# The Association Between Income and Life Expectancy in the United States, 2001-2014

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*The opinions expressed in this paper are those of the authors alone and do not necessarily reflect the views of the Internal Revenue Service, the U.S. Treasury Department, or any other agency of the Federal Government.*

# Introduction

- Well known that higher income is associated with longer life

  [e.g., Kitagawa and Hauser 1973, Pappas et al. 1993, Williams and Collins 1995, Meara et al., Olshansky et al. 2012, Waldron 2007, 2013]

- But several aspects of relationship between income and longevity remain unclear

  1. What is the shape of the income–life expectancy gradient?
  2. How are gaps in life expectancy changing over time?
  3. How do the gaps vary across local areas?
  4. What are the sources of the longevity gap?

# This Paper

- We use de-identified data from tax records covering the U.S. population from 1999-2014 to characterize income-mortality gradients
  - 1.4 billion observations → more granular analysis of relationship between income and mortality than in prior work
- Characterize life expectancy by income, over time, and across areas
  - More precise estimates at *national* level than in prior work
    - Large and growing gaps in longevity across income groups
  - New *local area* estimates by income group
    - Substantial variation in level and change in life expectancy across areas, especially for the poor

# This Paper

- We also characterize correlates of the spatial variation we document
  - But we do not identify causal mechanisms in this paper
- Focus primarily on constructing publicly available statistics
  - To facilitate future work on mechanisms and to measure progress systematically

# Outline

1. Data and Methodology
2. National Statistics on Income and Life Expectancy
3. Local Area Estimates
4. Predictors of Local Area Variation

# Part 1: Data and Methodology

# Data and Sample Definition

- Income data from de-identified 1999-2014 tax returns
- Mortality data from SSA DM-1 file
  - DM-1 death counts are closely aligned with CDC NCHS counts by year and across age distribution (less than 2% difference)

# Income Definition

- Baseline income concept: household earnings
  - For tax filers: Adjusted Gross Income minus Social Security and Disability benefits
  - For non-filers: W-2 earnings + UI benefits
- Exclude individuals with zero household income (8% of population at age 40)
  - Mortality rates for individuals with zero income measured imperfectly because deaths of non-residents are not tracked fully in SSA data
- Focus on percentile **ranks** in income distribution
  - Rank individuals in national income distribution within birth cohort, gender, and tax year

# Methodology

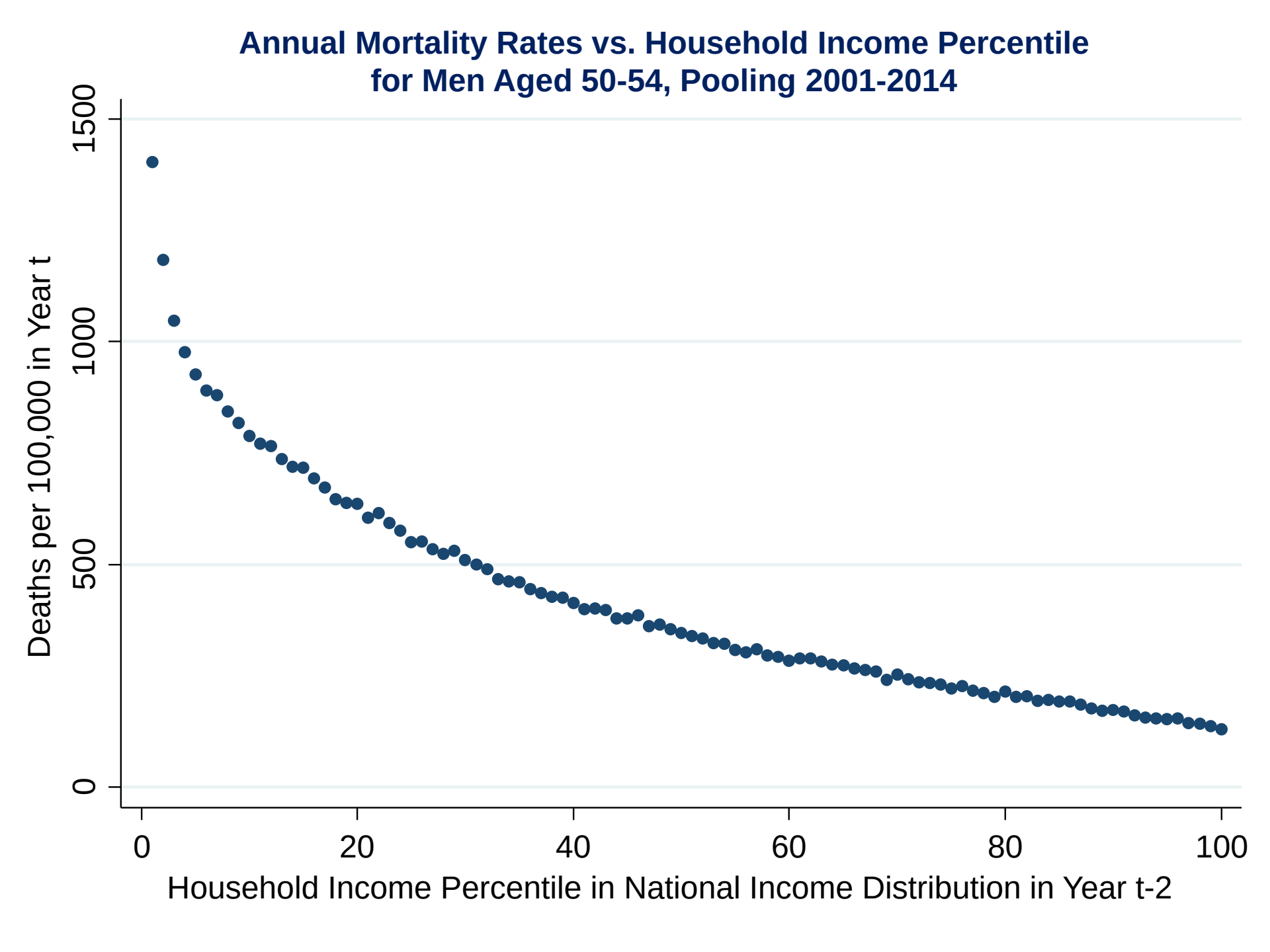
- Goal: estimate expected age of death conditional on an individual's income at age 40, controlling for differences in race and ethnicity
  - *Period* life expectancy: life expectancy for a hypothetical individual who experiences mortality rates at each age observed in a cross-section
- Straightforward to compute if one could observe mortality rates at all ages for all racial groups conditional on income at age 40
- Two missing data problems:
  1. Mortality rates conditional on income at age 40 unobserved at age > 55
  2. Race and ethnicity not observed in tax data

