DRIVERS OF MORTALITY IMPROVEMENT: SOA RESEARCH SPOTLIGHT

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JOURNEY TO PUBLICATION

TIMELINE

Initiation

COVID pause

Relaunch

Initial results approved for release

Publication

2020

2021

2022

June 2019 – Pre-research on data spanning 1980-2011

January 2020 – Project initiation with goal to extend depth of analysis and time period

March 2020 – All SOA research paused

January 2021 – Project starts up again

2021 – Significant US Census modeling, data, and privacy challenges

January 2022 – US Census approves first batch of regression results for public release (many more to come throughout 2022)

October 2022 – Report and accompanying Excel file with parameters published

Mortality and Longevity

Diversity, Equity and Inclusion

Mortality Improvement Trends
SEPTEMBER | 2022

SOA Research INSTITUTE

THESIS: THE LONGEVITY GAP ACROSS SOCIOECONOMIC VARIABLES IS GROWING BUT QUESTIONS REMAIN

1. How does mortality improvement differ across socioeconomic variables?

2. Are these differences changing over time?

3. What are the drivers (i.e., causes of death) for these differences?

4. Are the patterns likely to continue in the future?

Expected explanatory power	Explanatory variables
High	Attained age
	Gender
	Smoker status
	Calendar year regime
	Household income (deciles)
	Education (5 groups)
	Race/Ethnicity (4 groups)
	Employment status
	Marital status
Low	Occupation (5 groups)

DATA: GENERAL US POPULATION SURVEY-BASED DATA MATCHED WITH DEATH CERTIFICATE INFORMATION

	NLMS[1]	MDAC[2]
Time span of interviews	1980-2011	2008
Maximum follow-up time	11 years from interview	Less than 11 after interview
Time span of mortality data from NCHS	1980-2011	2008-2015
Records	1.26 million	2.28 million
Deaths	193,000	296,000
Person-years of exposure	30 million p-y	35 million p-y
Person Information	Current Population Survey	American Community Survey
Death Information	National Center for Health Statistics	National Center for Health Statistics

> Total observation period = 1980-2015 (No COVID-19 experience)

> Total deaths = 489,000

1. National Longitudinal Mortality Study (NLMS) - https://www.census.gov/topics/research/nlms.html
2. Mortality Disparities in American Communities (MDAC) - https://www.census.gov/topics/research/mdac.html

APPROACH: MULTIPLE REGRESSIONS

- Grouped the data into nine cohorts by entry year into the survey
- Ran a Cox (proportional hazards) regression on each cohort for 5 causes of death
  - All-cause
  - Cancer
  - Heart disease
  - Stroke
  - Pulmonary disease
- Calculated the implied mortality from the regression parameters
- Calculated the mortality improvement between periods

Variables and parameters are linear within the exponential. This allows us to have a baseline set of variables and then change one variable and measure the delta associated with that variable while controlling for other variables.

$$h(t;\ x_1, x_2, \ldots, x_p) = h_0(t) * e^{(B_1 x_1 + B_2 x_2 + \ldots + B_p x_p)}$$

$x_i =$ indicates the presence of an explanatory variable

$h_0(t) =$ basline hazard rate (all $x_i = 0$)

$$q(x_1, x_2, \ldots, x_p) = q(means) * \frac{h(t; means)}{h(t; x_1, x_2, \ldots, x_p)}$$

