Dependency Ratio 2019 TR
Population 65+/(20-64)

Legend:
- Actual and TR Intermediate
- TFR remains at 3.0 after 1964
- TFR remains at 3.3 after 1964

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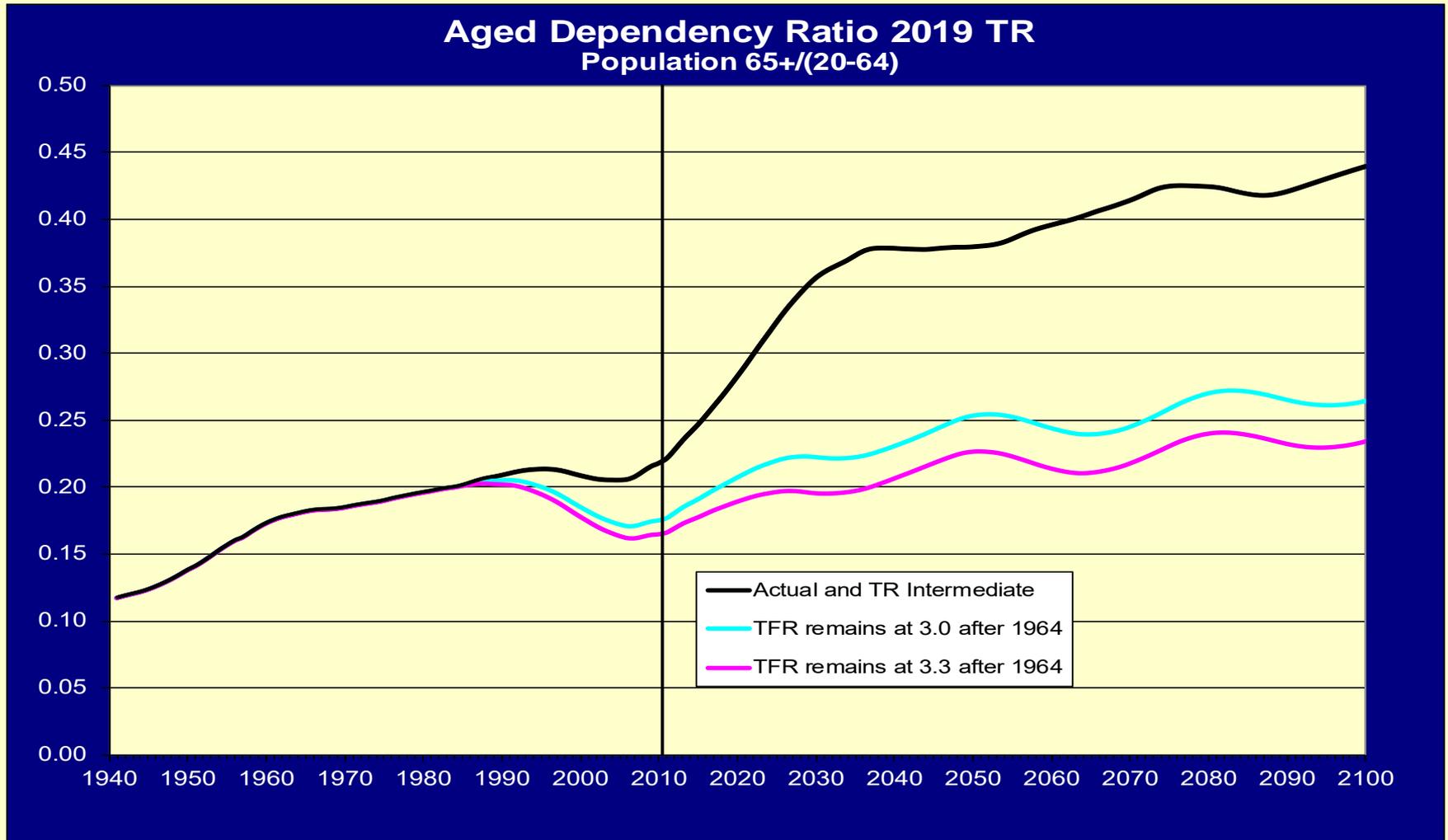
Considerations in Projecting Mortality

- ☐ Variation over time periods
- ☐ Variation by age
- ☐ Variation by earnings level
- ☐ Changing causes of death
- ☐ Cohort considerations
- ☐ Health spending, obesity, smoking, opioids
- ☐ Is there a limit on human longevity?
- ☐ Our projections for the United States

Life Expectancy at Birth Not a Useful Indicator; Age Distribution of Death Rates Most Important

Period Life Expectancy at Birth using the 2019 TR

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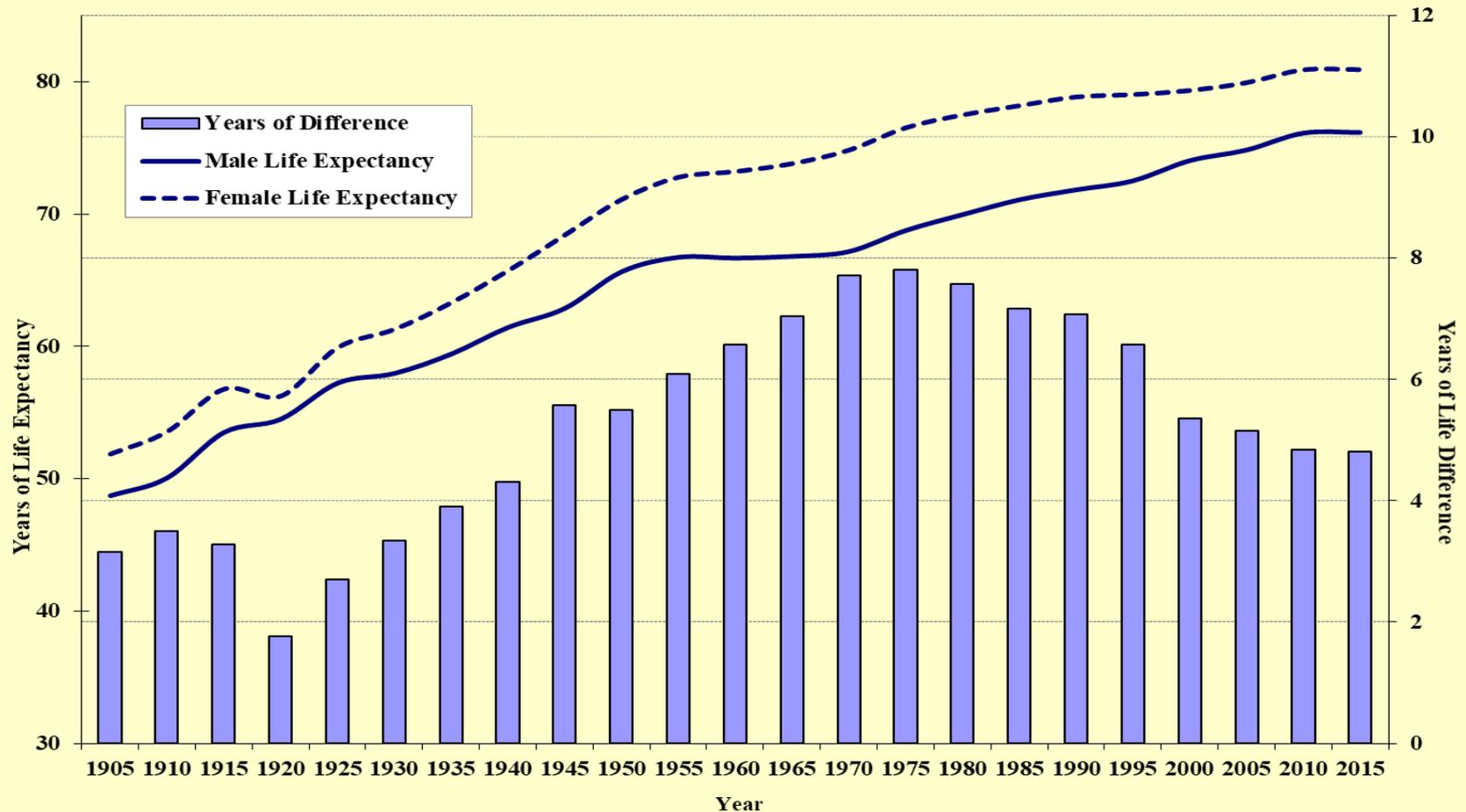
Mortality Decline *Varies* Over Time
Conditions: Antibiotics/economy 1936-54; Medicare/Medicaid 1968-82

Female Historical (2019 Trustees Report)
Annual Percent Reduction in U.S. Mortality Rates