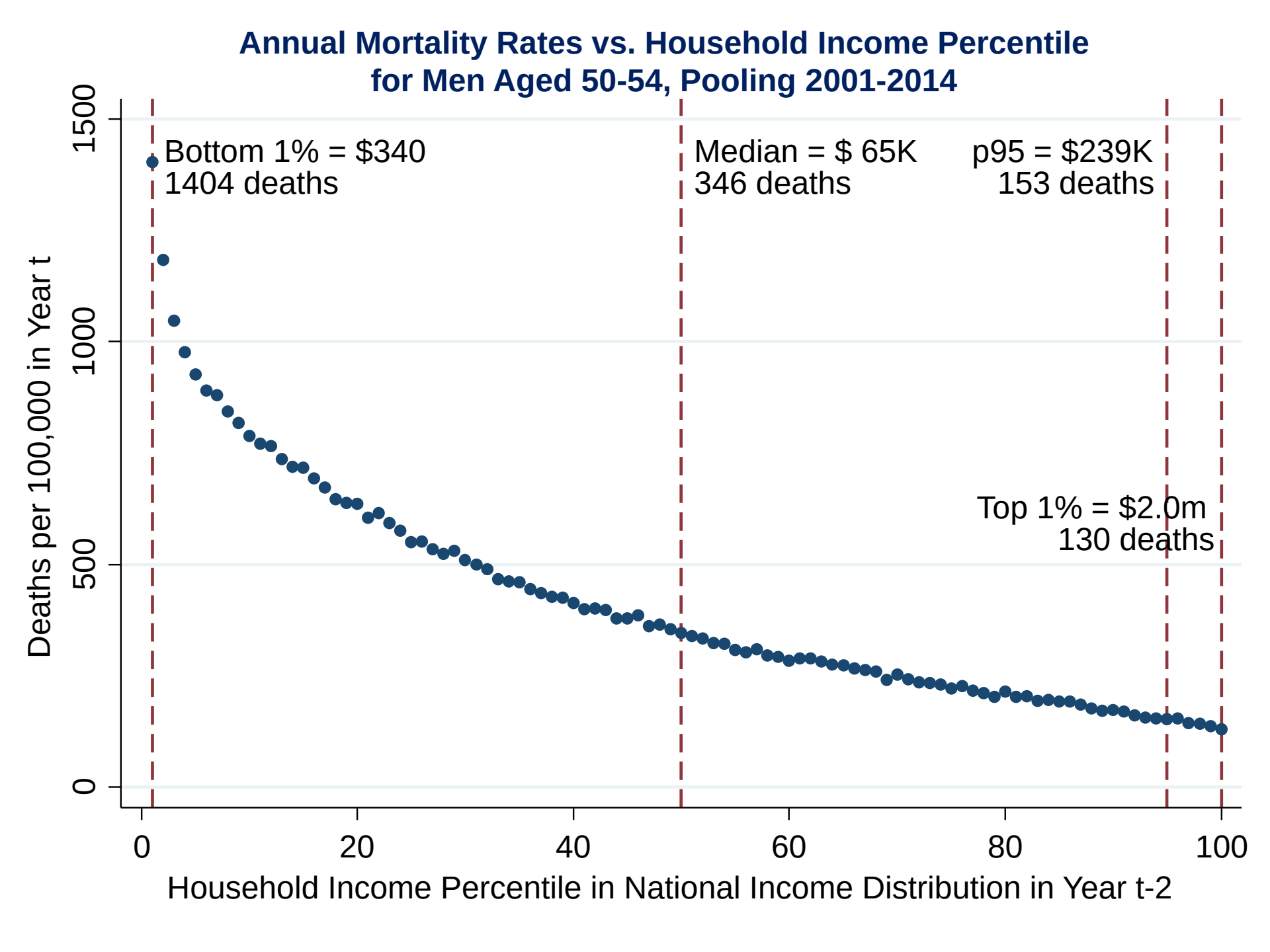
# Methodology

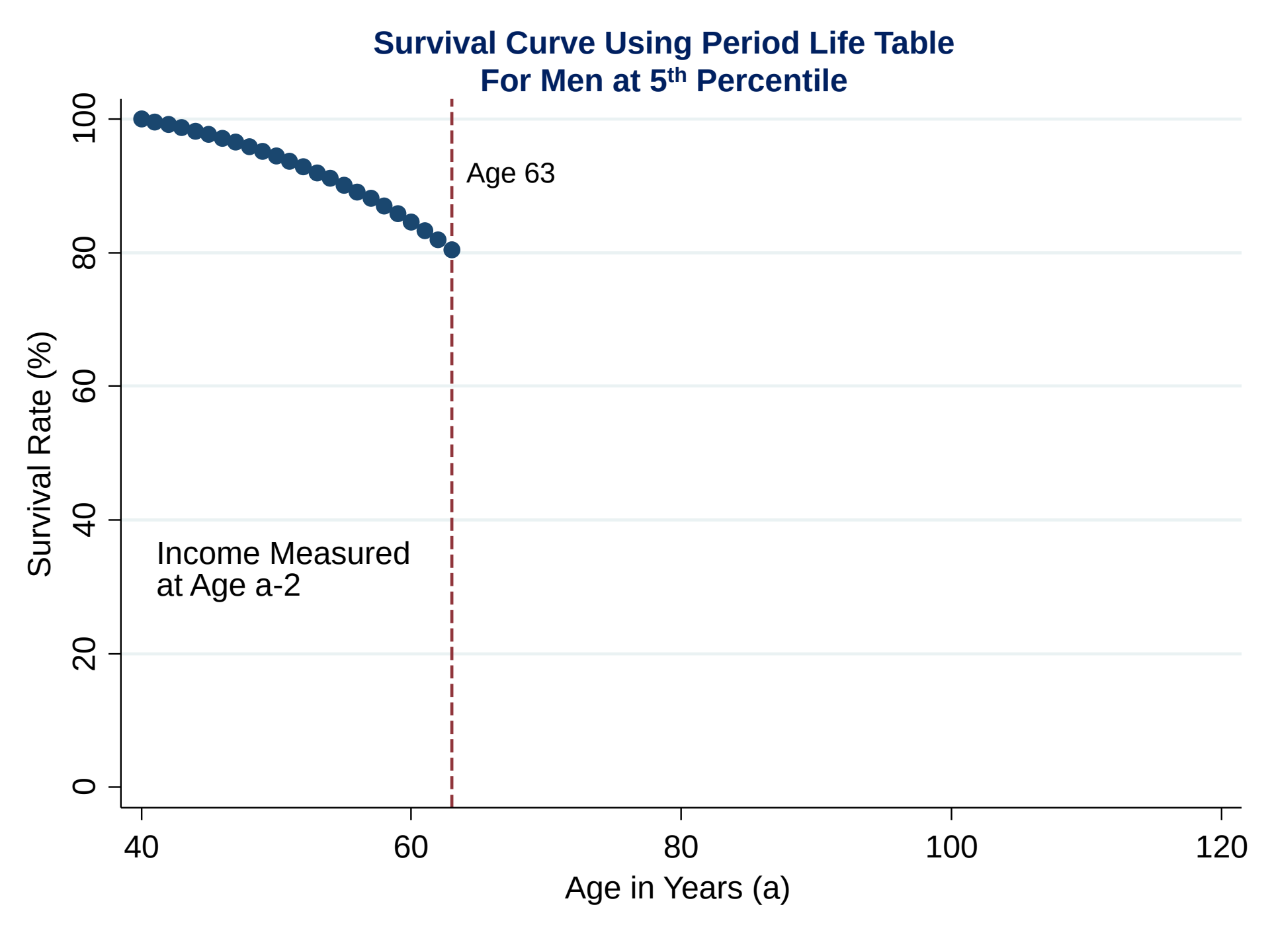
- Three steps to estimate life expectancy by income group:
  1. Calculate mortality rates by income rank and age for available ages
  2. Use age profile of mortality rates to estimate Gompertz models
  3. Adjust for racial differences in mortality rates

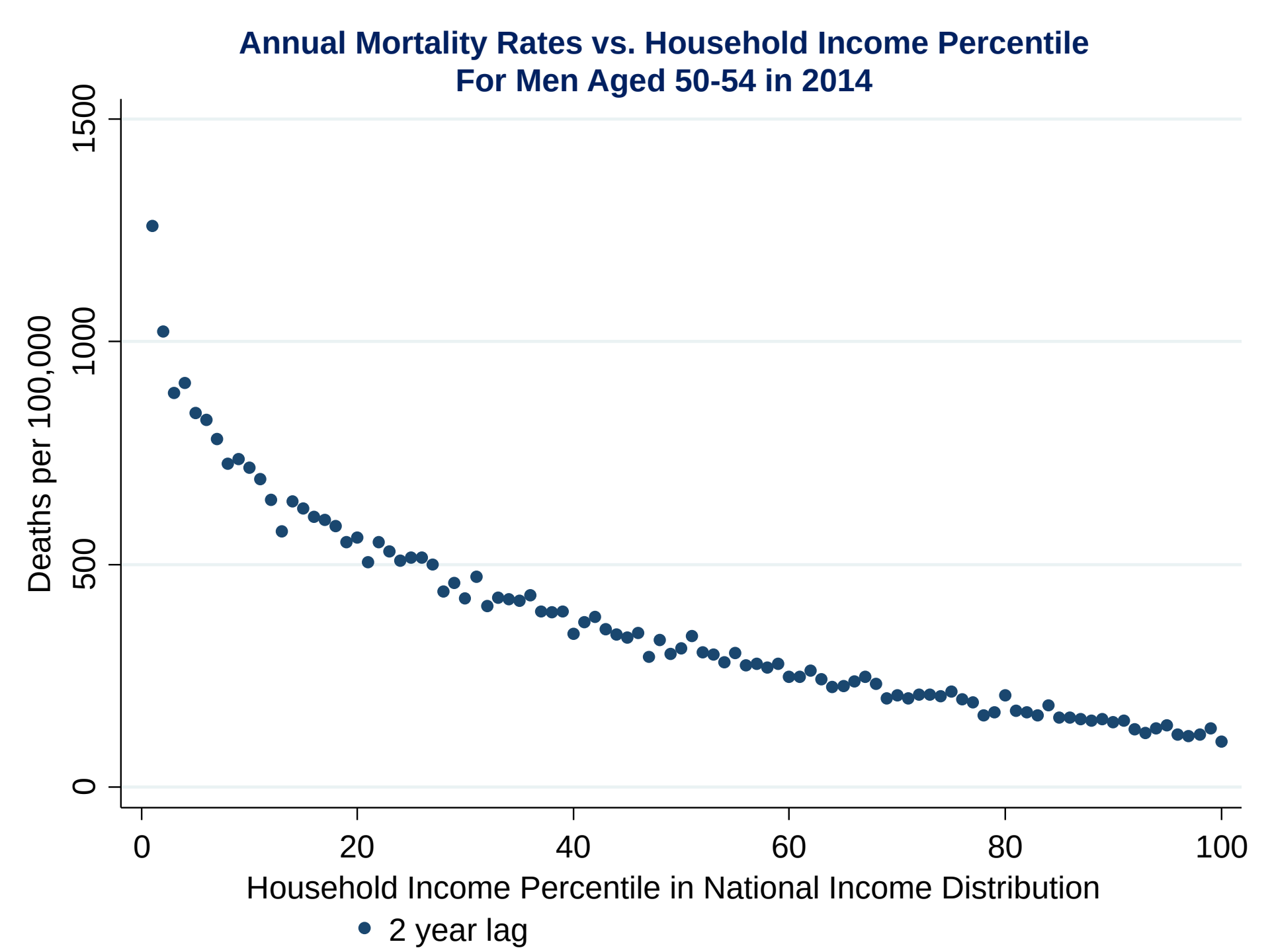
# Step 1: Calculating Observed Mortality Rates

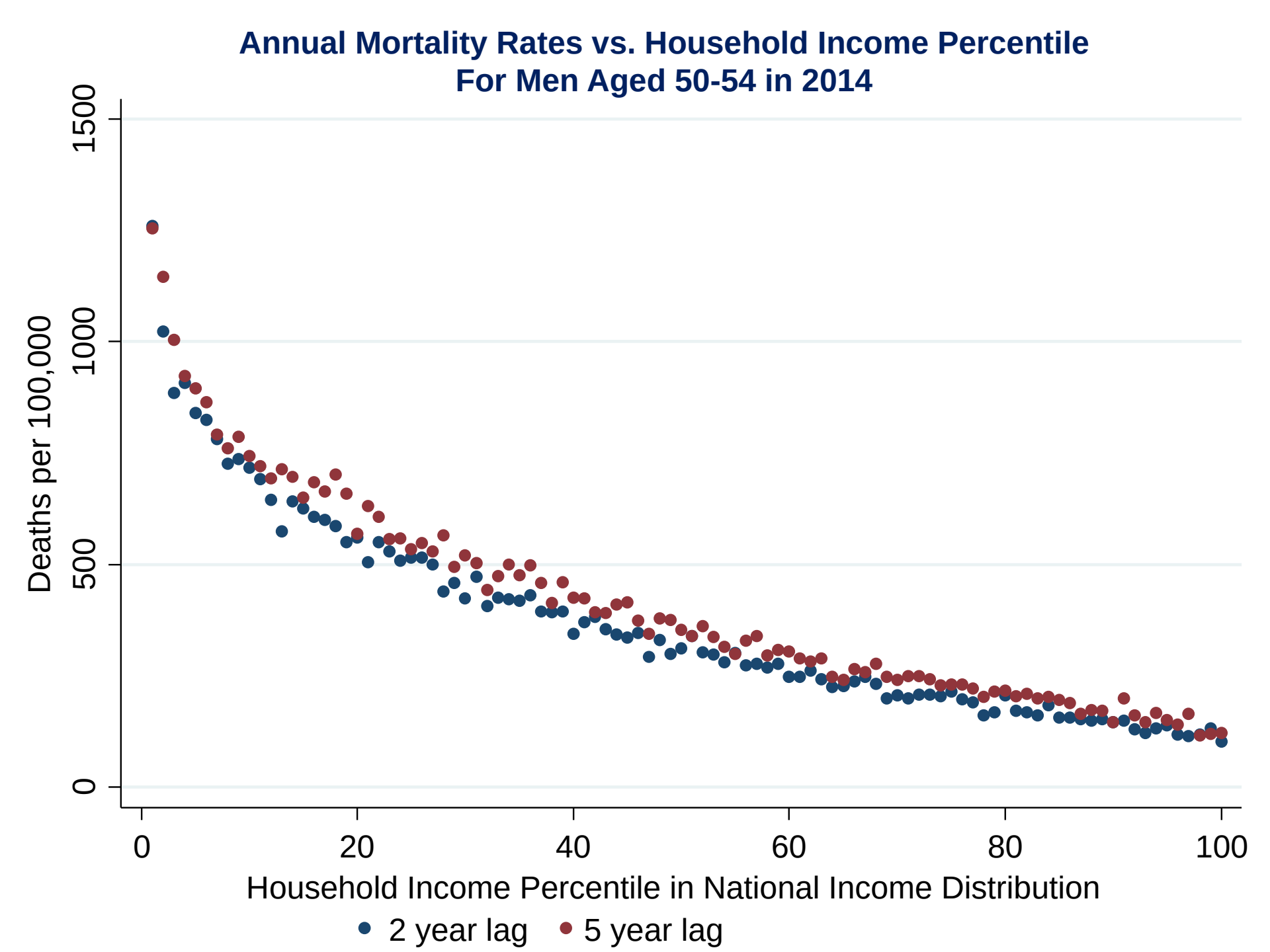
- For “working age” sample (below age 63), start by calculating mortality rates as a function of income percentile at age *a* – *2* (two year lag)
  - Then return to original goal of estimating mortality rates as a function of income percentile at age 40