41 regressions with 50 parameters each

# ANNUALIZED MORTALITY IMPROVEMENT DIFFERENTIALS 1980 TO 2015
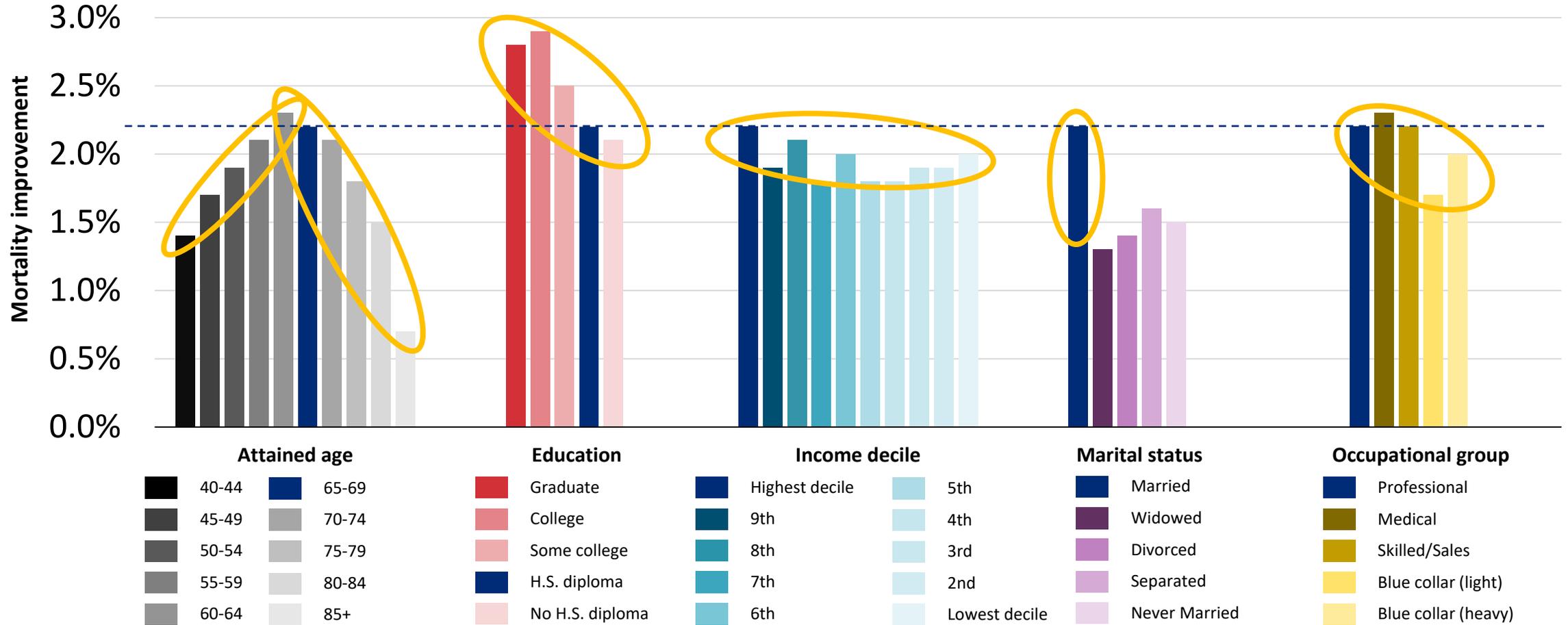
# BASELINE RESULTS FOR ALL-CAUSE, CANCER, HEART DISEASE, PULMONARY DISEASE, AND STROKE
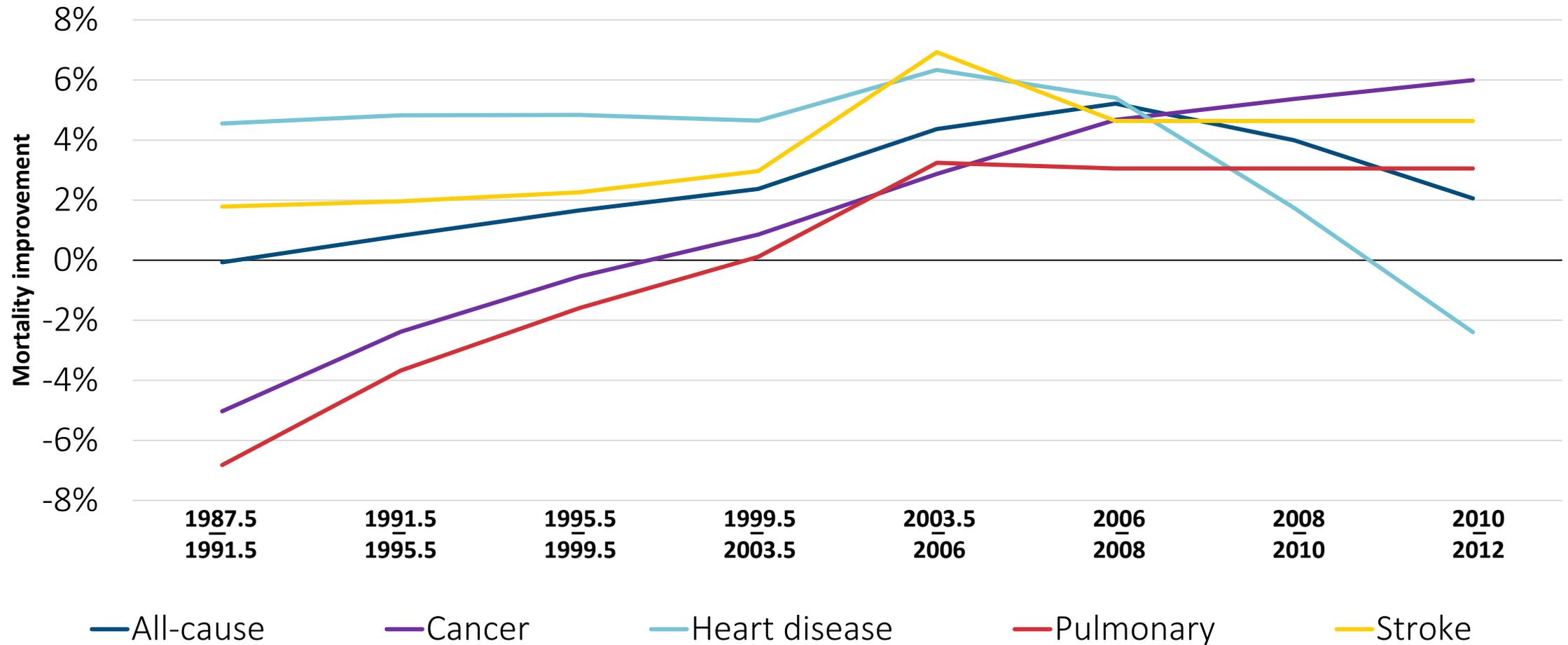
ATTAINED AGE RESULTS – ALL-CAUSE
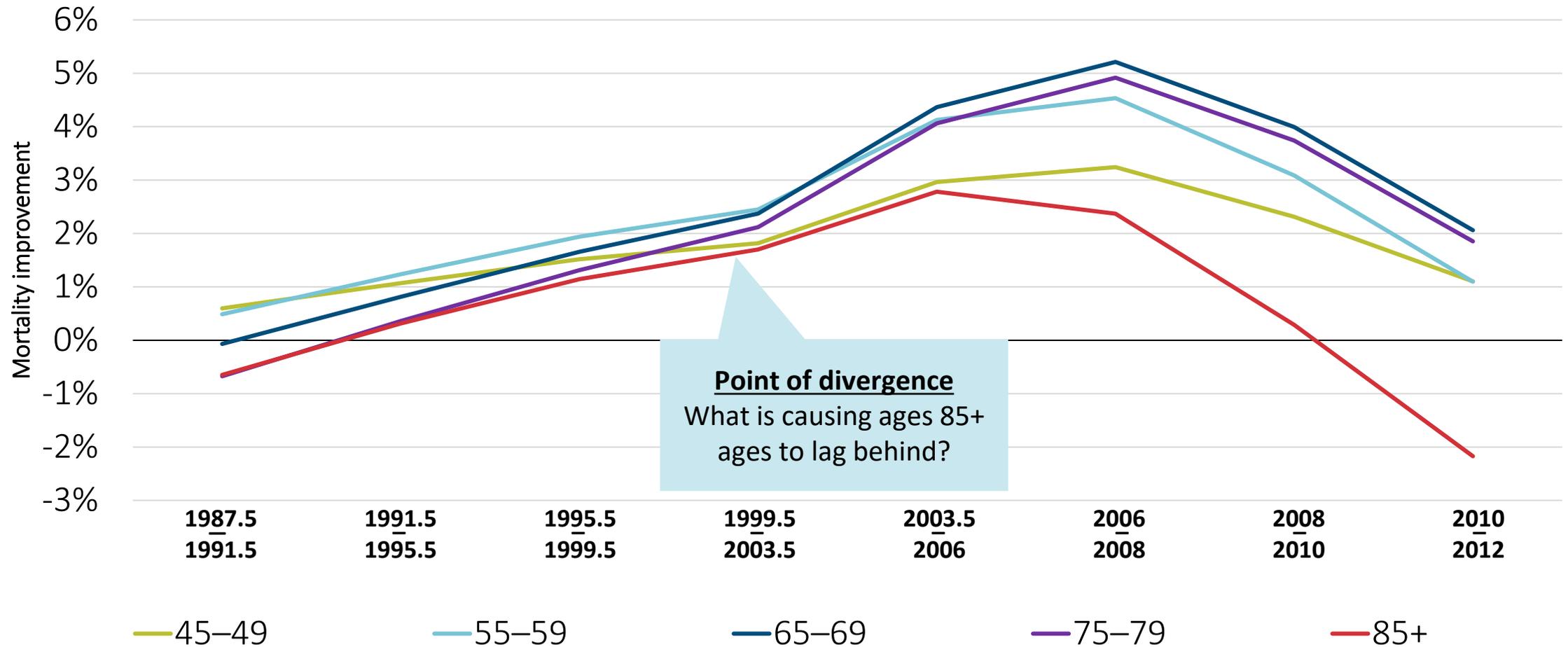
ATTAINED AGE RESULTS – CANCER