Male Historical (2019 Trustees Report)
Annual Percent Reduction in U.S. Mortality Rates
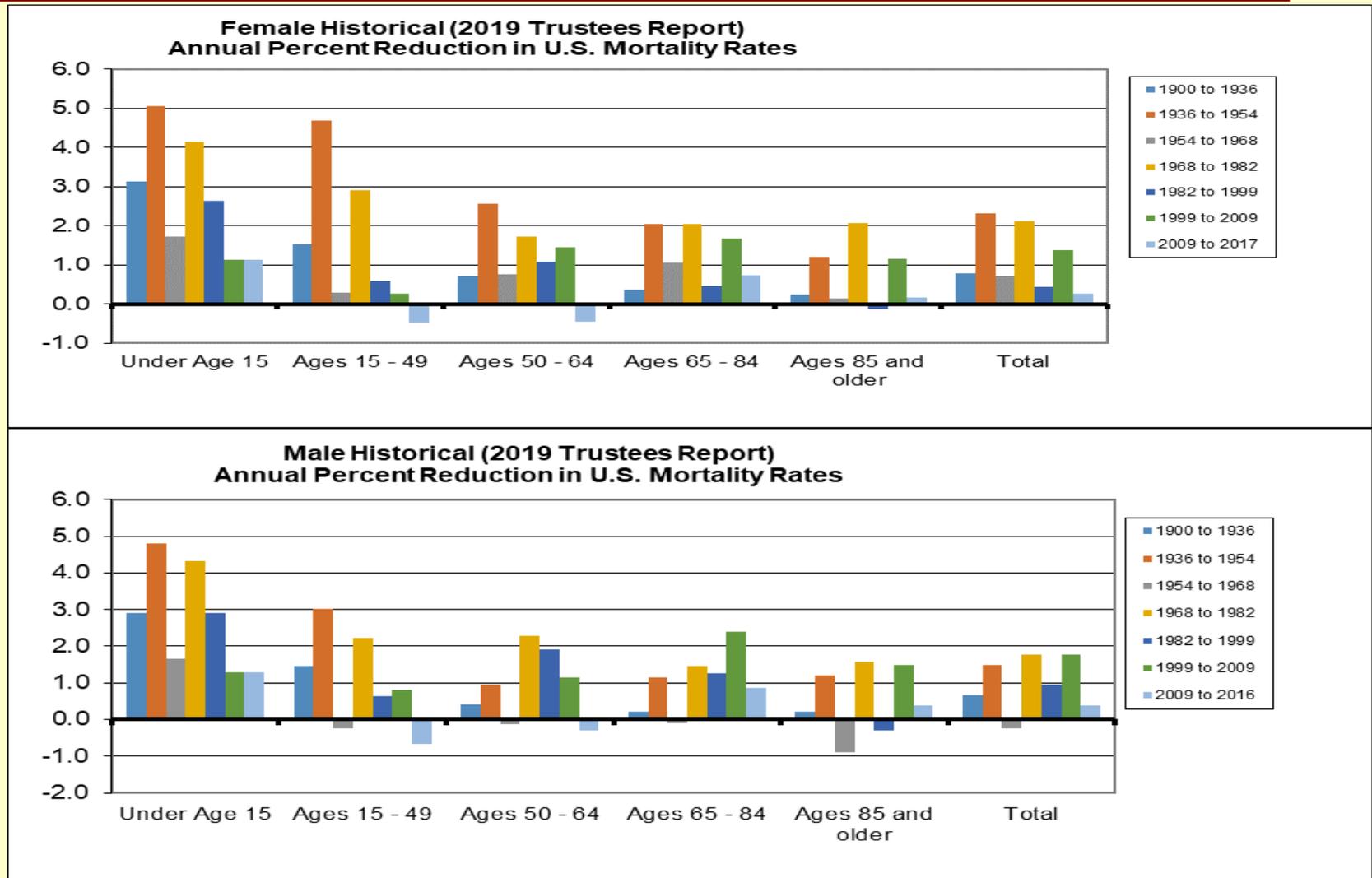
Opioids? Affected Age 15-64 Mortality Decline Since 1999, but Not the Deceleration Since 2009
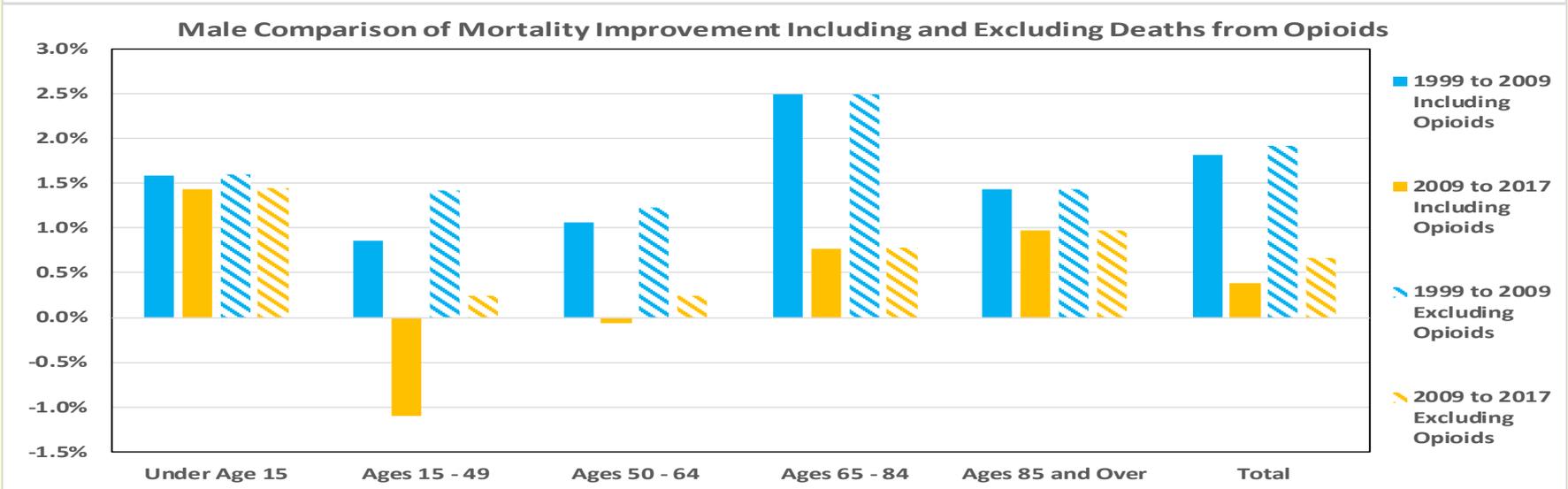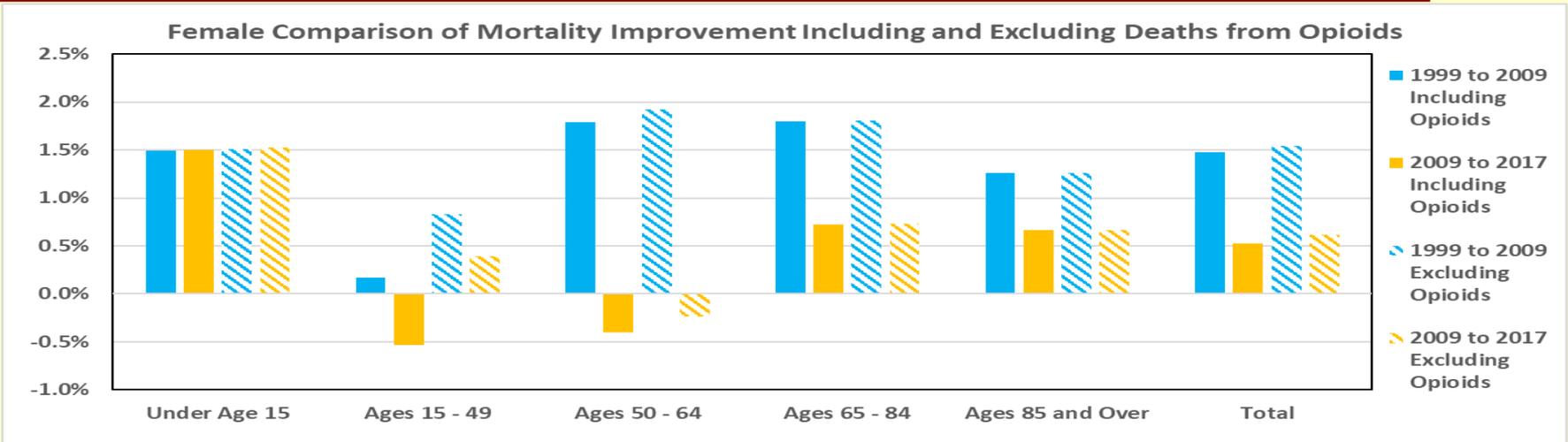
Mortality Experience: All Ages
Reductions falling short of expectations since 2009

Age-Sex-Adjusted Death Rates
(Total, All Ages)
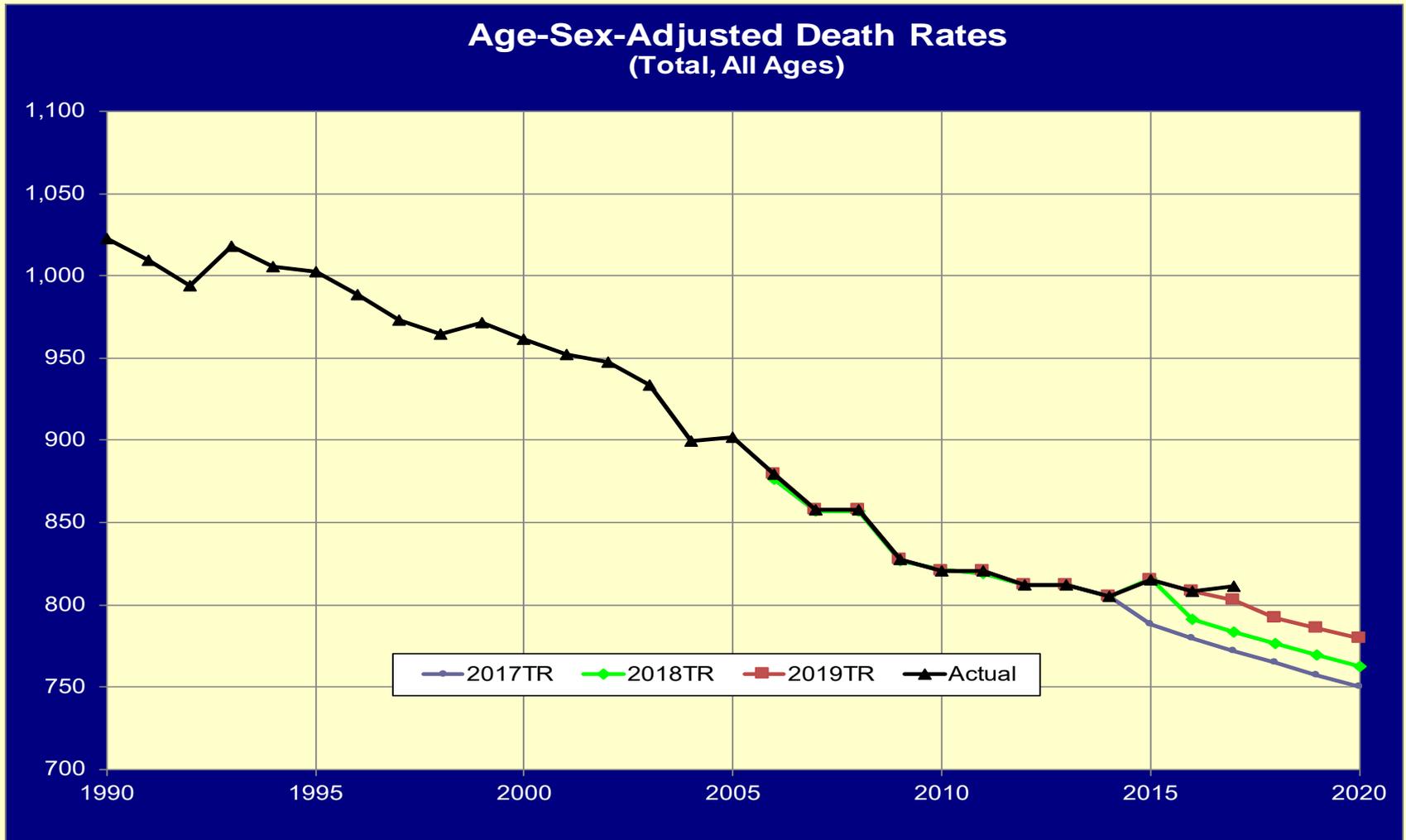
Mortality Experience: Ages 65 and Over
Reductions falling short of expectations since 2009

Age-Sex-Adjusted Death Rates
(Ages 65 and Older)