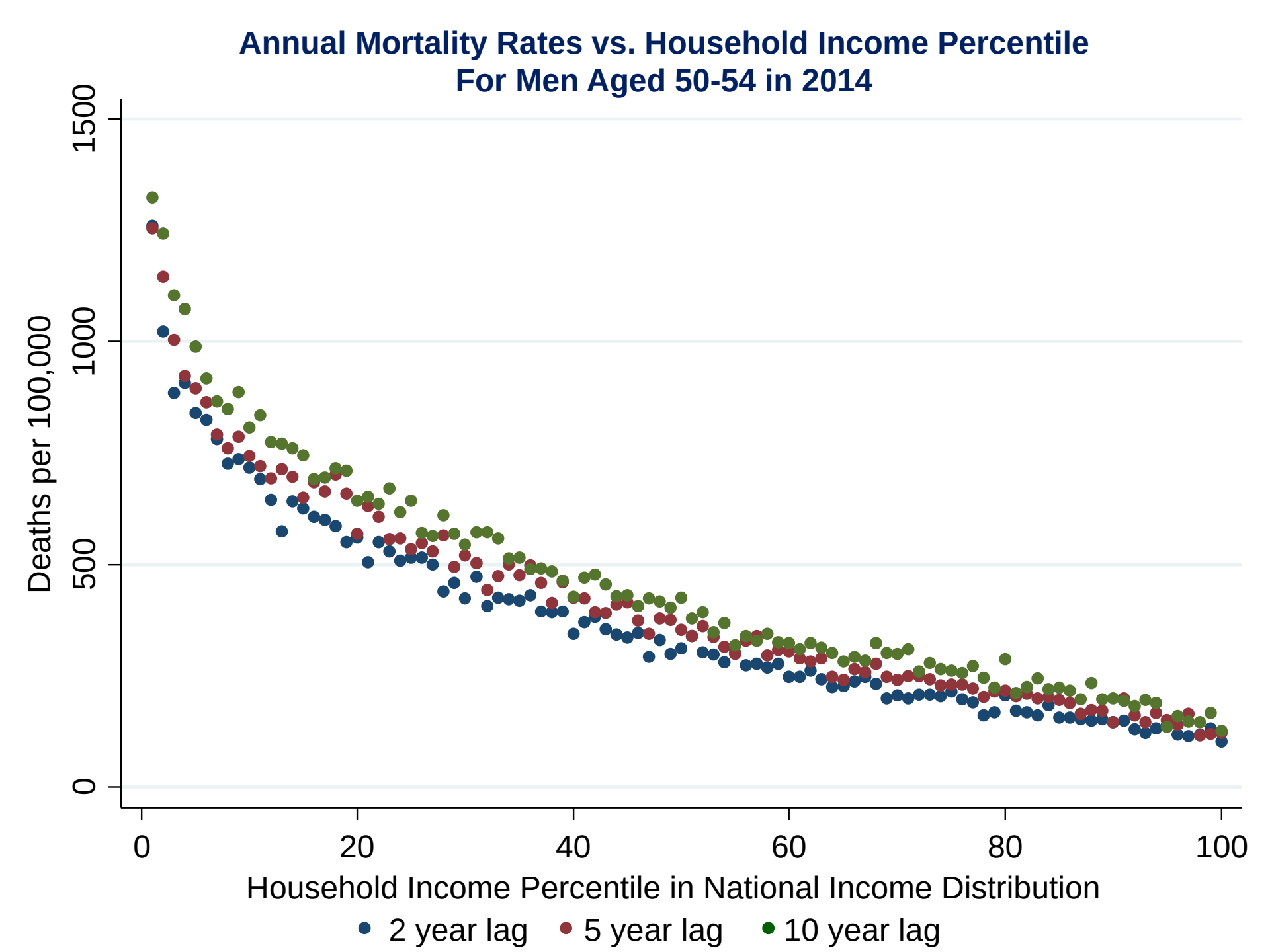

Annual Mortality Rates vs. Household Income Percentile
for Men Aged 50-54, Pooling 2001-2014
Deaths per 100,000 in Year t
0
500
1000
1500
0
20
40
60
80
100
Household Income Percentile in National Income Distribution in Year t-2

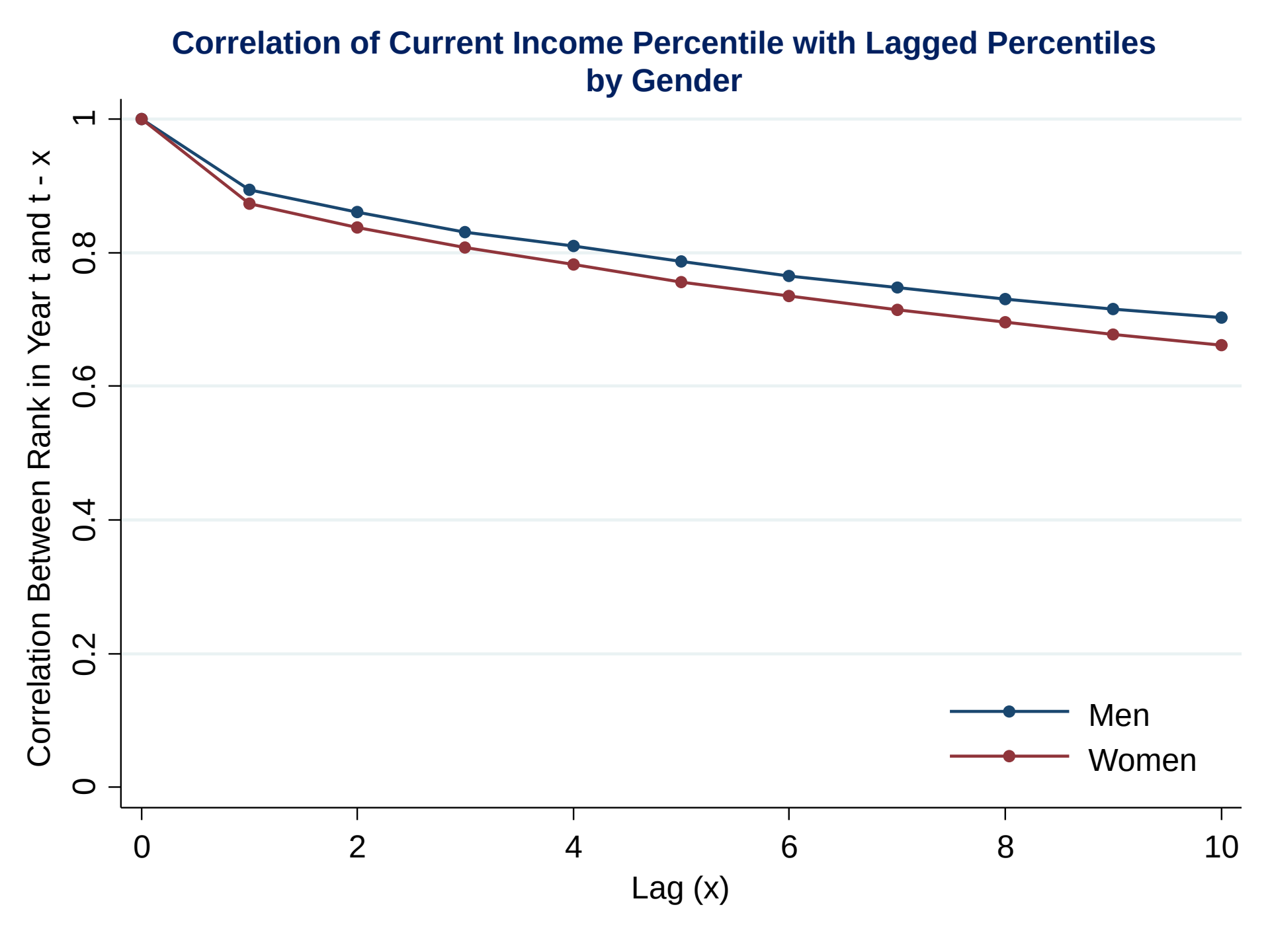

Annual Mortality Rates vs. Household Income Percentile
for Men Aged 50-54, Pooling 2001-2014
Bottom 1% = $340
1404 deaths
Median = $ 65K
346 deaths
p95 = $239K
153 deaths
Top 1% = $2.0m
130 deaths
Deaths per 100,000 in Year t
0
500
1000
1500
0
20
40
60
80
100
Household Income Percentile in National Income Distribution in Year t-2