Older ages are experiencing lower cancer-related mortality improvement in recent periods

Legend: 45-49 | 55-59 | 65-69 | 75-79 | 85+
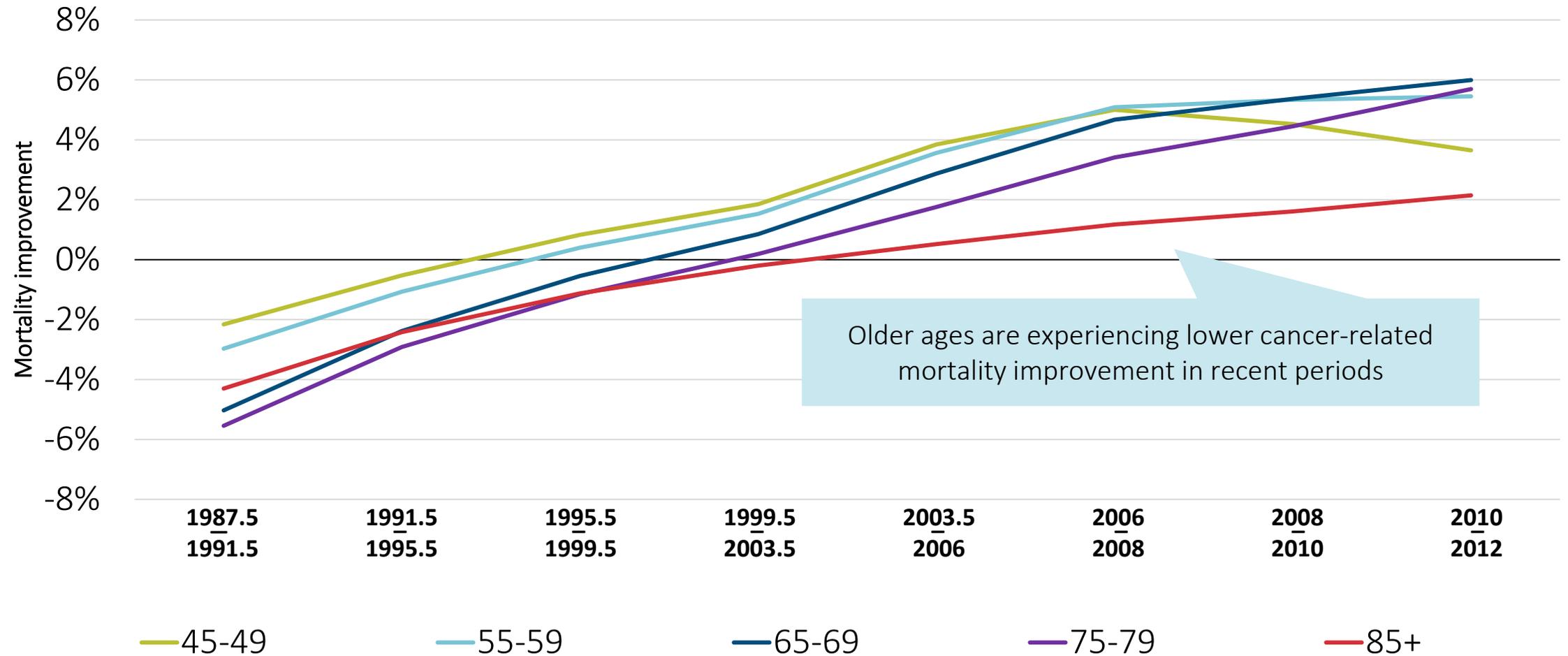
ATTAINED AGE RESULTS – PULMONARY

Extreme deterioration early in the study period

Convergence to other age groups in more recent periods likely as a result of smoking cessation