Legend: 2017TR, 2018TR, 2019TR, Actual
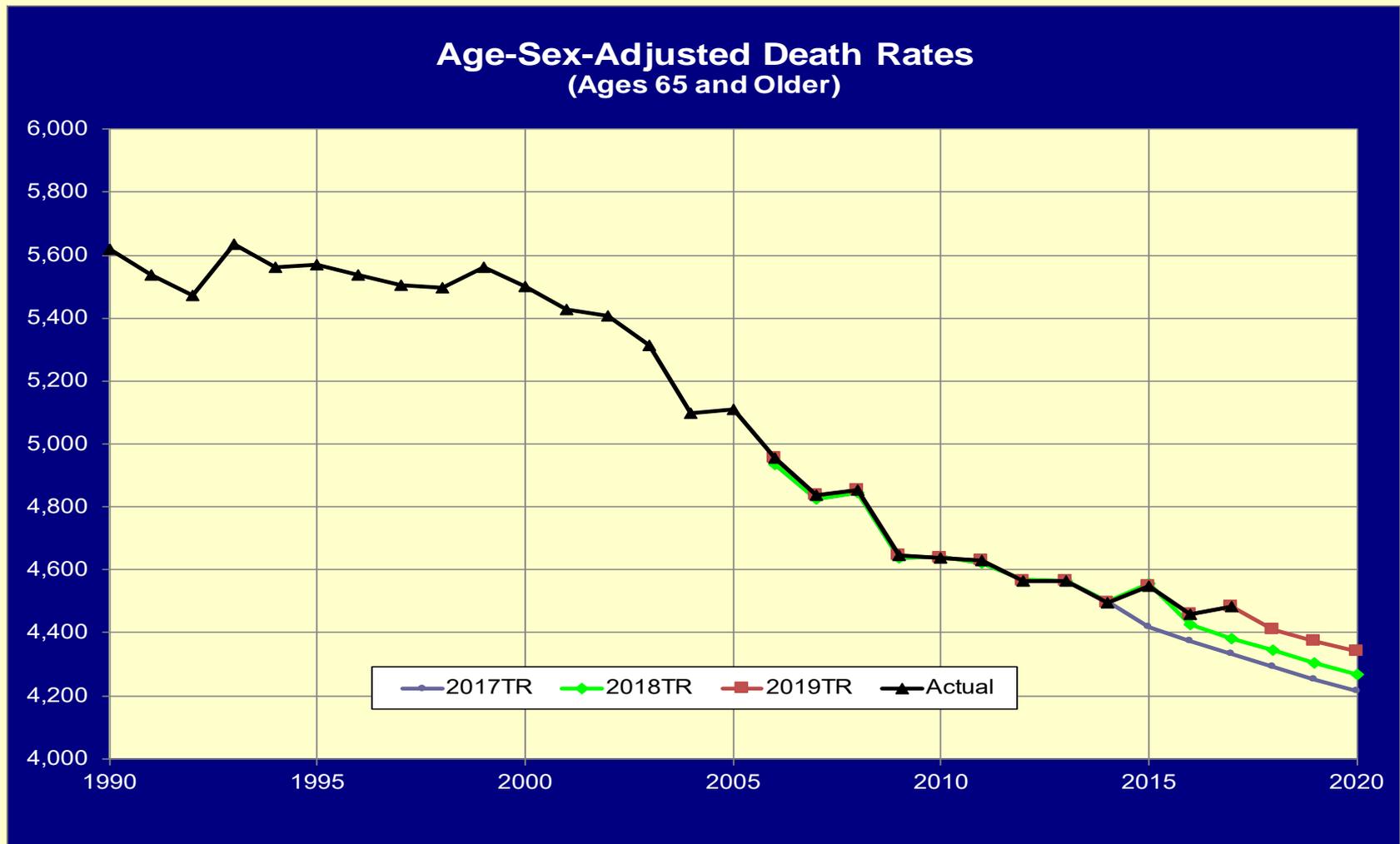
Variation by Age is Substantial
Age-gradient in past reduction is clear

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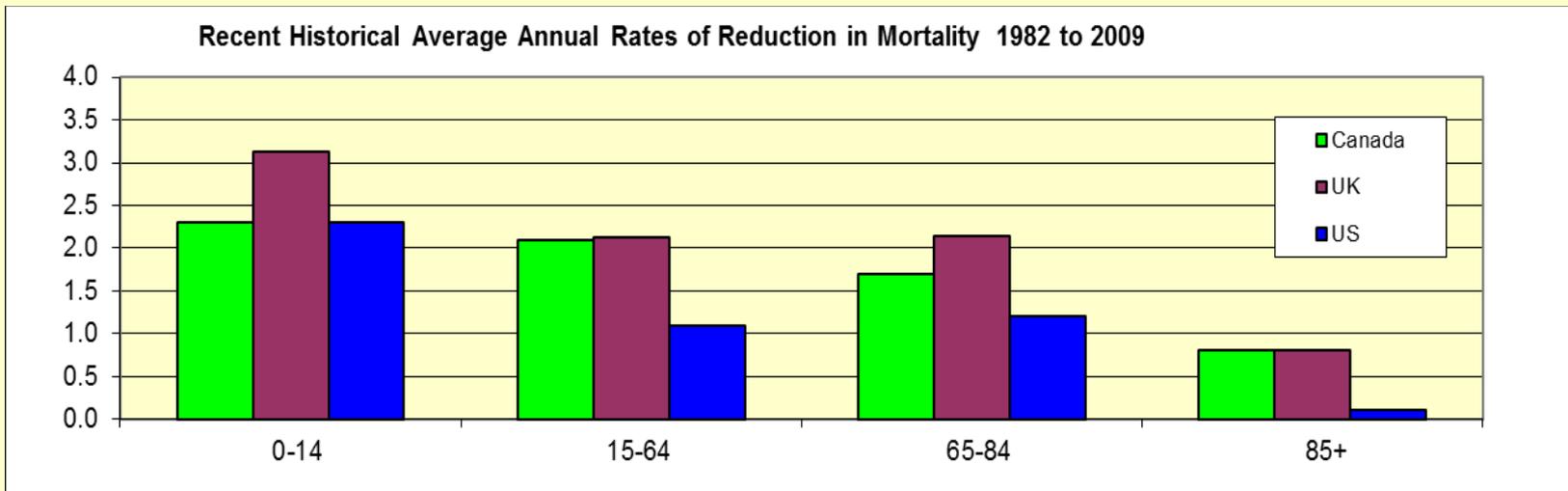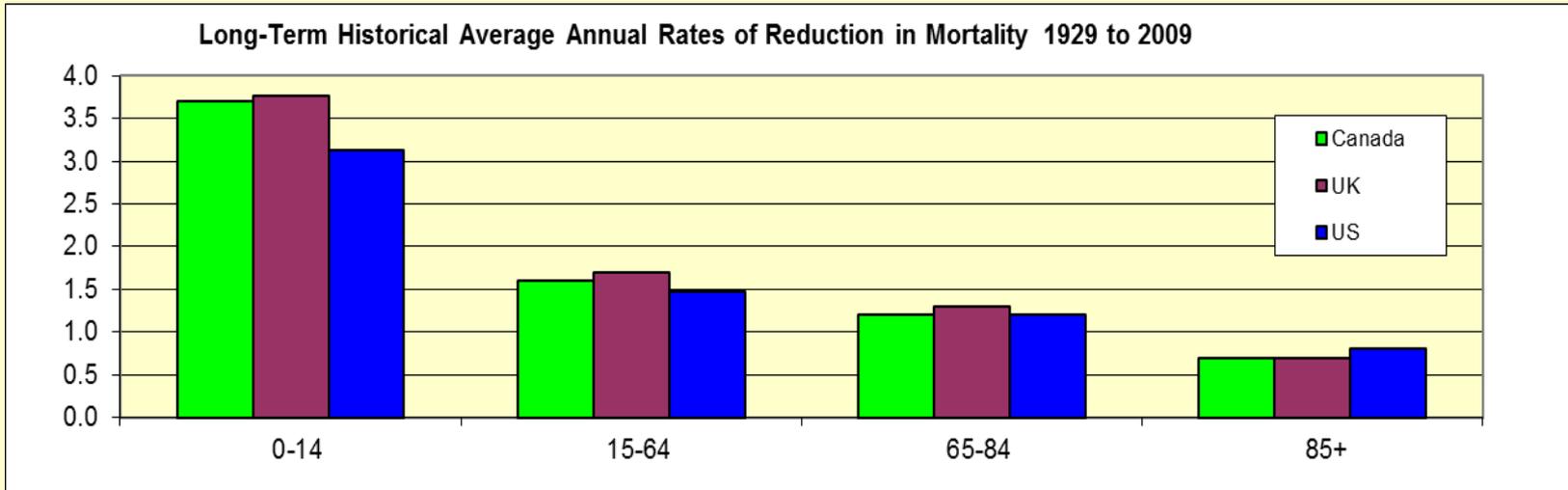
Mortality By Career-Average Earnings Level: Actuarial Study #124