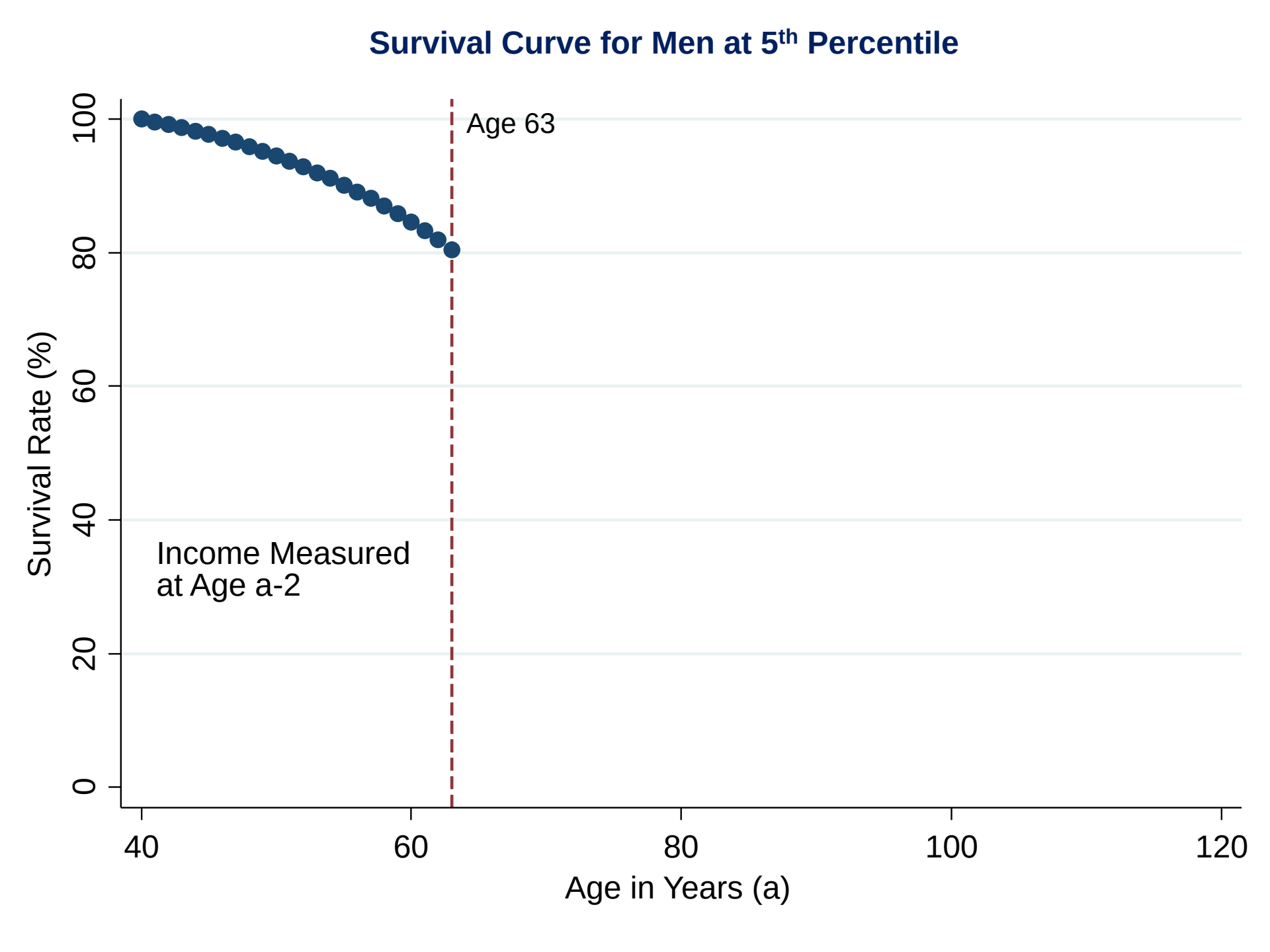

Survival Curve Using Period Life Table
For Men at 5th Percentile
Survival Rate (%)
0
20
40
60
80
100
Age 63
Income Measured
at Age a-2
40
60
80
100
120
Age in Years (a)

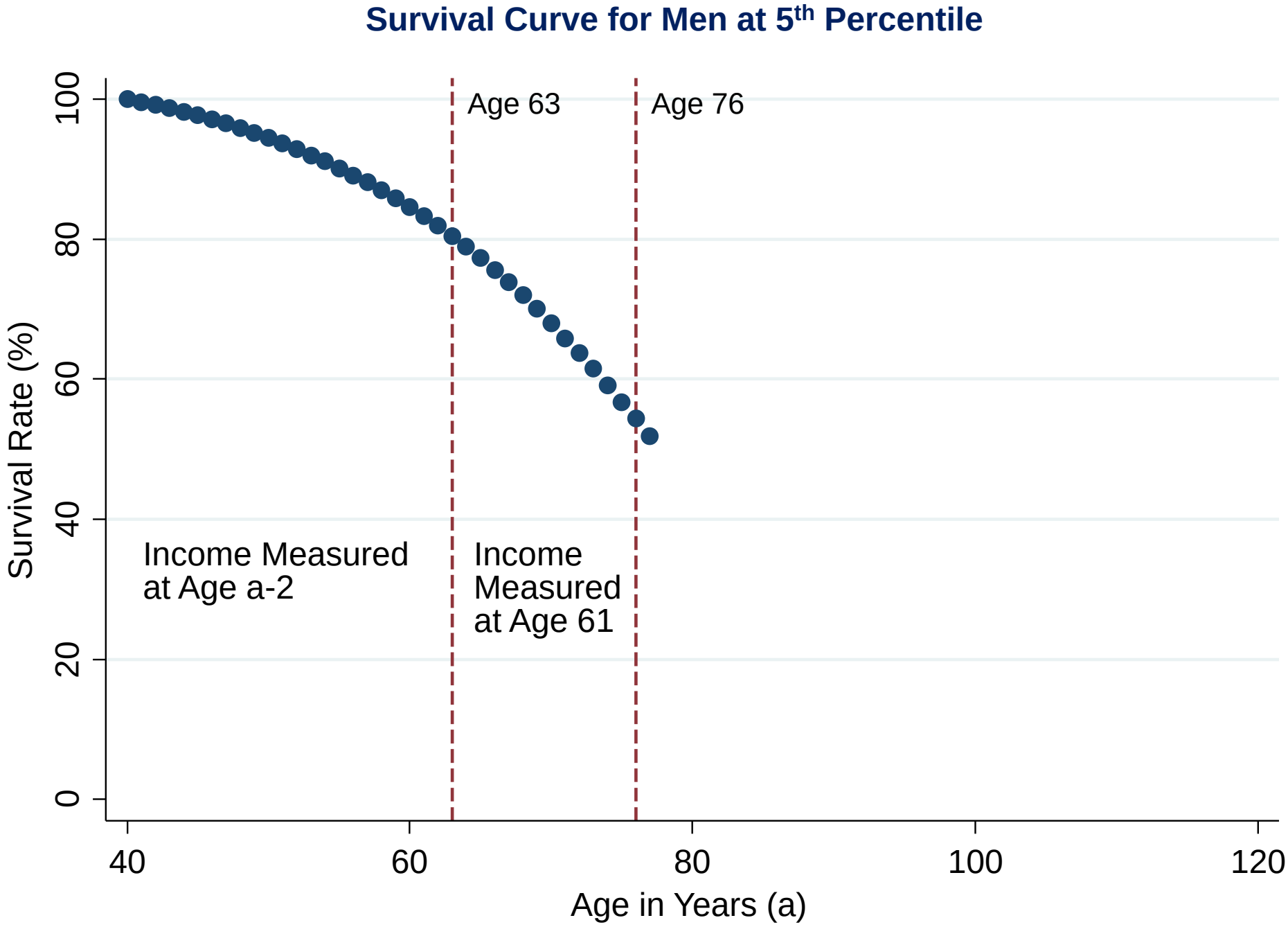

Annual Mortality Rates vs. Household Income Percentile
For Men Aged 50-54 in 2014
Deaths per 100,000
0
500
1000
1500
0
20
40
60
80
100
Household Income Percentile in National Income Distribution
2 year lag

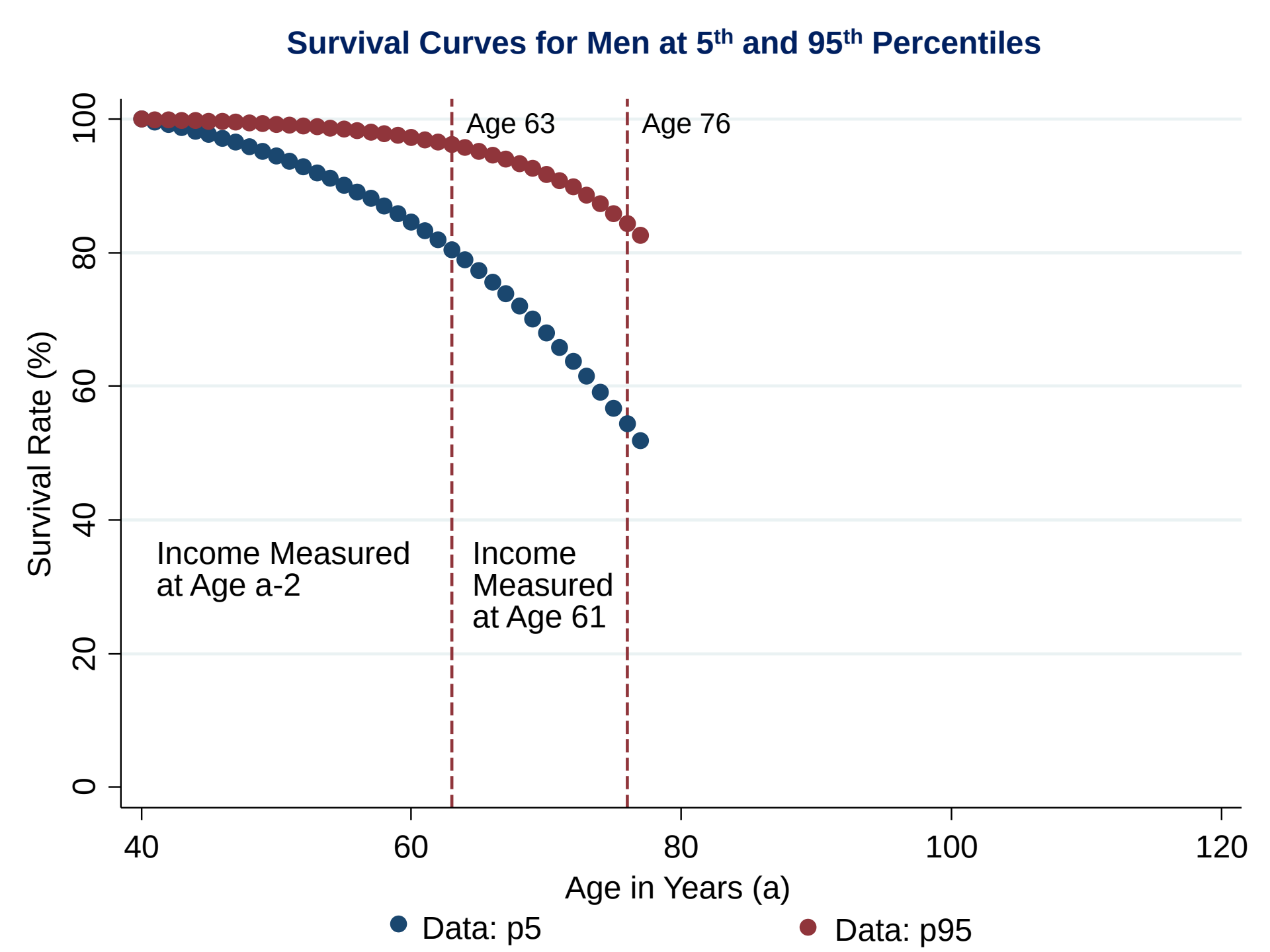

Annual Mortality Rates vs. Household Income Percentile
For Men Aged 50-54 in 2014
Deaths per 100,000
0
500
1000
1500
0
20
40
60
80
100
Household Income Percentile in National Income Distribution
2 year lag
5 year lag