Legend: 45-49, 55-59, 65-69, 75-79, 85+
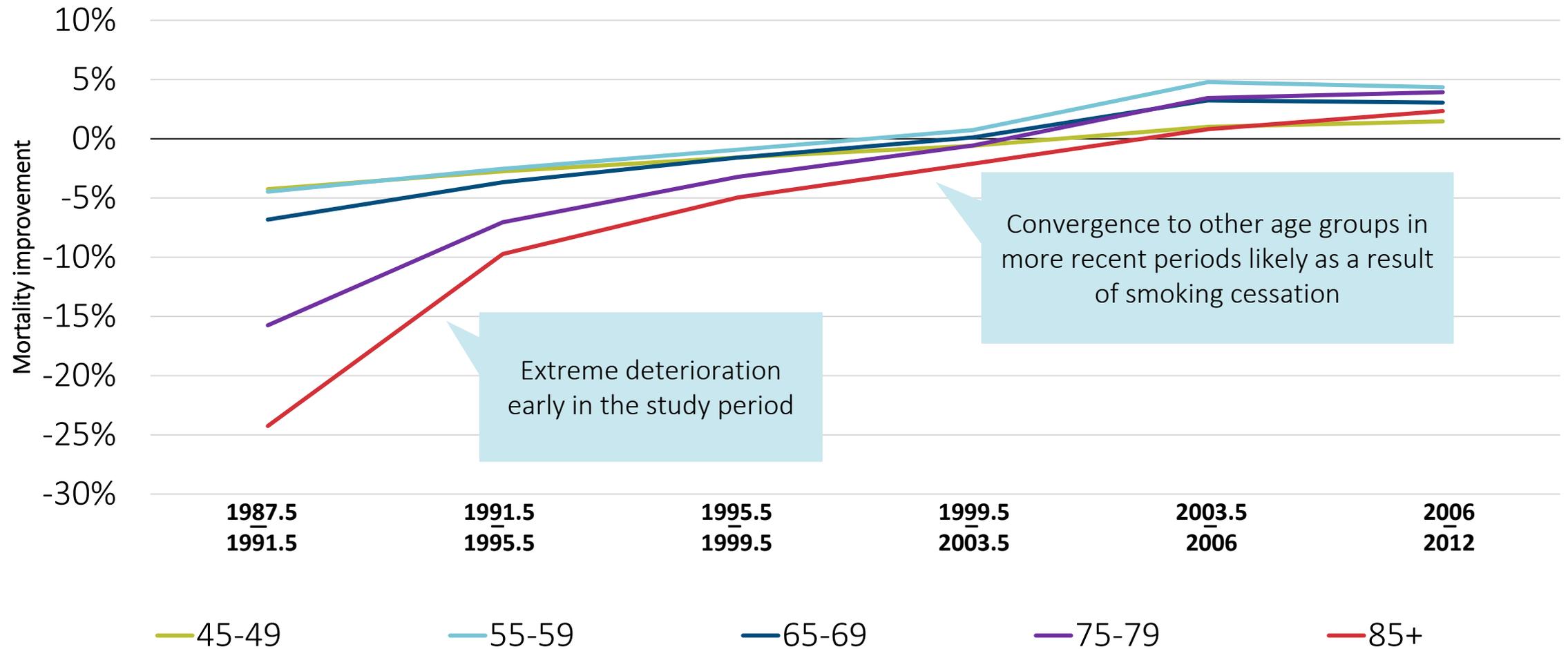
EDUCATIONAL ATTAINMENT RESULTS – ALL-CAUSE