Age group 65-69 relative mortality ratios—not diverging?
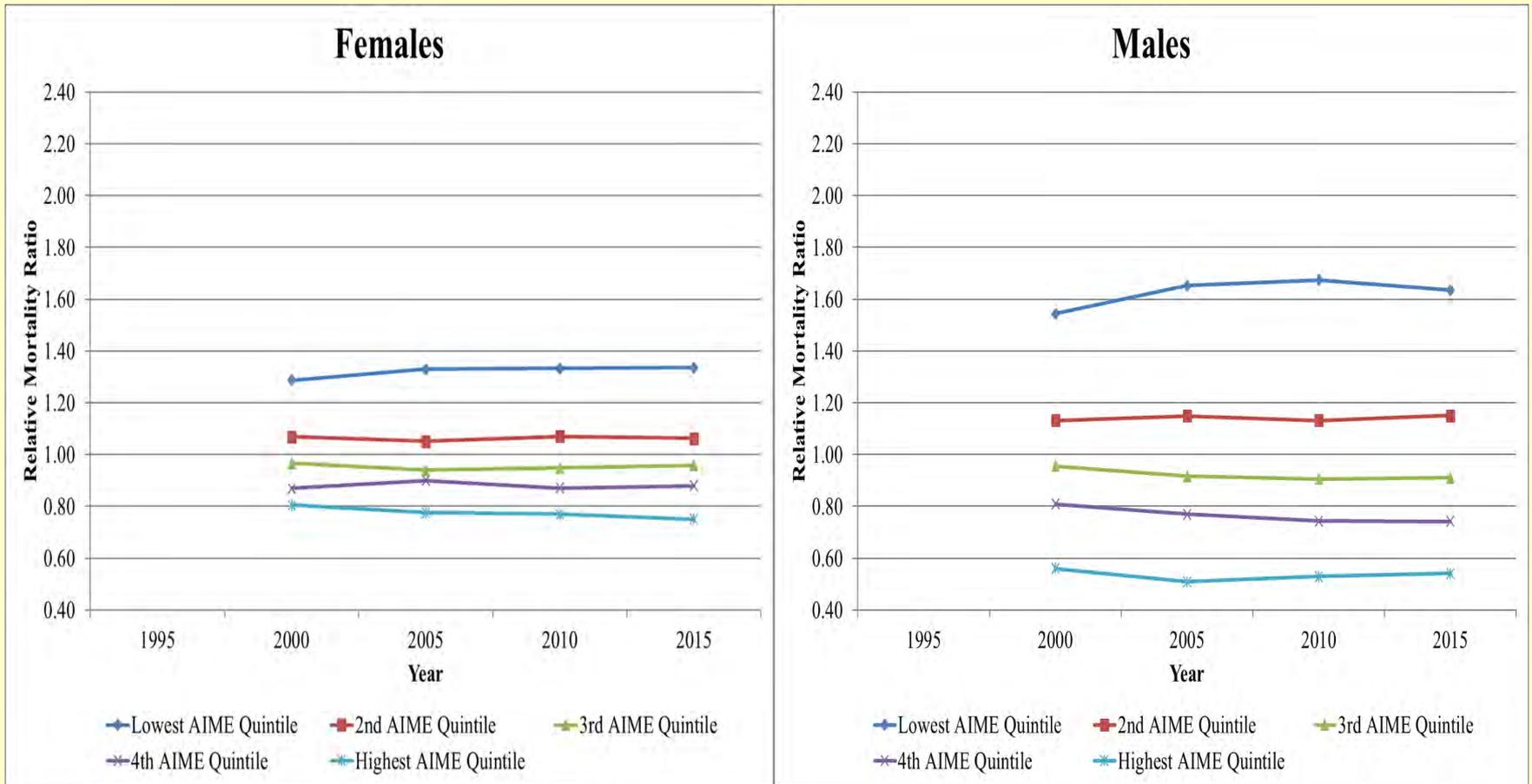
Mortality Decline by *Cause* of Death:
Rate of change from 1979 to 2017
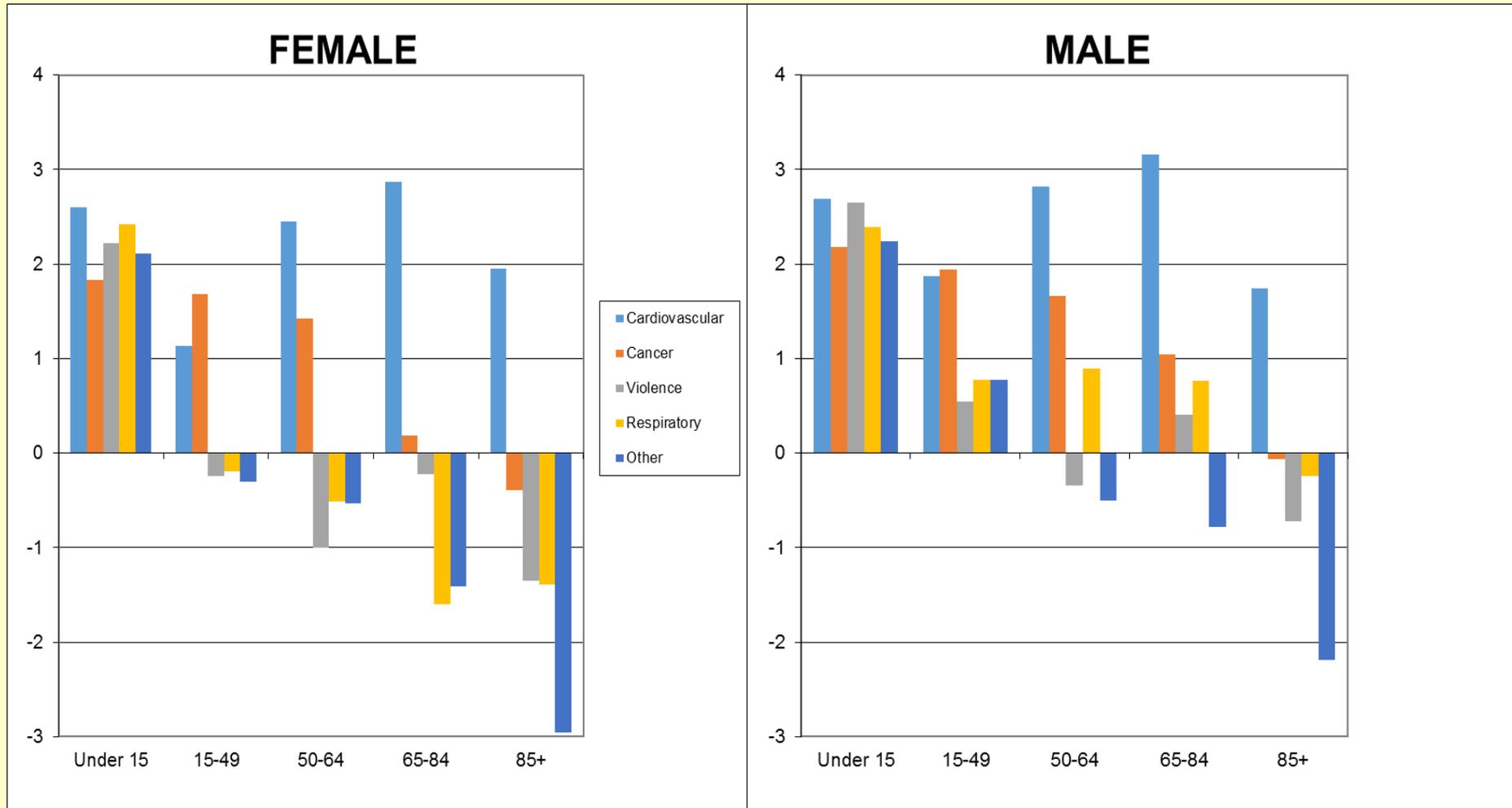
Age-adjusted Death Rates for Heart Disease, Cancer, Stroke, and Unintentional Injuries: United States, 1900-2015

(courtesy Robert Anderson, NCHS)

Rate per 100,000 standard population

Heart disease

Cancer

Stroke

Unintentional injuries
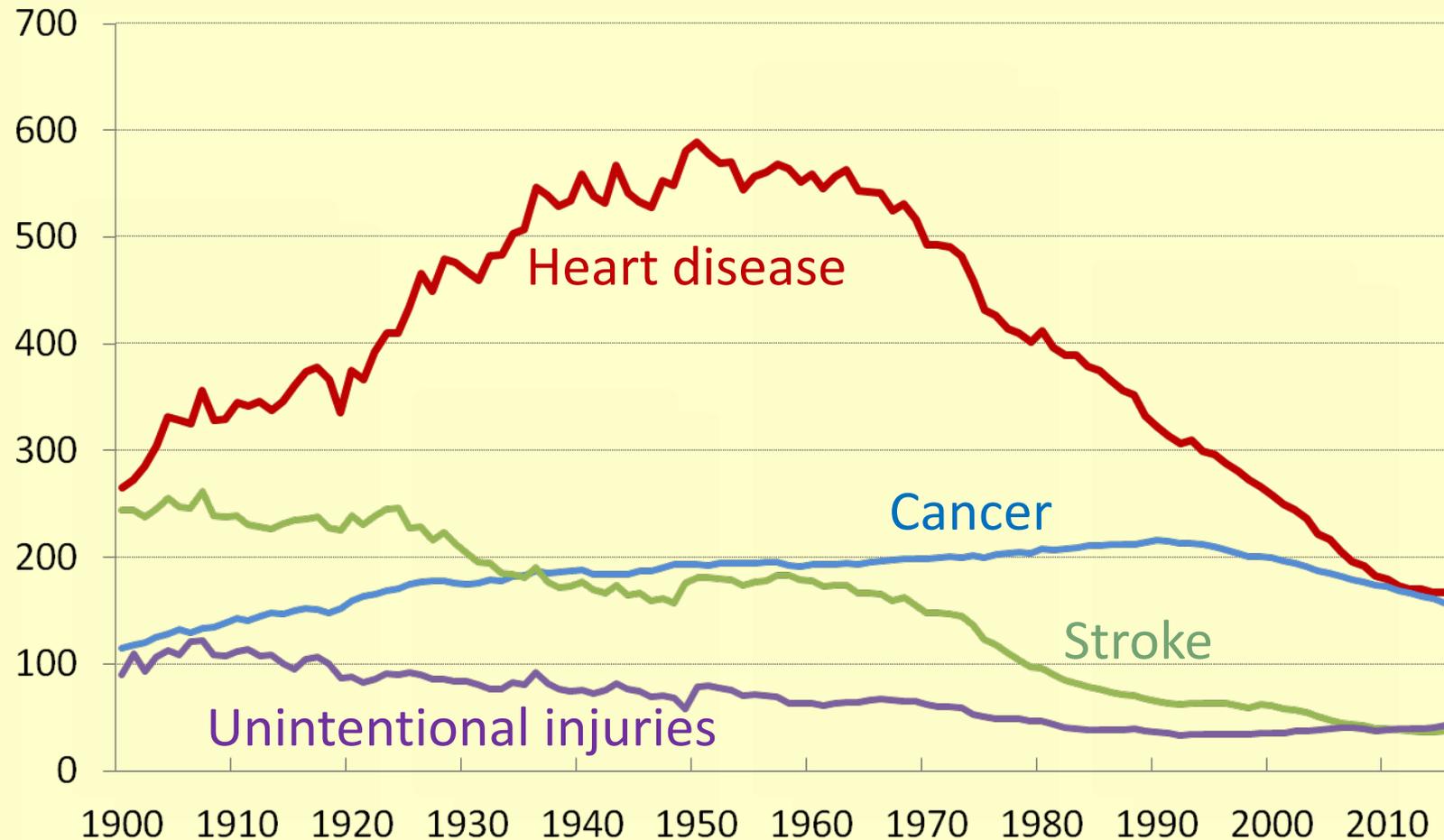
NOTE: Data prior to 1933 contain death-registration States only. Data for 2015 is provisional.

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Developing Assumptions by Cause

- Scientific approach reflecting biology
- Trustees and SSA/OCACT develop in consultation with other experts
- Johns Hopkins survey of medical researchers and clinicians came to very similar medium-term expectations—independently
  - Trustees' medium-term rates by cause had not been published

Cardiovascular: JHU Less Optimistic than Trustees Over Age 50 for Next 30 Years

Cardiovascular Disease-Female
Average Annual Percent Reduction
JHU values are for the period 2009-2040