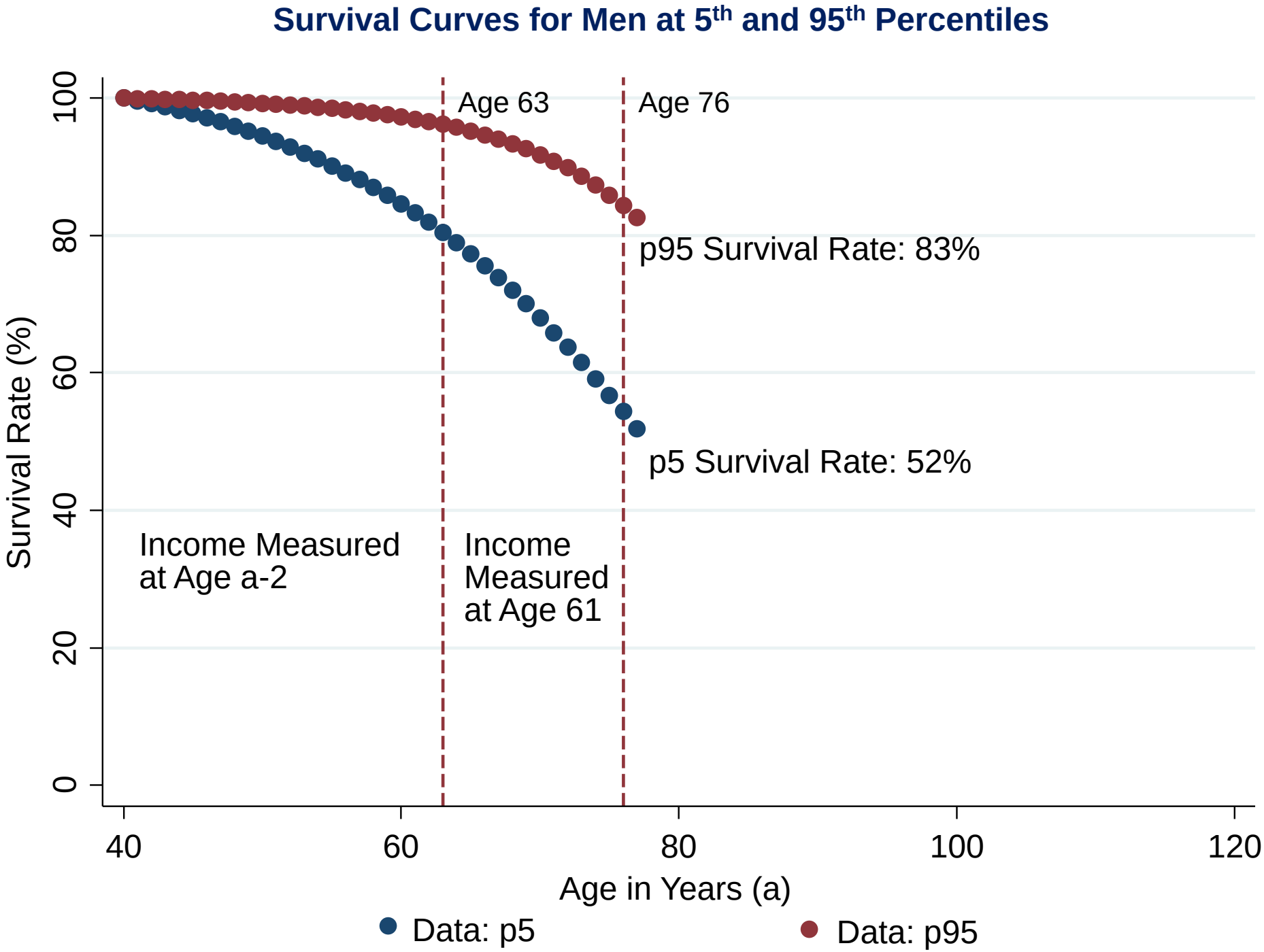

Annual Mortality Rates vs. Household Income Percentile
For Men Aged 50-54 in 2014
Deaths per 100,000
0
500
1000
1500
0
20
40
60
80
100
Household Income Percentile in National Income Distribution
2 year lag
5 year lag
10 year lag


Correlation of Current Income Percentile with Lagged Percentiles by Gender
Correlation Between Rank in Year t and t - x
0
0.2
0.4
0.6
0.8
1
0
2
4
6
8
10
Lag (x)
Men
Women


Survival Curve for Men at 5th Percentile
Age 63
Income Measured
at Age a-2
Survival Rate (%)
0
20
40
60
80
100
40
60
80
100
120
Age in Years (a)


Survival Curve for Men at 5th Percentile
Age 63
Age 76
Income Measured at Age a-2
Income Measured at Age 61
Survival Rate (%)
0
20
40
60
80
100
40
60
80
100
120
Age in Years (a)


Survival Curves for Men at 5th and 95th Percentiles
Age 63
Age 76
Income Measured at Age a-2
Income Measured at Age 61
Survival Rate (%)
0
20
40
60
80
100
40
60
80
100
120
Age in Years (a)
Data: p5
Data: p95

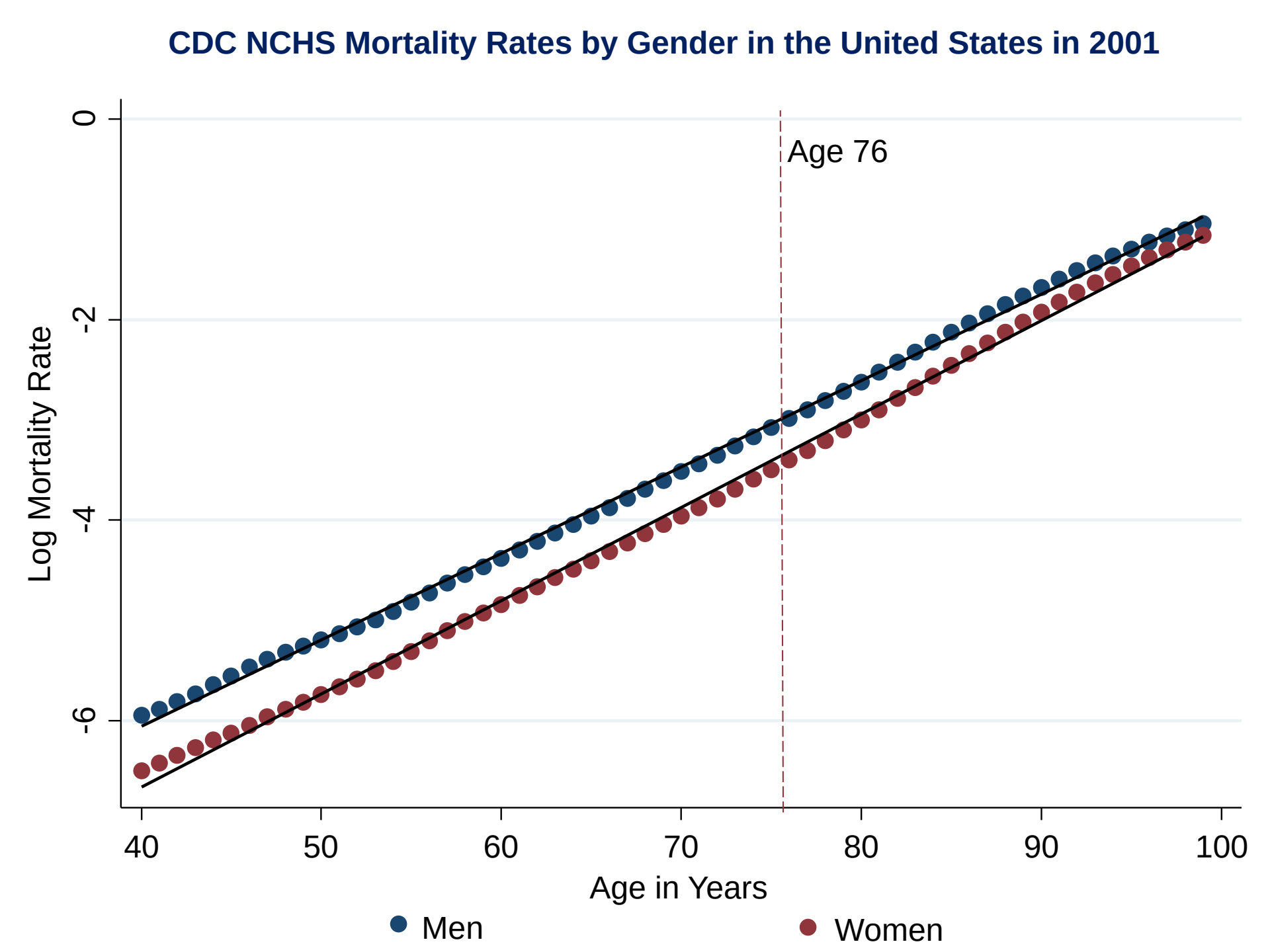

Survival Curves for Men at 5th and 95th Percentiles
Age 63
Age 76
p95 Survival Rate: 83%
p5 Survival Rate: 52%
Income Measured at Age a-2
Income Measured at Age 61
Survival Rate (%)
0
20
40
60
80
100
40
60
80
100
120
Age in Years (a)
Data: p5
Data: p95