Point of divergence
Why are those with a college education experiencing greater improvement after this point?
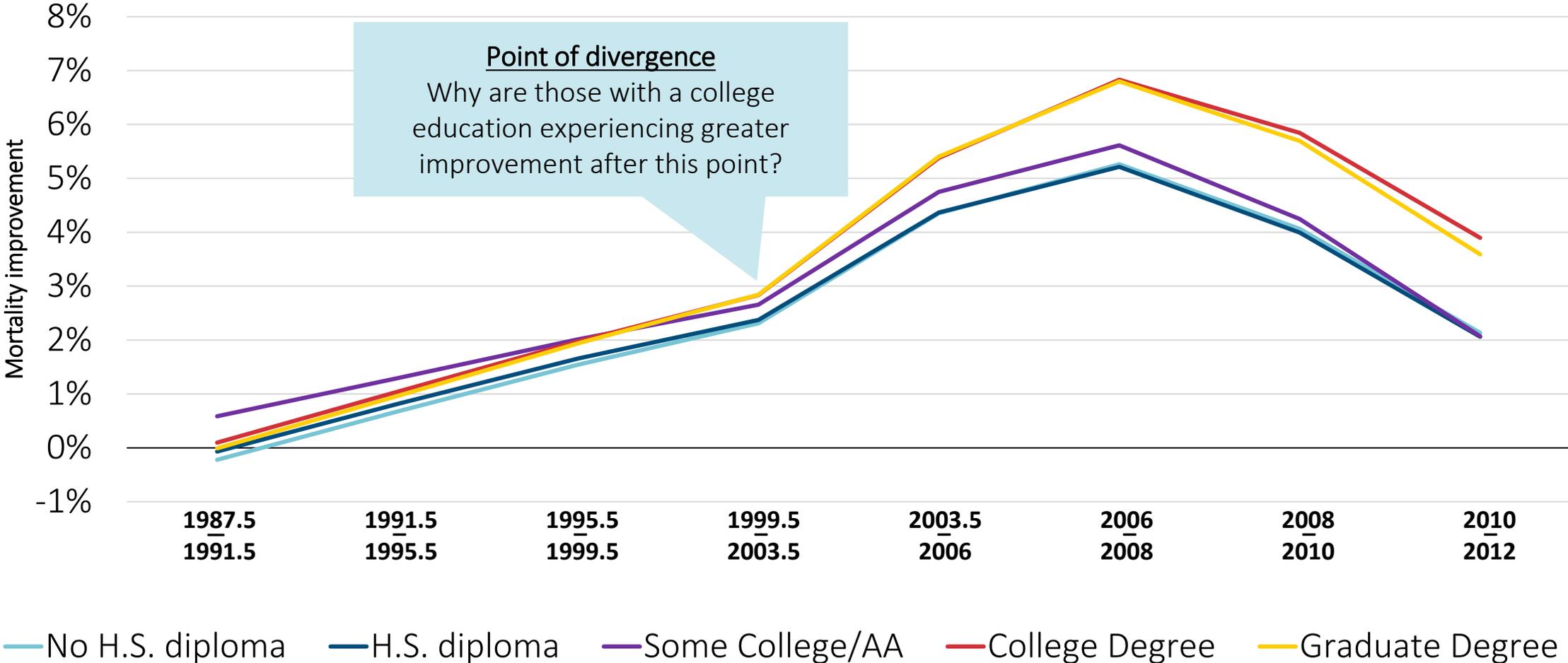
EDUCATIONAL ATTAINMENT RESULTS – HEART
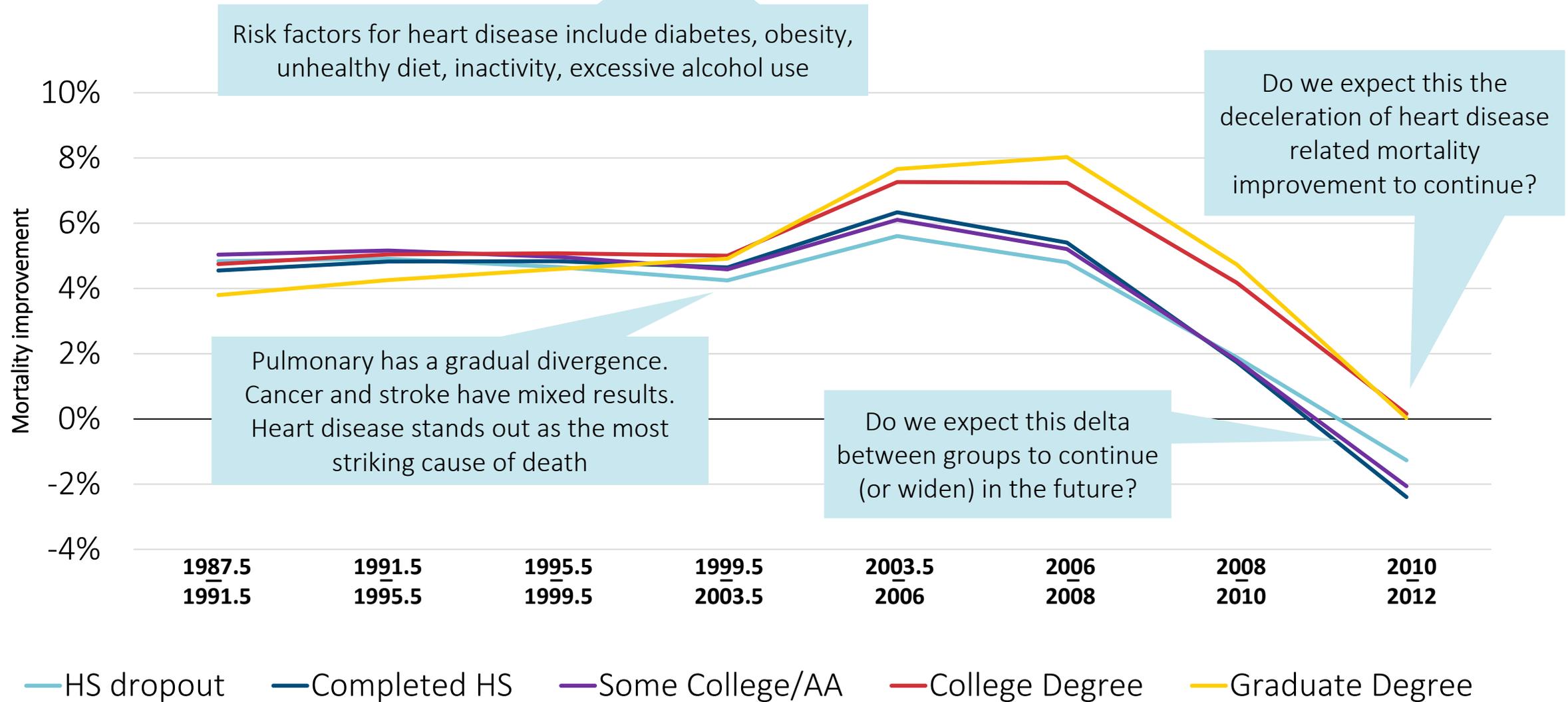
INCOME DECILE RESULTS – ALL-CAUSE

Point of divergence
Why are lower income groups decelerating so much more rapidly than other groups?
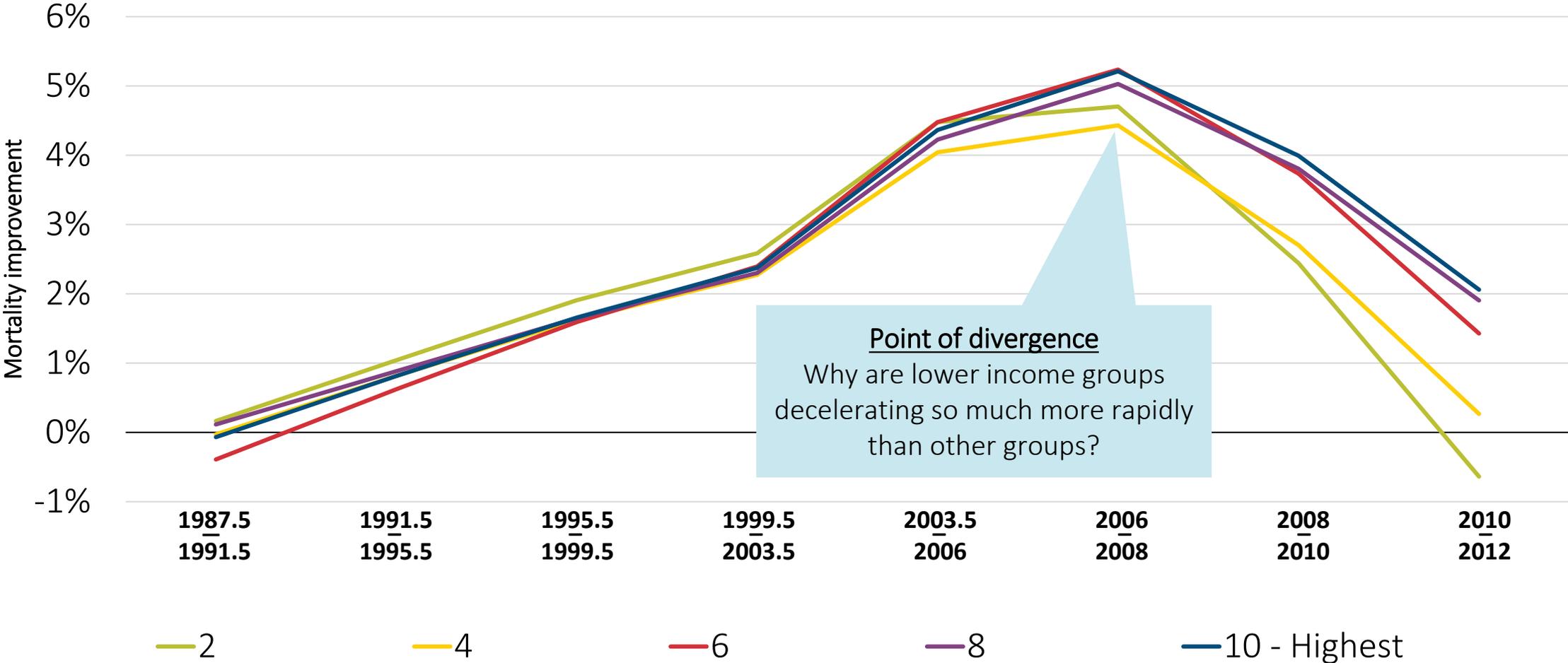
INCOME DECILE RESULTS – PULMONARY