Cardiovascular Disease-Male
Average Annual Percent Reduction
JHU values are for the period 2009-2040
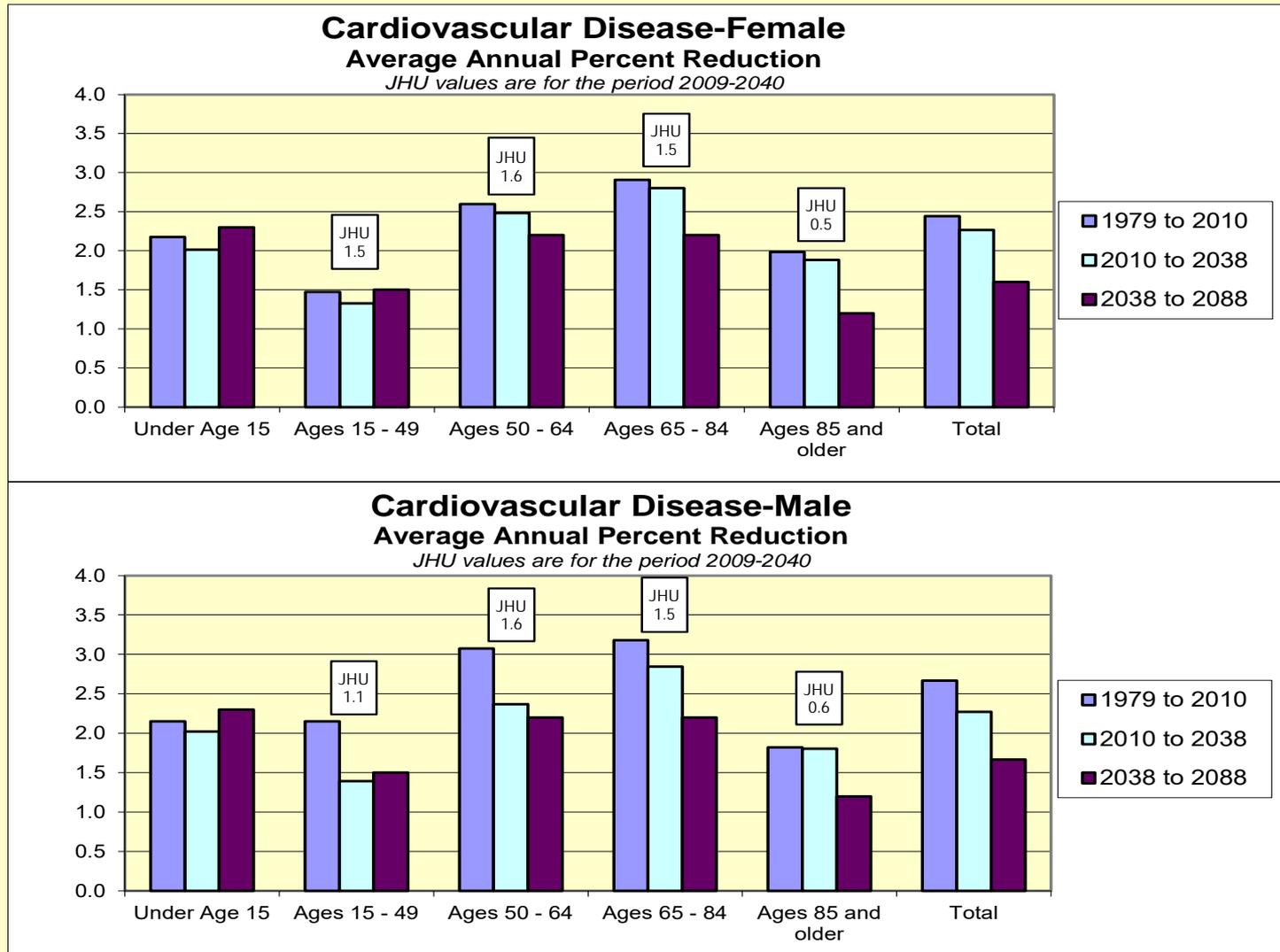
Respiratory: JHU More Optimistic Under Age 50, Less Optimistic Over Age 85

Respiratory-Female
Average Annual Percent Reduction
JHU values are for the period 2009-2040

JHU 1.7 | JHU 0.8 | JHU 0.5 | JHU 0.1

Legend: 1979 to 2010 | 2010 to 2038 | 2038 to 2088

Categories: Under Age 15 | Ages 15 - 49 | Ages 50 - 64 | Ages 65 - 84 | Ages 85 and older | Total

Respiratory-Male
Average Annual Percent Reduction
JHU values are for the period 2009-2040

JHU 1.5 | JHU 0.8 | JHU 0.4 | JHU 0.4

Legend: 1979 to 2010 | 2010 to 2038 | 2038 to 2088

Categories: Under Age 15 | Ages 15 - 49 | Ages 50 - 64 | Ages 65 - 84 | Ages 85 and older | Total

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Cancer: JHU Very Similar
to Trustees' Expectations

Cancer-Female
Average Annual Percent Reduction
JHU values are for the period 2009-2040

Cancer-Male
Average Annual Percent Reduction
JHU values are for the period 2009-2040
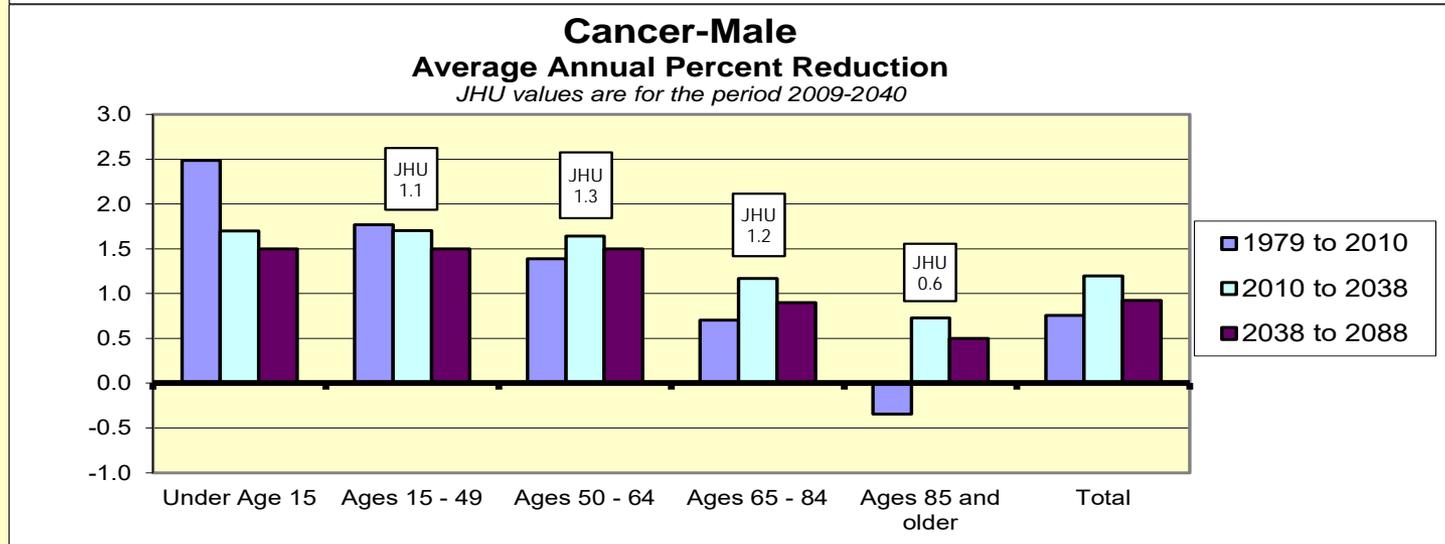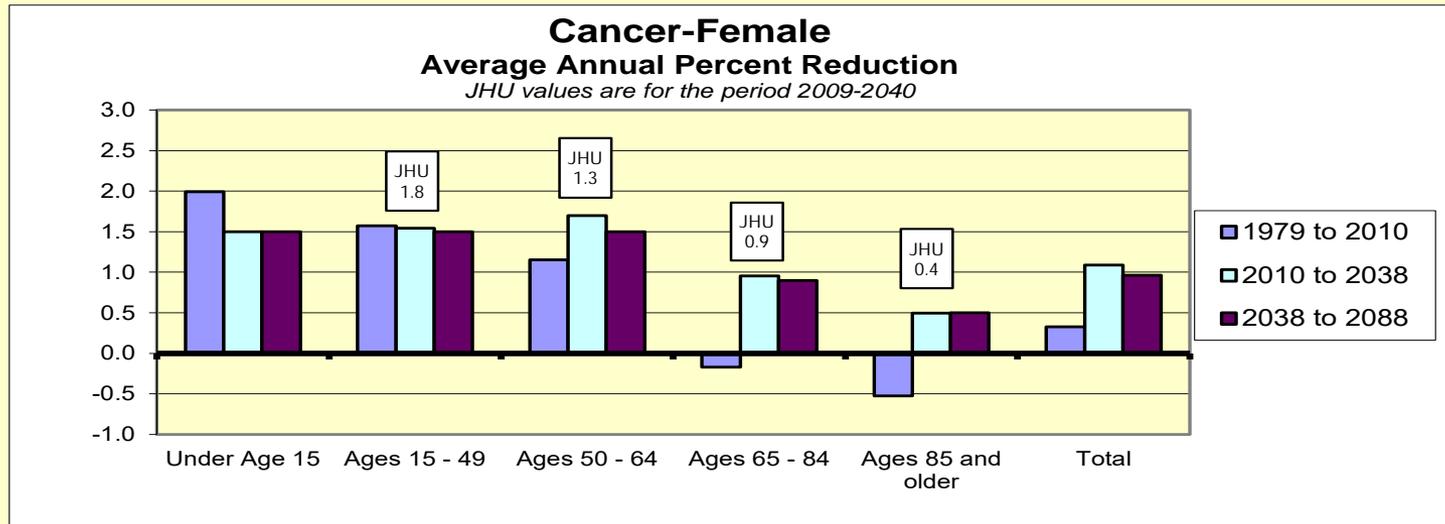
Cohort Considerations

☐ Post-World War 2 births—special conditions:

   – Antibiotics when young; statins, etc. later

☐ What does change up to age x say above age x?

   – If cohort is fundamentally healthier at x:

      Then expect lower mortality over age x

   – But if medical interventions have just reduced deaths:

      Then cohort mortality over age x could be worse, with increased numbers of impaired survivors

   – What does one cohort imply for the next cohort?

   *Further changes depend on conditions, not trend*

How Future Conditions Might Change

- ☐ Smoking decline for women
  - – Started and stopped later than men
- ☐ Obesity—sedentary lifestyle
- ☐ Health spending—must decelerate
  - – Advances help only if they apply to all
- ☐ Human limits
  - – Increasing understanding of deceleration