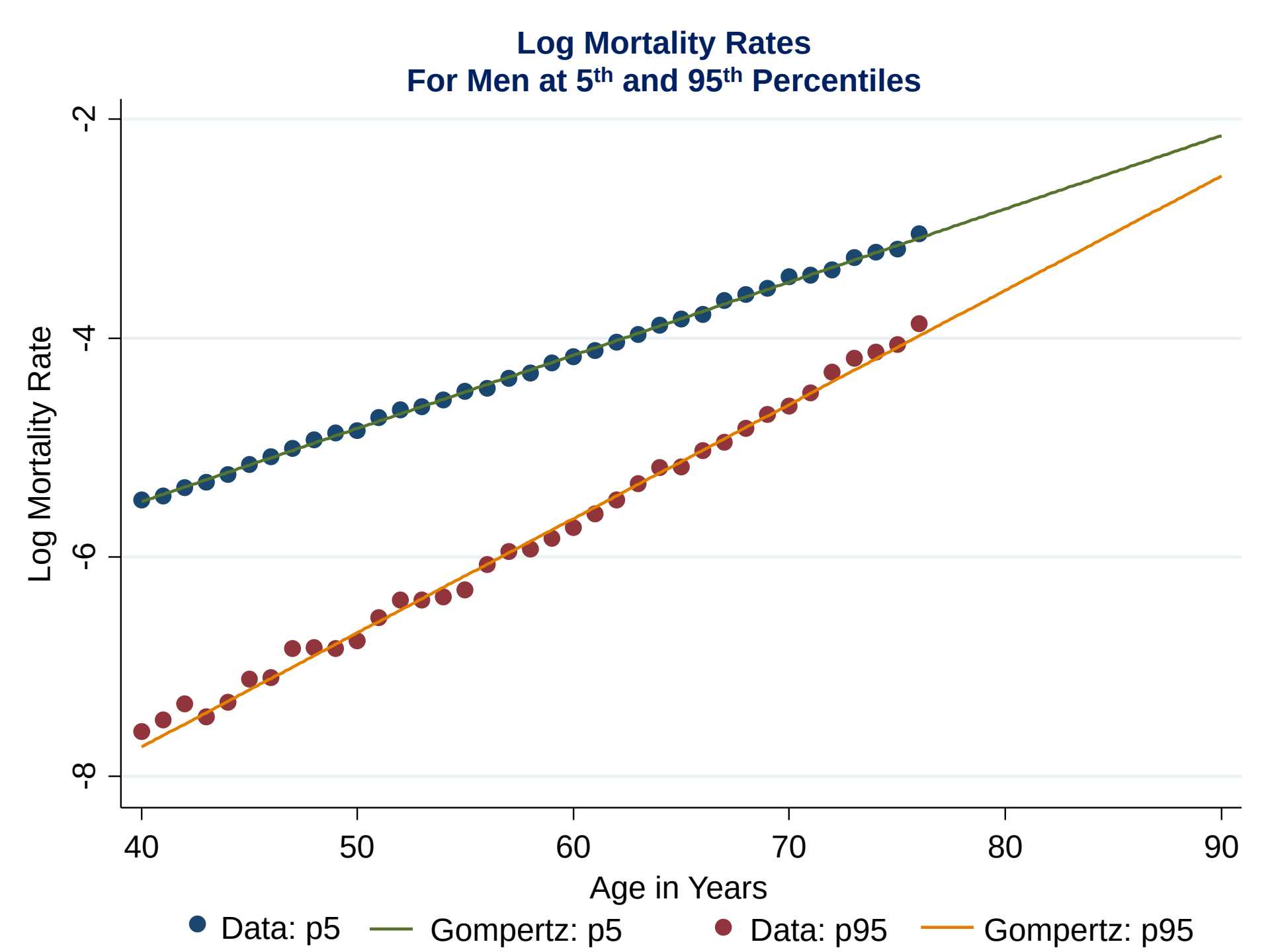
# Step 2: Predicting Mortality Rates at Older Ages

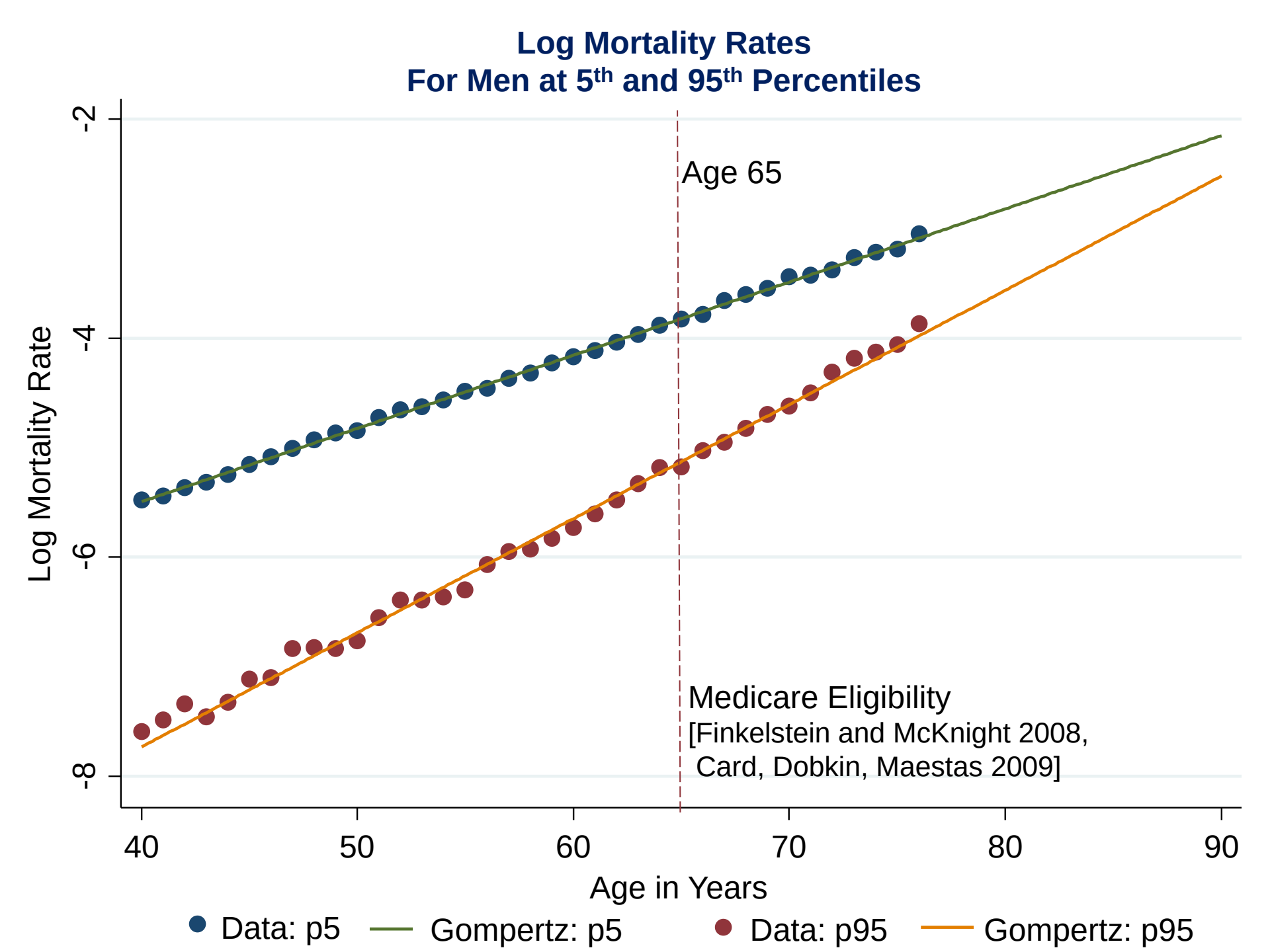
- To calculate life expectancy, need estimates of mortality rates beyond age 76

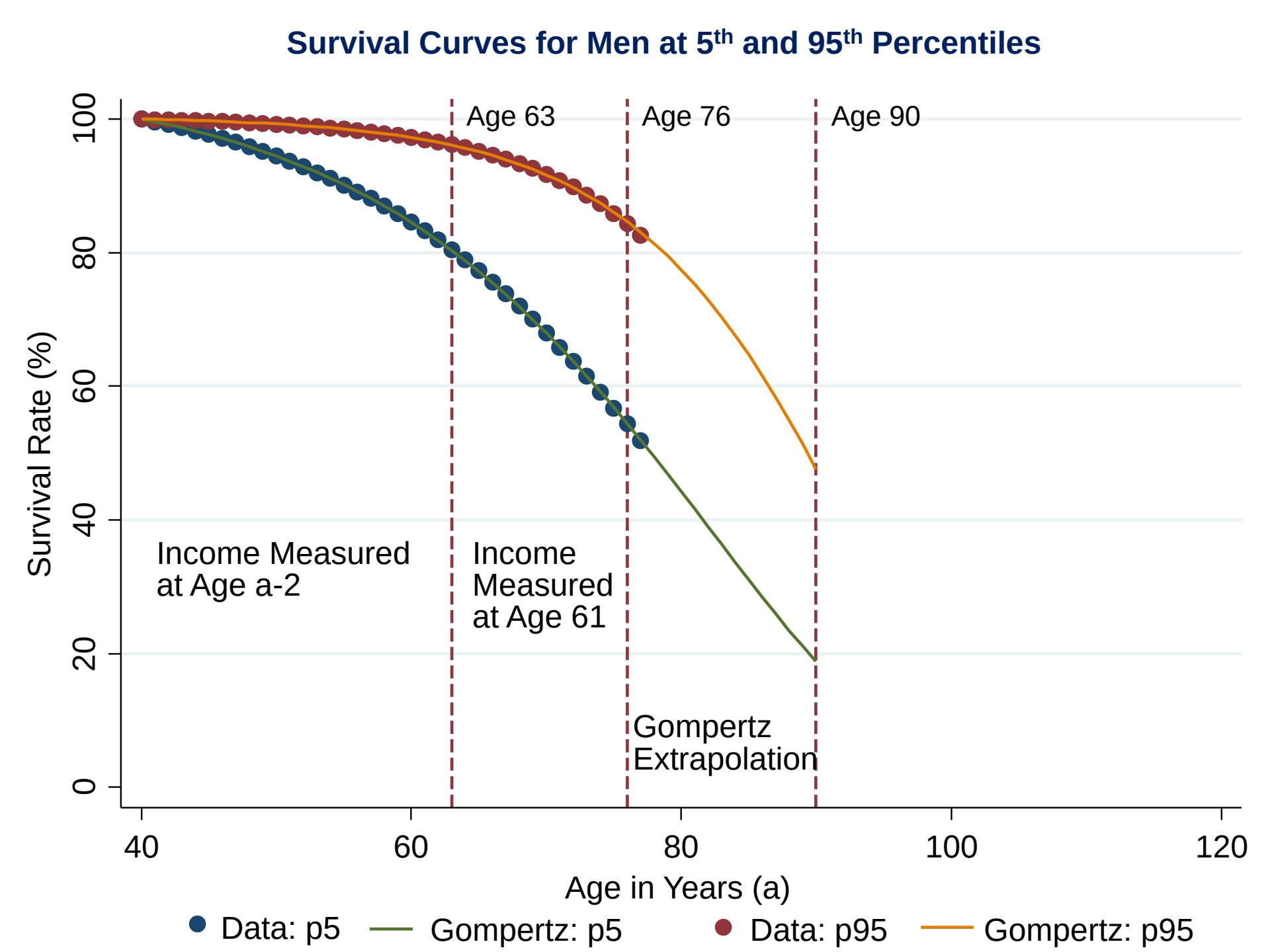
- Gompertz (1825) documented a robust empirical regularity: mortality rates grow exponentially with age