Mortality improvement

Lower income groups experienced very steady/flat improvement patterns, while upper income groups experienced rapid acceleration

Legend: 2 · 4 · 6 · 8 · 10 - Highest
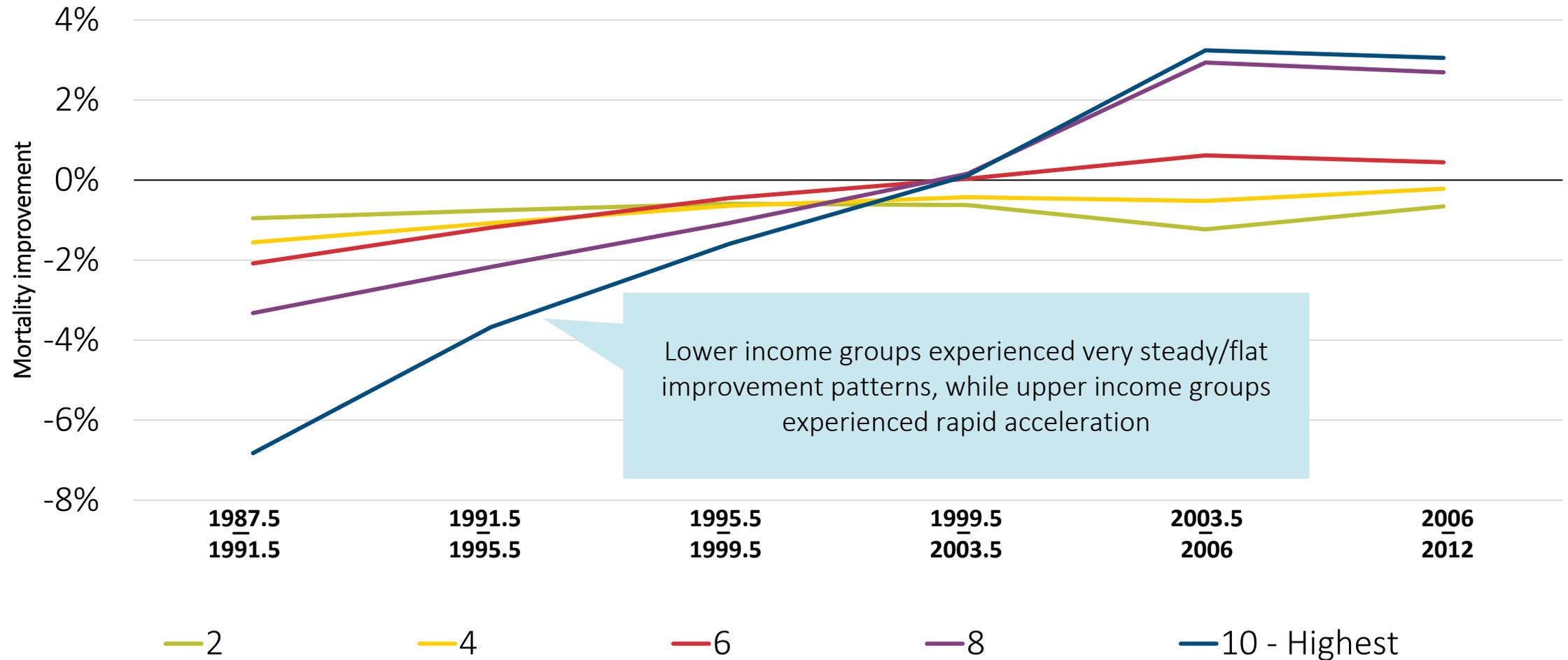
MARITAL STATUS RESULTS – ALL-CAUSE
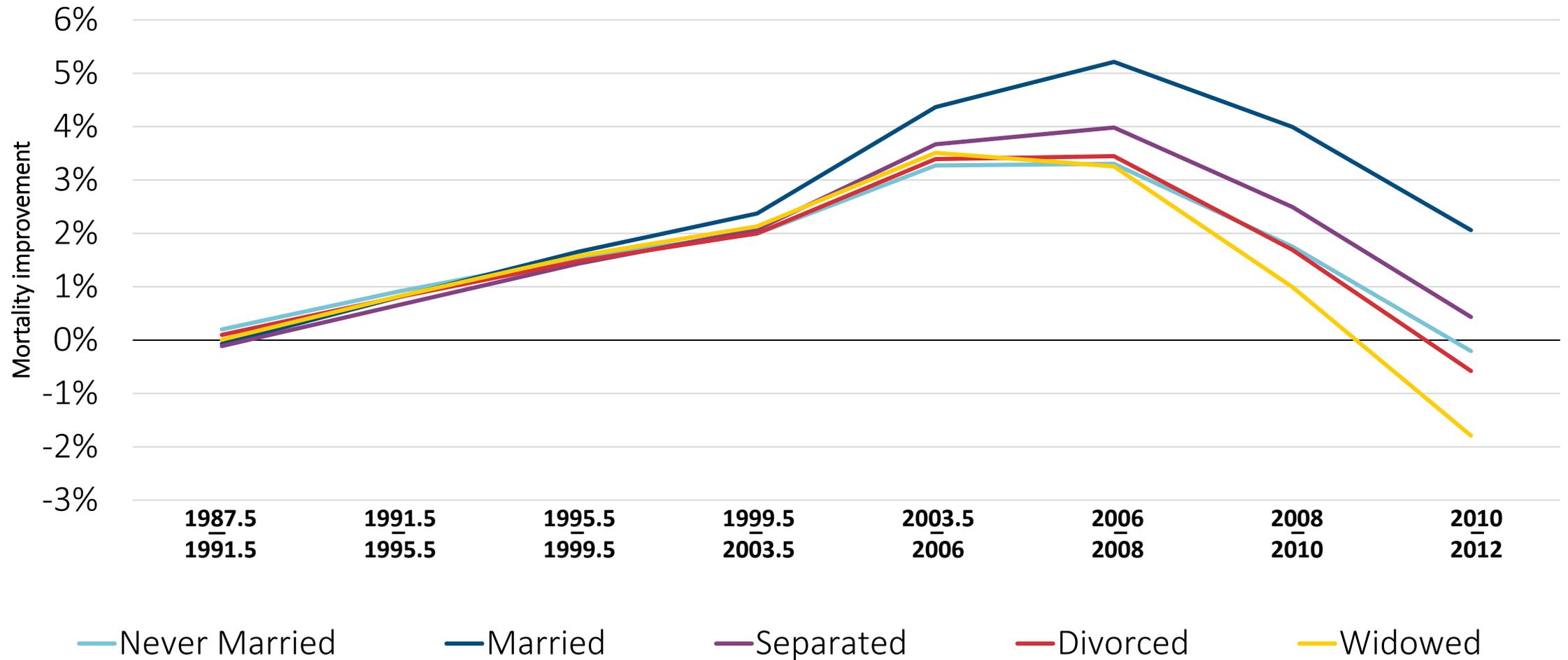
OCCUPATION RESULTS – ALL-CAUSE