Trends in Obesity: US 1971-2006
*Sam Preston 2010—must consider **cumulative** effects*
Increasing duration of obesity for aged in future
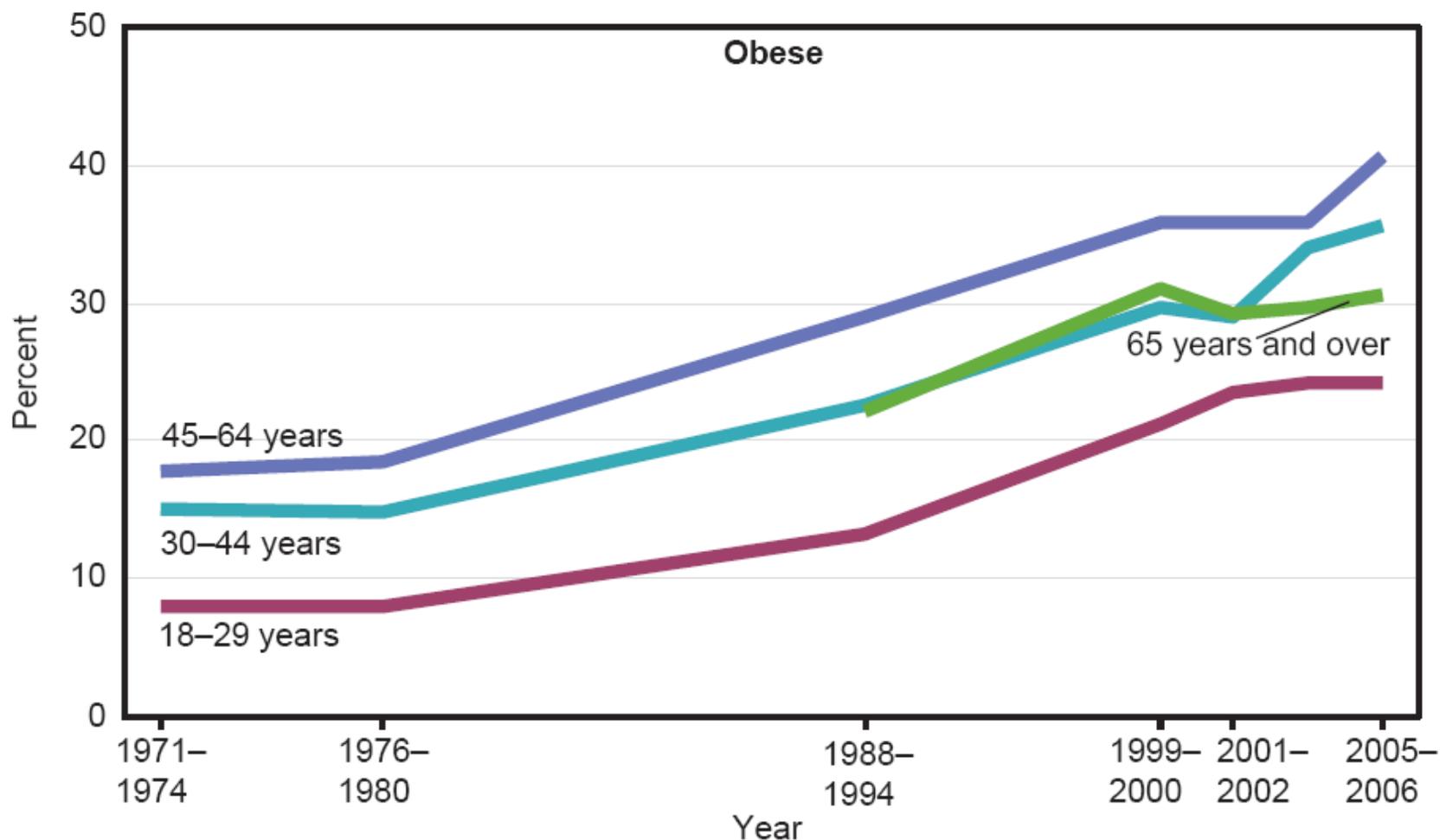
Does Health Spending Affect Mortality?

*Note rise, at least through 2009*

National Health Expenditures With and Without Medicare and Medicaid as a Percent of GDP

Legend:
- NHE/GDP
- (NHE-Med&Med)/GDP
- NIPA NHE/GDP
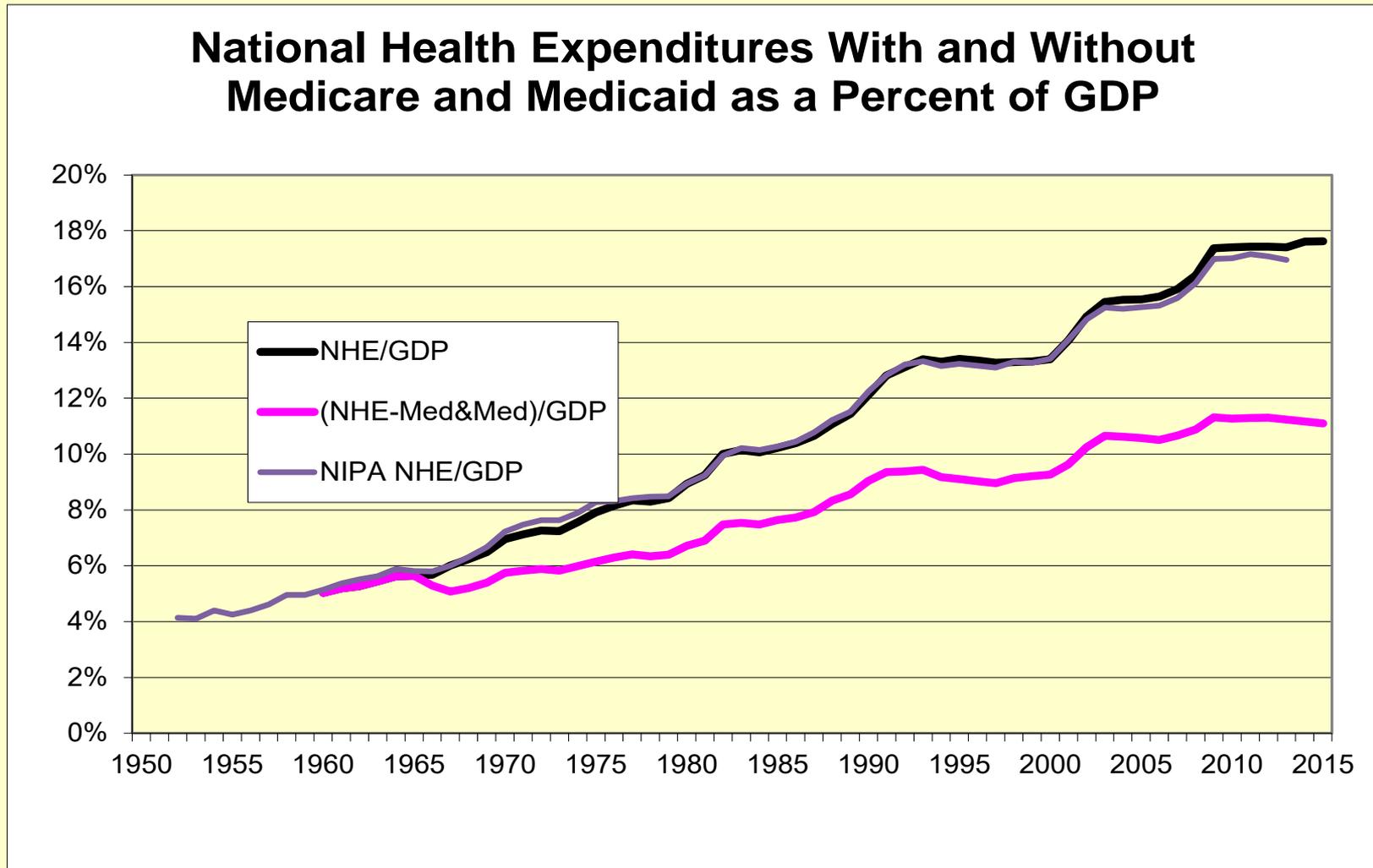
Health Spending Cannot Continue to Rise at Historical Rates
Note Trustees' deceleration

Annual Percent Change in Medicare Cost per Beneficiary Relative to GDP per Worker: 2015 TR
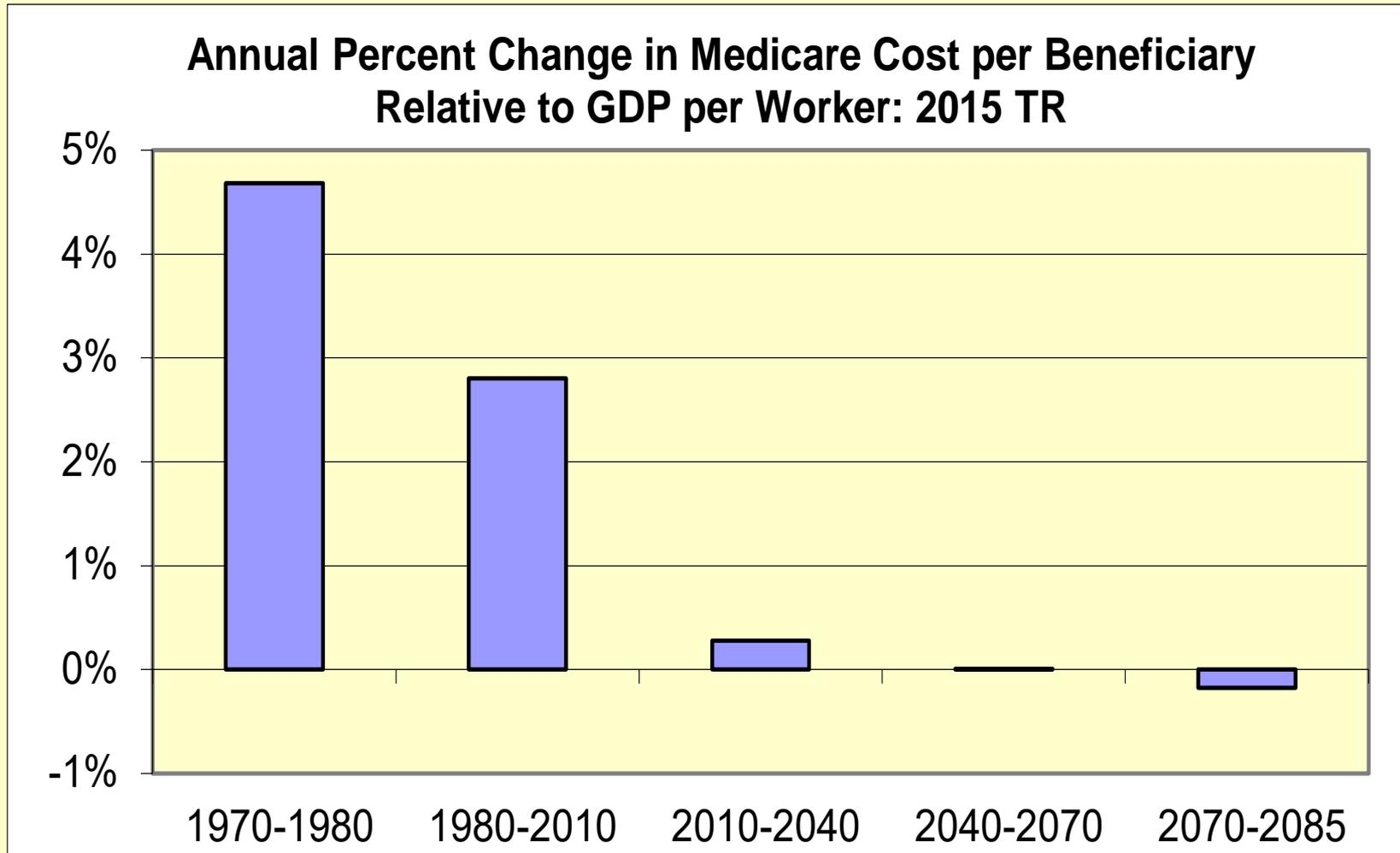
Is There an Omega?

It appears we are rectangularizing the survival curve
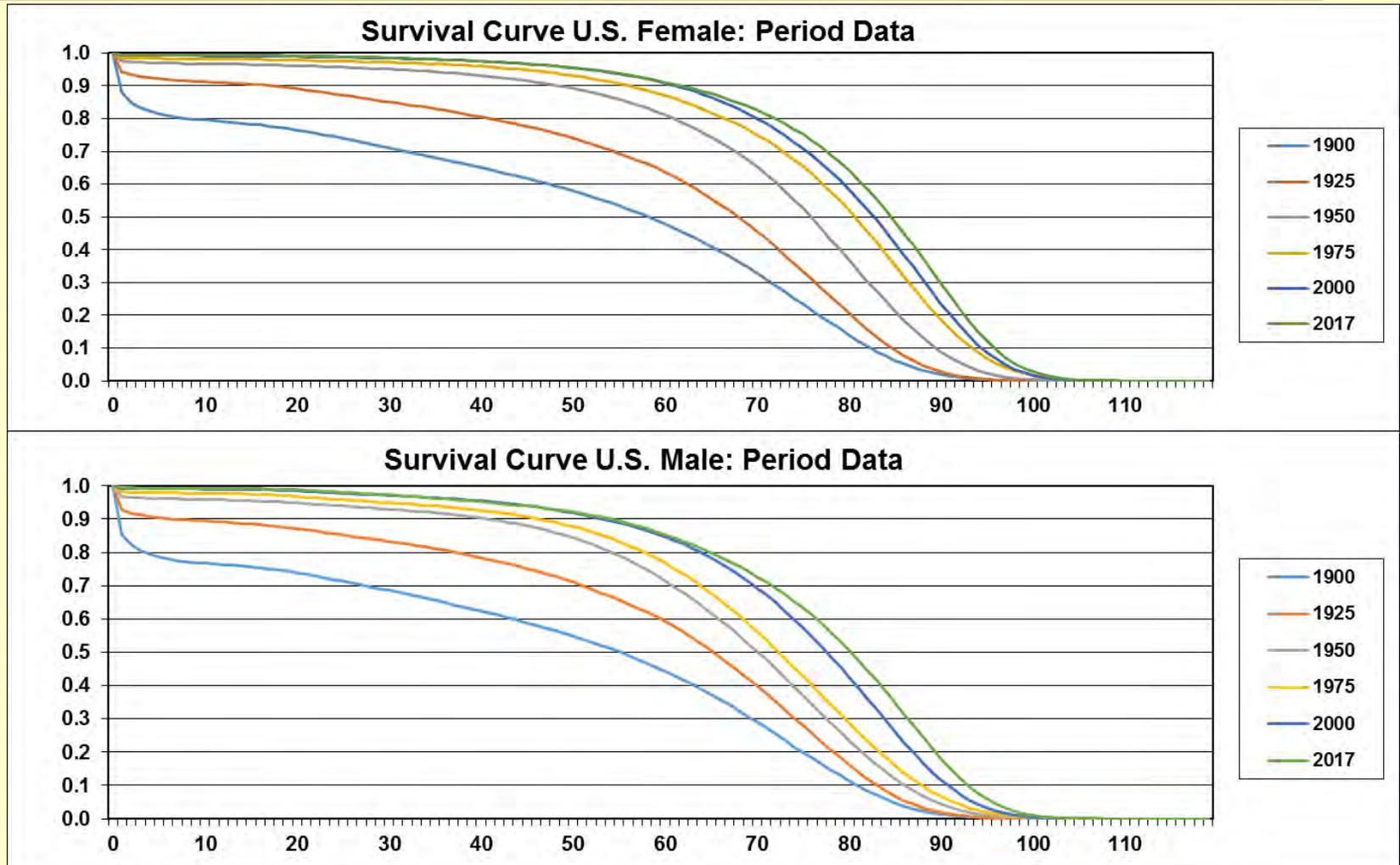
Death Rates Will Continue to Decline: But How Fast and for Whom?

- Must understand past and future conditions
  - Persistent historical "age gradient"
  - Avoid simple extrapolation of past periods
    - » Cannot ignore changing conditions
      - "Limits" on longevity due to physiology
      - Latter half of 20th century was extraordinary
    - » So deceleration seems likely
    - » Cause-specific rates allow basis for assumptions
  - Results: in the 1982 TR, we projected LE65 for 2013 to be 19.0; actual was 19.1

Ultimate (2043 to 2093) Projected Rates of Decline: Similar to Period Since 1900 for Age 50+


Historical and Projected Age-Sex-Adjusted Decline in U.S. Death Rates
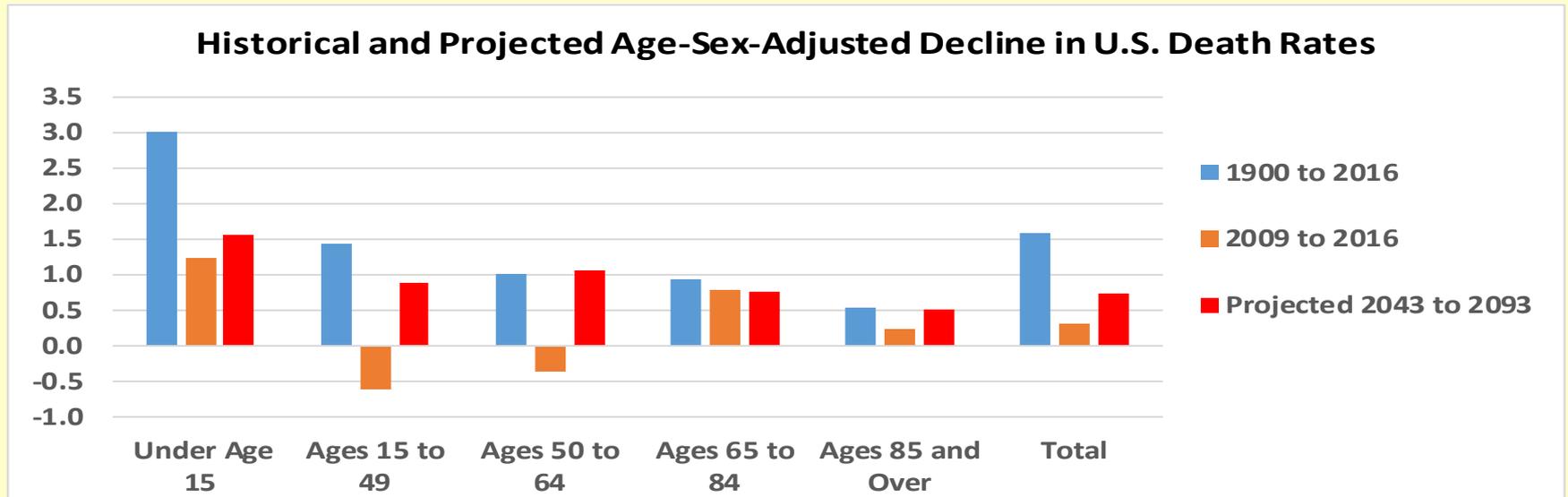
Historical and Projected Age-Sex-Adjusted Decline in U.S. Death Rates

	1900 to 2016	2009 to 2016	Projected 2043 to 2093
Under Age 15	3.01	1.23	1.55
Ages 15 to 49	1.44	-0.60	0.89
Ages 50 to 64	1.02	-0.35	1.06
Ages 65 to 84	0.95	0.79	0.76
Ages 85 and Over	0.55	0.24	0.51
Total	1.58	0.31	0.73

Intermediate projections in the 2019 Trustees Report

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Projected Age-Sex-Adjusted Death Rates, All Ages

Total Age-Sex-Adjusted Death Rates for Alternative II of the 2019 TR
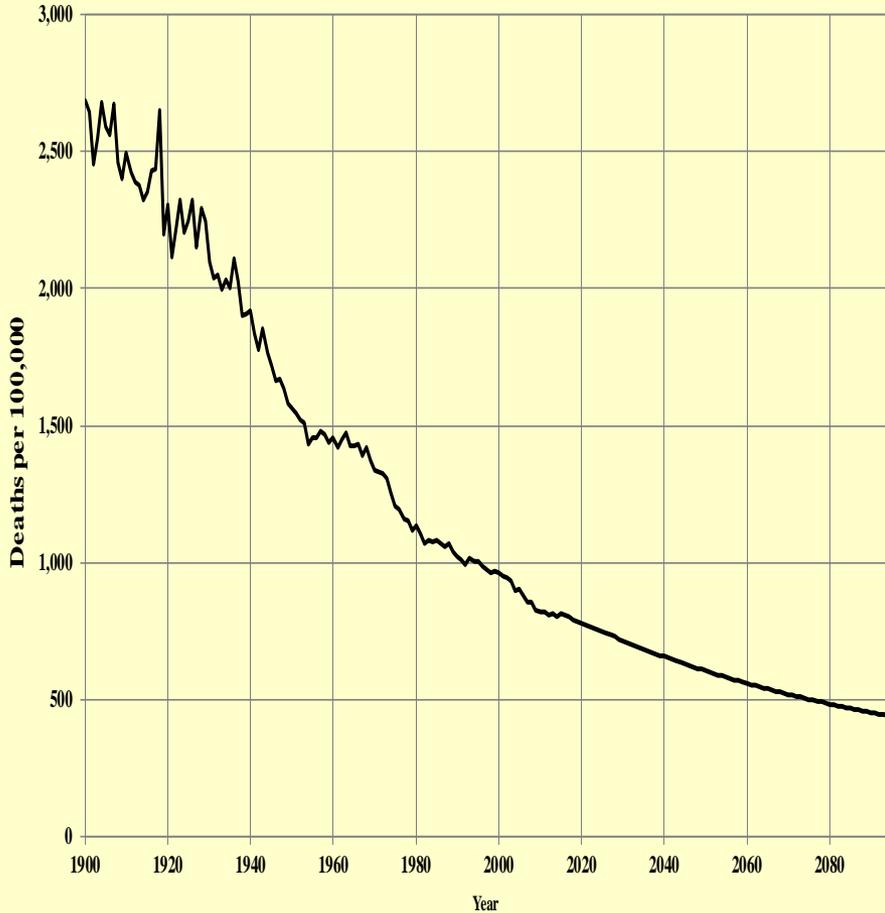
Total Age-Sex-Adjusted Death Rates for Alternative II of the 2019 TR

LOG Scale
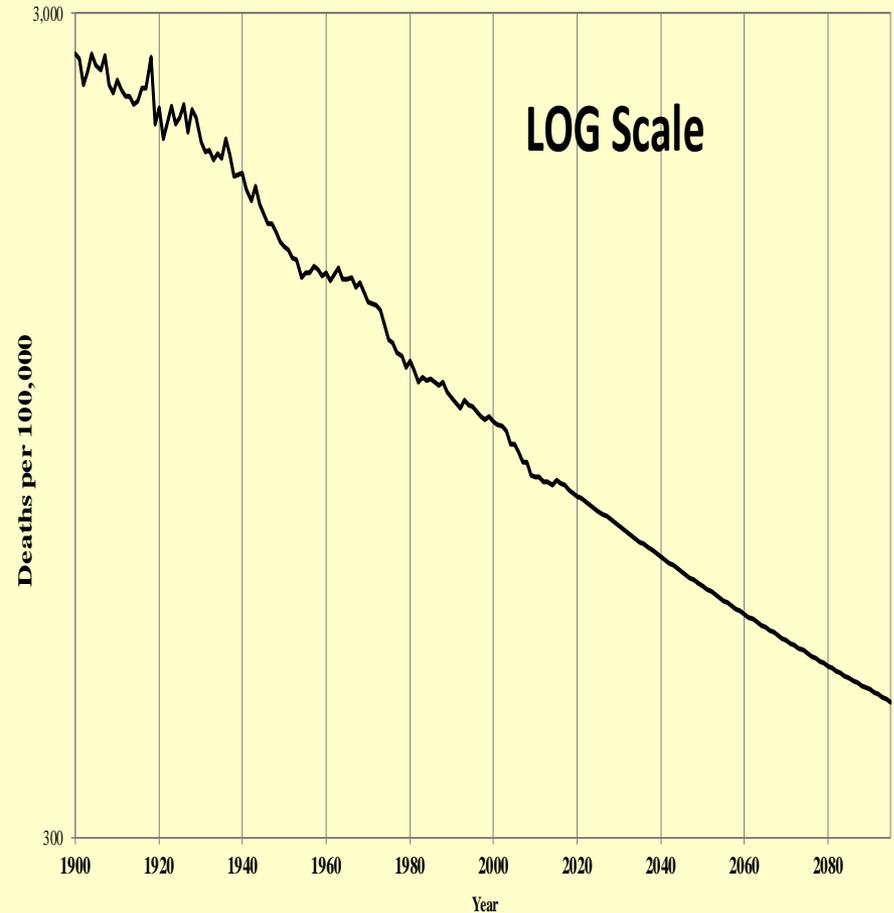
Projected Age-Sex-Adjusted Death Rates, Ages 65 and Over