Although the professional group has the highest improvement, the pattern is not an intuitive gradient across occupation groups

Mortality improvement

Legend:
- Professional
- Skilled/sales
- Medical
- Blue Collar (light physical duties)
- Blue Collar (heavy physical duties)

X-axis labels:
- 1987.5 / 1991.5
- 1991.5 / 1995.5
- 1995.5 / 1999.5
- 1999.5 / 2003.5
- 2003.5 / 2006
- 2006 / 2008
- 2008 / 2010
- 2010 / 2012
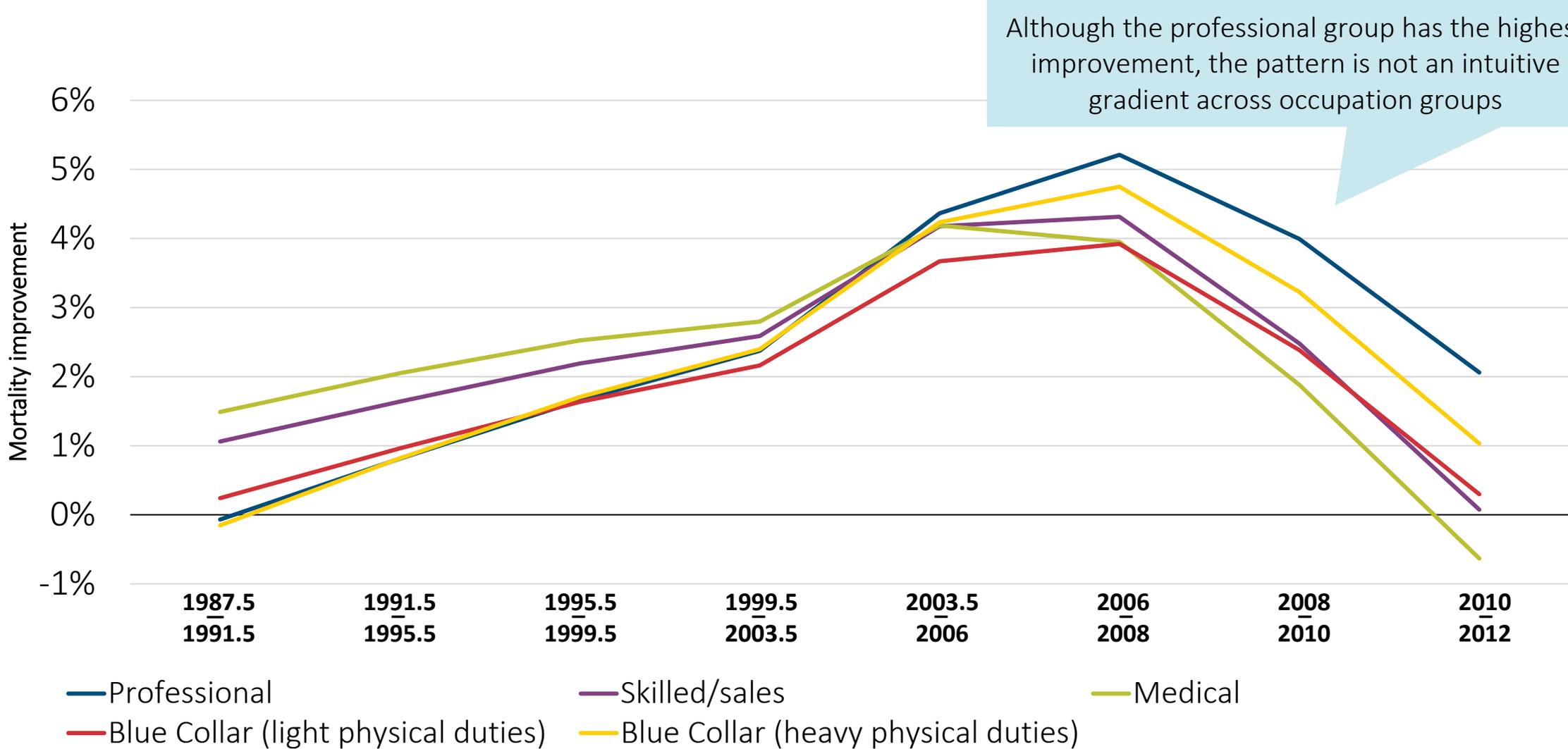
APPLICATION FOR PRACTITIONERS – ALL-CAUSE

What if we combine effects and layer them on one at a time?