Age-Adjusted Death Rates for 65 and Older Under Alternative II of the 2019 TR
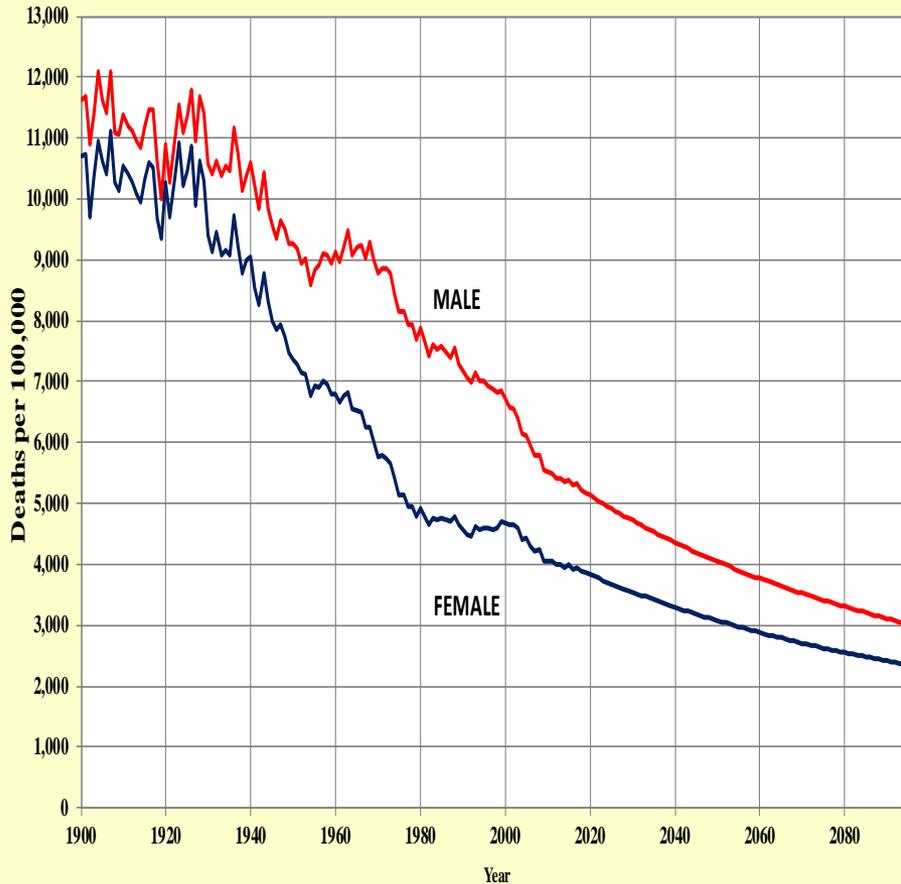
Age-Adjusted Death Rates for 65 and Older Under Alternative II of the 2019 TR
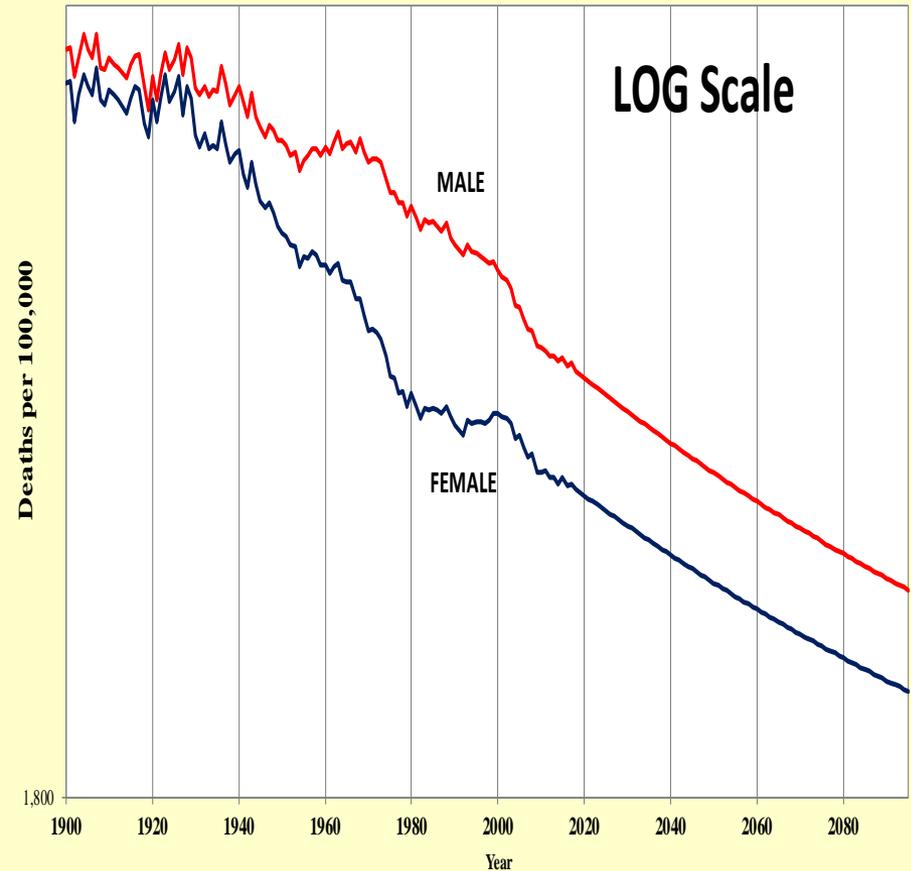
Ultimately, the Changing Age Distribution of the Population is the Main Factor for Social Security

Age Distribution of the Population Age 25+, 1940 to 2100 (2019 TR)
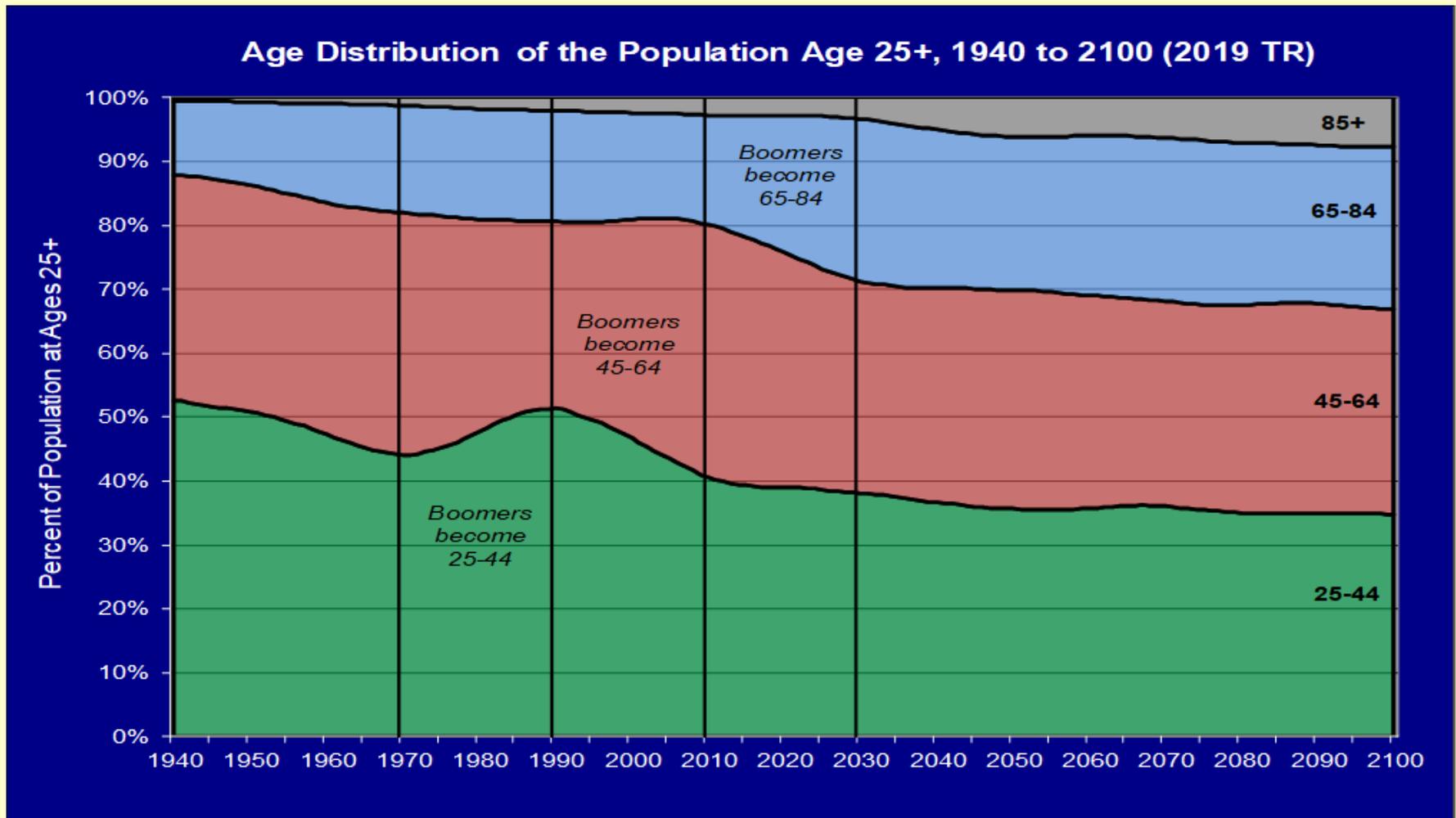
For More Information…
http://www.ssa.gov/oact/

- Documentation of Trustees Report data & assumptions
https://www.ssa.gov/oact/TR/2019/2019_Long-Range_Demographic_Assumptions.pdf

- Historical and projected mortality rates

  https://www.ssa.gov/oact/HistEst/DeathHome.html

- Annual Trustees Reports

  https://www.ssa.gov/oact/TR/index.html