Mortality improvement

HS diploma → College

Skilled/sales → Prof.

5th → 10th

HS diploma, 5th income decile, skilled/sales

FOR MORE INFORMATION:

https://www.soa.org/resources/research-reports/2022/mortality-improvement-trends/
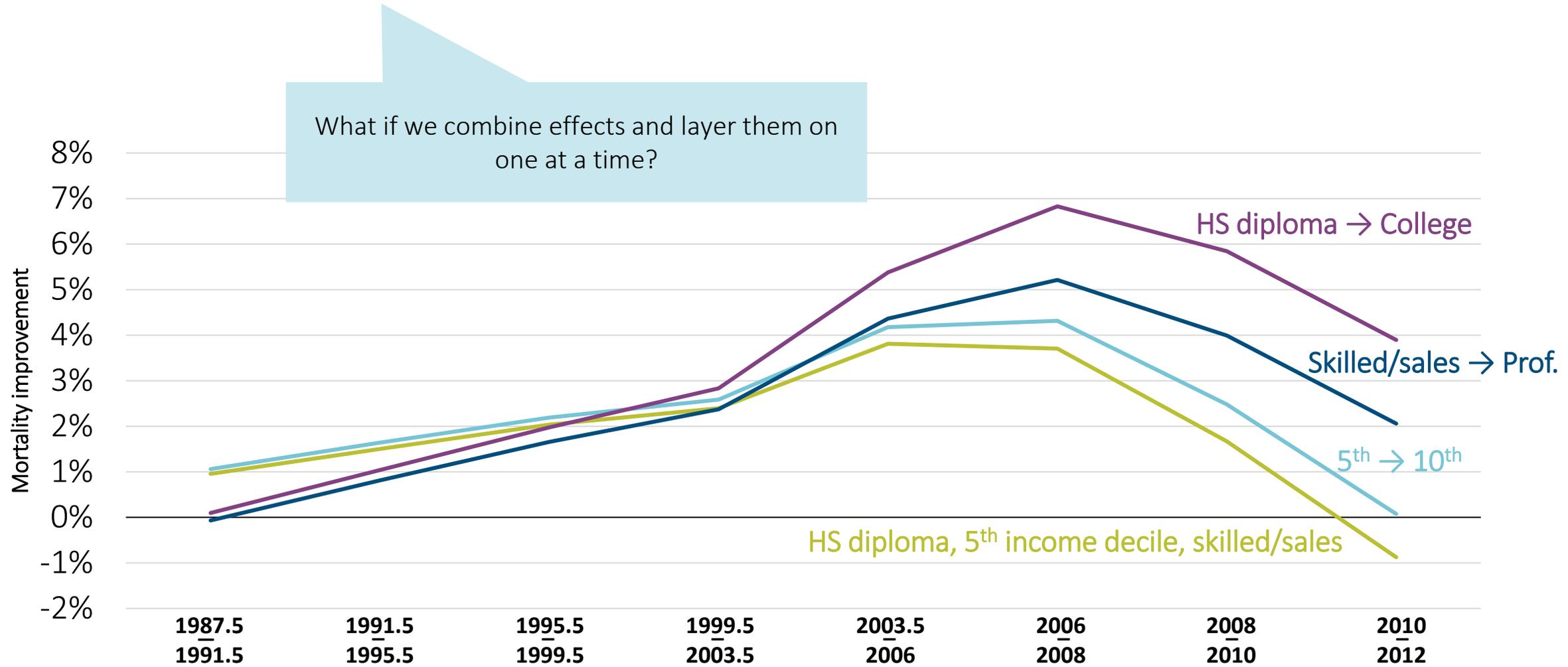
- Report

- Parameter Excel file

- Smoothing dynamic link library (.dll)

Any opinions and conclusions expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed. The statistical summaries reported in this document have been cleared by the Census Bureau's Disclosure Review Board release authorization numbers CBDRB-FY22-CES004-012, CBDRB-FY22-CES004-014, CBDRB-FY22-CES004-015, CBDRB-FY22-CES004-016, CBDRB-FY22-CES004-037, and CBDRB-FY22-CES004-038.

User input	
Sex	Male
Smoker Status	Not Asked
Income Decile	10
Education	High School diploma
Race/Ethnicity	White Non-Hispanic
Employment Status	Employed
Marital Status	Married
Occupation	Professional
Cause of Death	All cause

Users can select input values and observe the resulting improvement values based on regression results

Also included are confidence intervals, death counts, and parameters provided by the US Census

Mortality improvement								
	1987.5-1991.5	1991.5-1995.5	1995.5-1999.5	1999.5-2003.5	2003.5-2006	2006-2008	2008-2010	2010-2012
40-44	0.31%	0.86%	1.34%	1.63%	2.64%	2.87%	2.03%	1.01%
45-49	0.60%	1.07%	1.52%	1.82%	2.96%	3.24%	2.31%	1.10%
50-54	0.83%	1.44%	2.00%	2.37%	3.74%	3.71%	1.95%	-0.27%
55-59	0.49%	1.24%	1.94%	2.45%	4.13%	4.54%	3.09%	1.10%
60-64	0.58%	1.35%	2.11%	2.69%	4.59%	5.04%	3.31%	0.87%
65-69	-0.07%	0.81%	1.66%	2.37%	4.37%	5.21%	3.99%	2.06%
70-74	-0.47%	0.49%	1.38%	2.14%	4.14%	5.31%	4.69%	3.52%
75-79	-0.67%	0.36%	1.31%	2.12%	4.06%	4.92%	3.74%	1.85%
80-84	-0.97%	0.21%	1.24%	2.05%	3.87%	4.43%	2.89%	0.63%
85+	-0.65%	0.31%	1.15%	1.70%	2.78%	2.37%	0.29%	-2.17%

Q&A