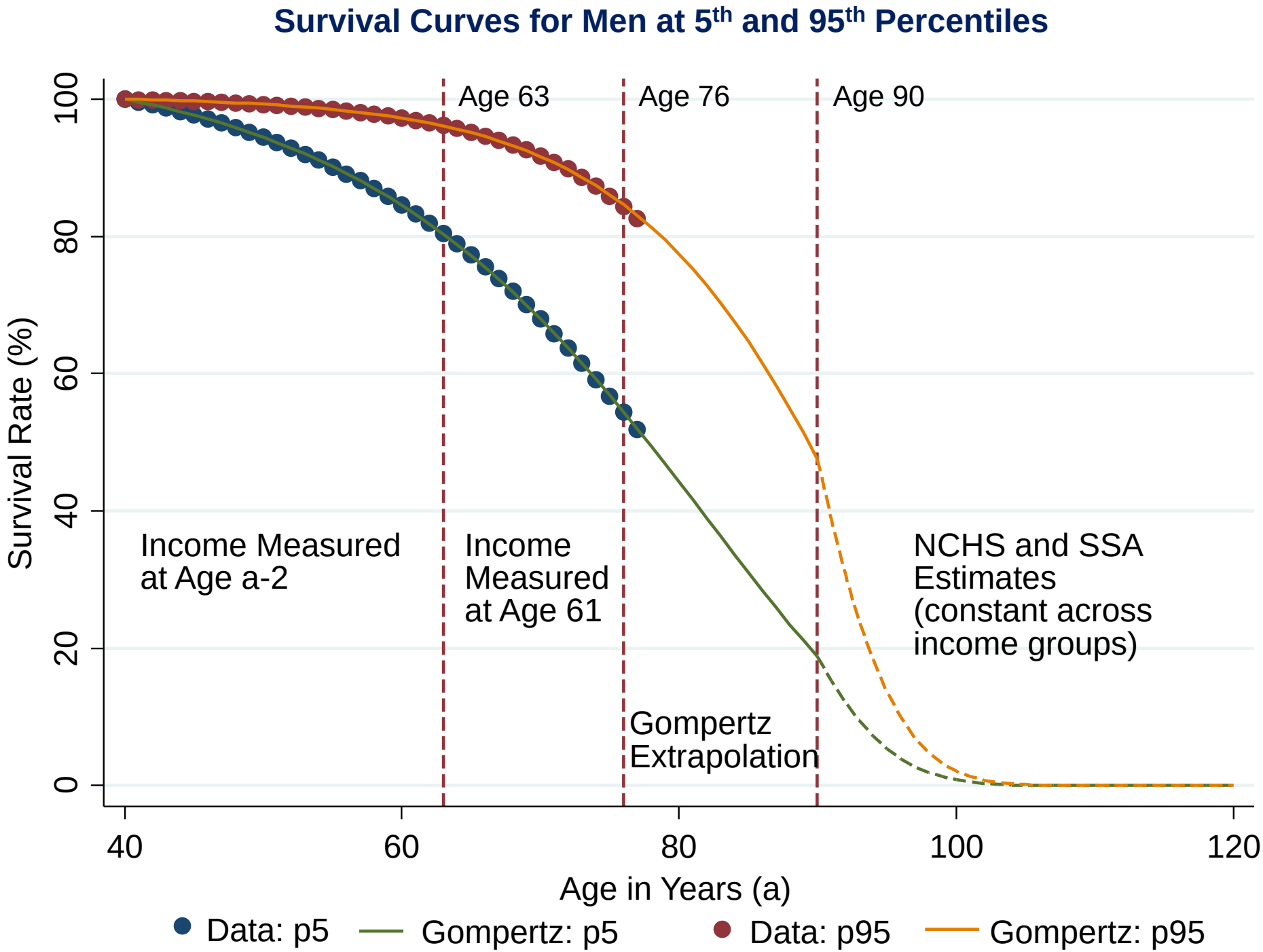
$$m(a) = k\, e^{\beta a}$$
$$\Rightarrow \log m(a) = \kappa + \beta a$$


CDC NCHS Mortality Rates by Gender in the United States in 2001
Age 76
Log Mortality Rate
0
-2
-4
-6
40
50
60
70
80
90
100
Age in Years
Men
Women


Log Mortality Rates
For Men at 5th and 95th Percentiles
Log Mortality Rate
-2
-4
-6
-8
40
50
60
70
80
90
Age in Years
Data: p5
Gompertz: p5
Data: p95
Gompertz: p95


Log Mortality Rates
For Men at 5th and 95th Percentiles
Log Mortality Rate
-2
-4
-6
-8
Age 65
Medicare Eligibility
[Finkelstein and McKnight 2008,
Card, Dobkin, Maestas 2009]
40
50
60
70
80
90
Age in Years
Data: p5
Gompertz: p5
Data: p95
Gompertz: p95


Survival Curves for Men at 5th and 95th Percentiles
Age 63
Age 76
Age 90
Income Measured at Age a-2
Income Measured at Age 61
Gompertz Extrapolation
Survival Rate (%)
0
20
40
60
80
100
40
60
80
100
120
Age in Years (a)
Data: p5
Gompertz: p5
Data: p95
Gompertz: p95


Survival Curves for Men at 5th and 95th Percentiles
Survival Rate (%)
0
20
40
60
80
100
Age 63
Age 76
Age 90
Income Measured at Age a-2
Income Measured at Age 61
NCHS and SSA Estimates (constant across income groups)
Gompertz Extrapolation
40
60
80
100
120
Age in Years (a)
Data: p5
Gompertz: p5
Data: p95
Gompertz: p95

# Step 3: Race and Ethnicity Adjustment

- Final step: adjust for racial and ethnic differences in life expectancy
  - CDC statistics show that for males, life exp. of whites is 3.8 years higher than blacks and 2.7 years lower than Hispanics
  - Race shares vary across income groups and especially across areas, potentially biasing raw comparisons
- Perform race (and ethnicity) adjustment to answer the question:

*"What would life expectancy be if each **income group** and **area** had the same black, Hispanic and Asian shares as the U.S. population as a whole at age 40?"*

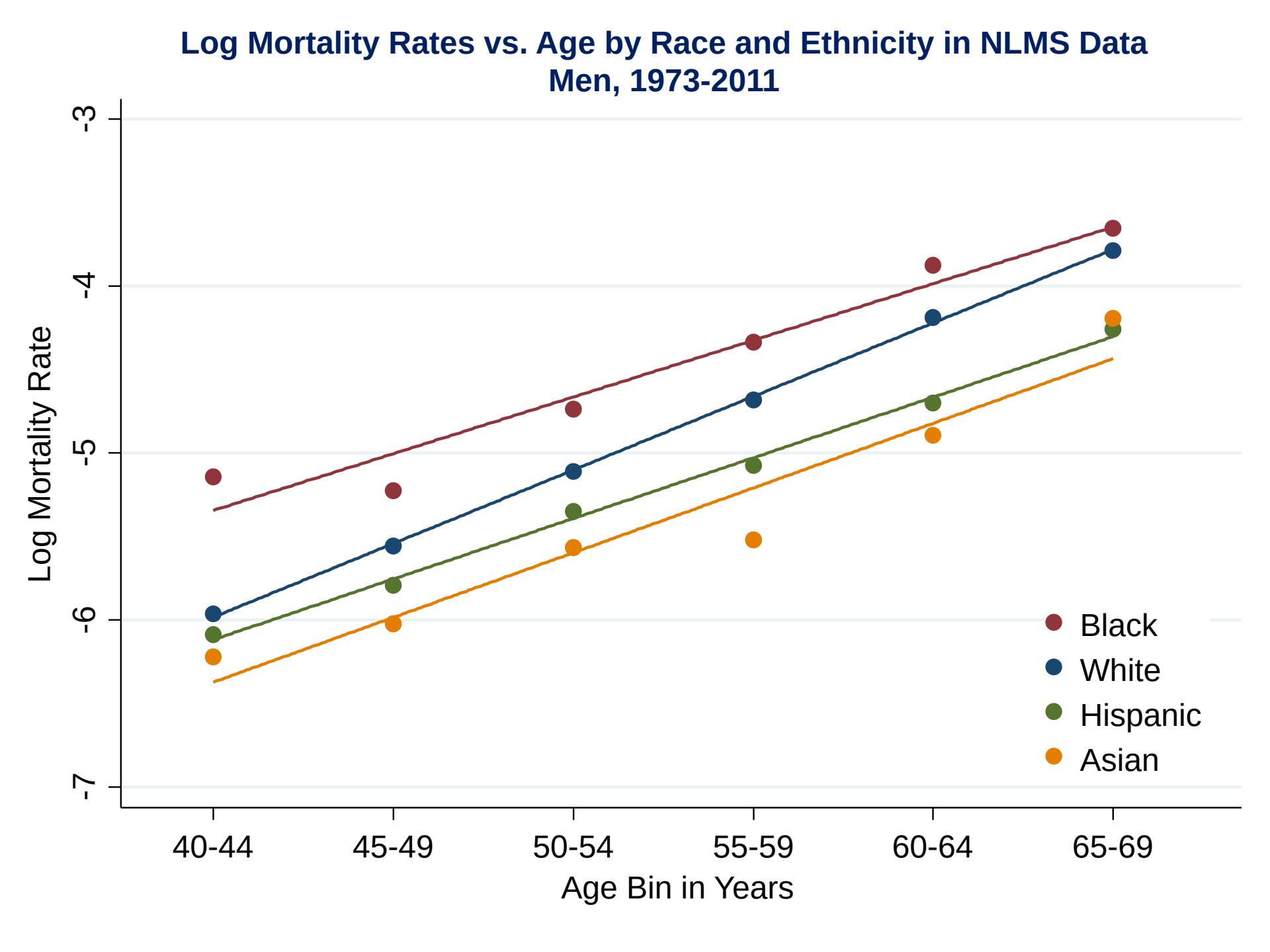
# Race and Ethnicity Adjustment

*"What would life expectancy be if each **income group** and **area** had the same black, Hispanic and Asian shares as the U.S. population as a whole at age 40?"*

- Construct race-adjusted measures of life expectancy in four steps:

1. Estimate differences in mortality by race controlling for income using data from National Longitudinal Mortality Study

    - Assume racial differences do not vary across areas


Log Mortality Rates vs. Age by Race and Ethnicity in NLMS Data
Men, 1973-2011
Log Mortality Rate
-3
-4
-5
-6
-7
40-44
45-49
50-54
55-59
60-64
65-69
Age Bin in Years
Black
White
Hispanic
Asian

# Race and Ethnicity Adjustment

*"What would life expectancy be if each **income group** and **area** had the same black, Hispanic and Asian shares as the U.S. population as a whole at age 40?"*

- Construct race-adjusted measures of life expectancy in four steps:

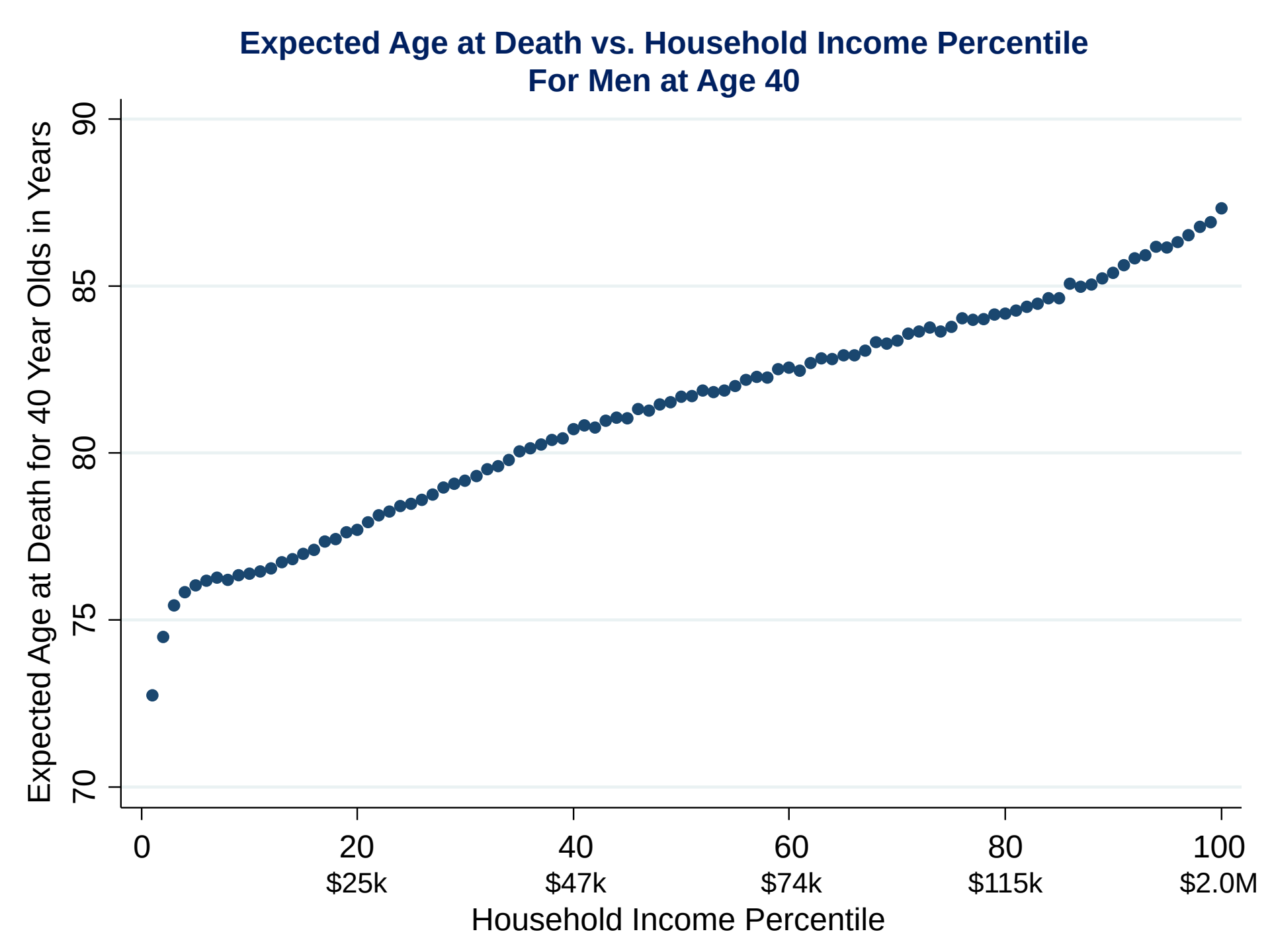
1. Estimate differences in mortality by race controlling for income using data from National Longitudinal Mortality Study

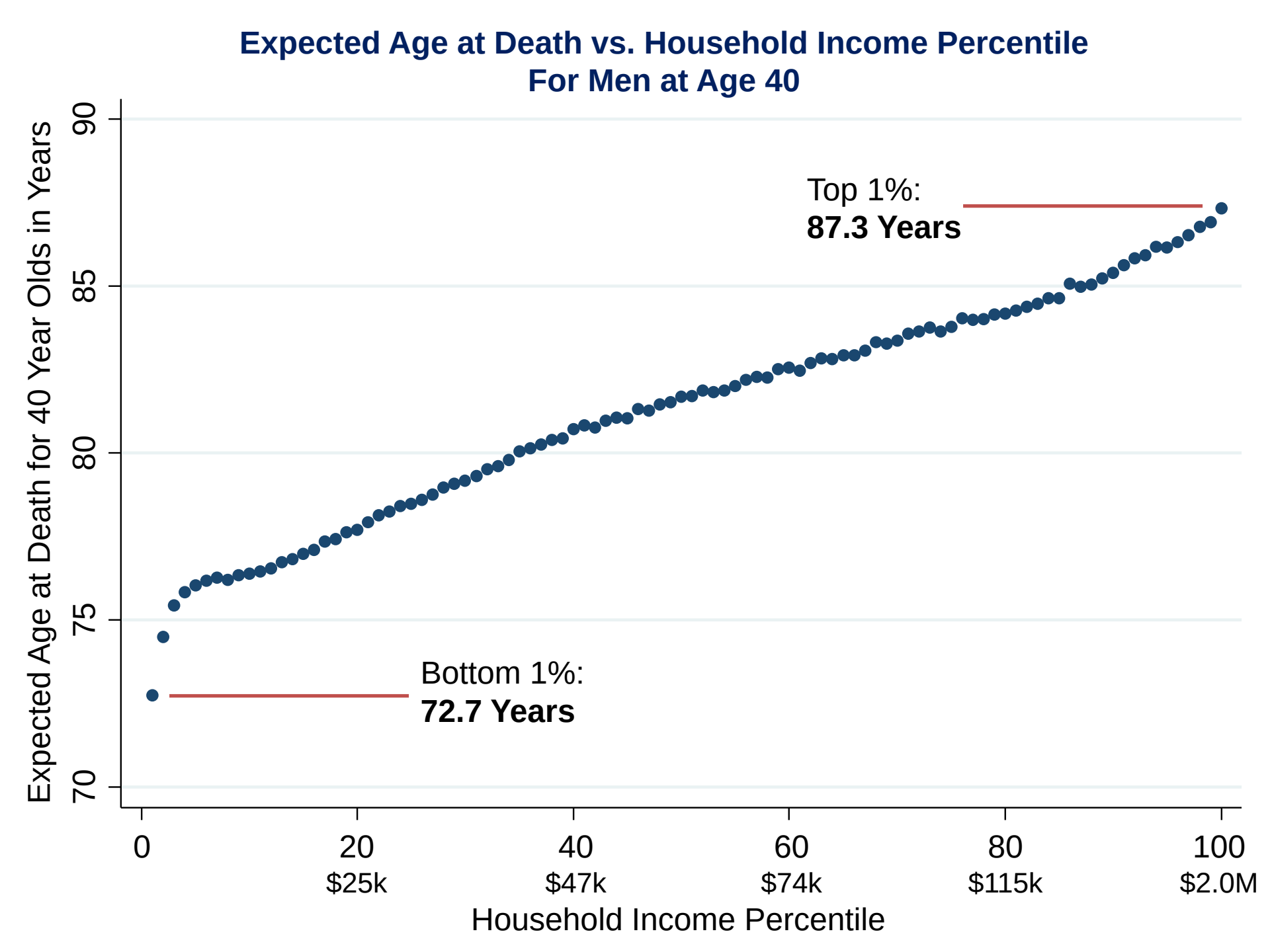
2. Estimate racial demographics in each income group and area using Census data

3. Recover mortality rates by race in each income group and area from aggregate rates in tax data and race differences from NLMS

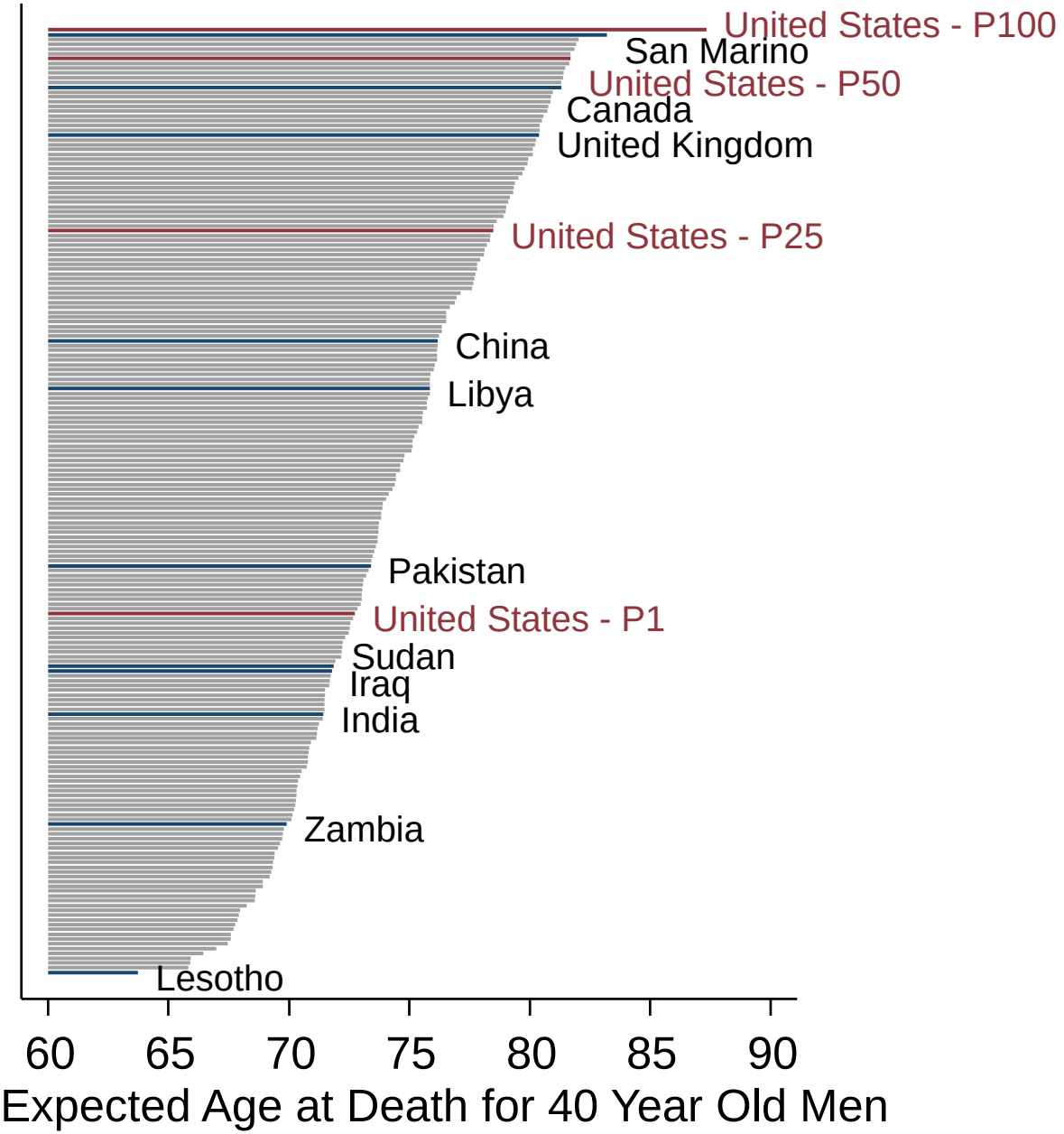
4. Calculate life expectancy that would prevail if racial demographics were the same as the national demographics at age 40 (for men, 12% black, 12% Hispanic, 4% Asian)

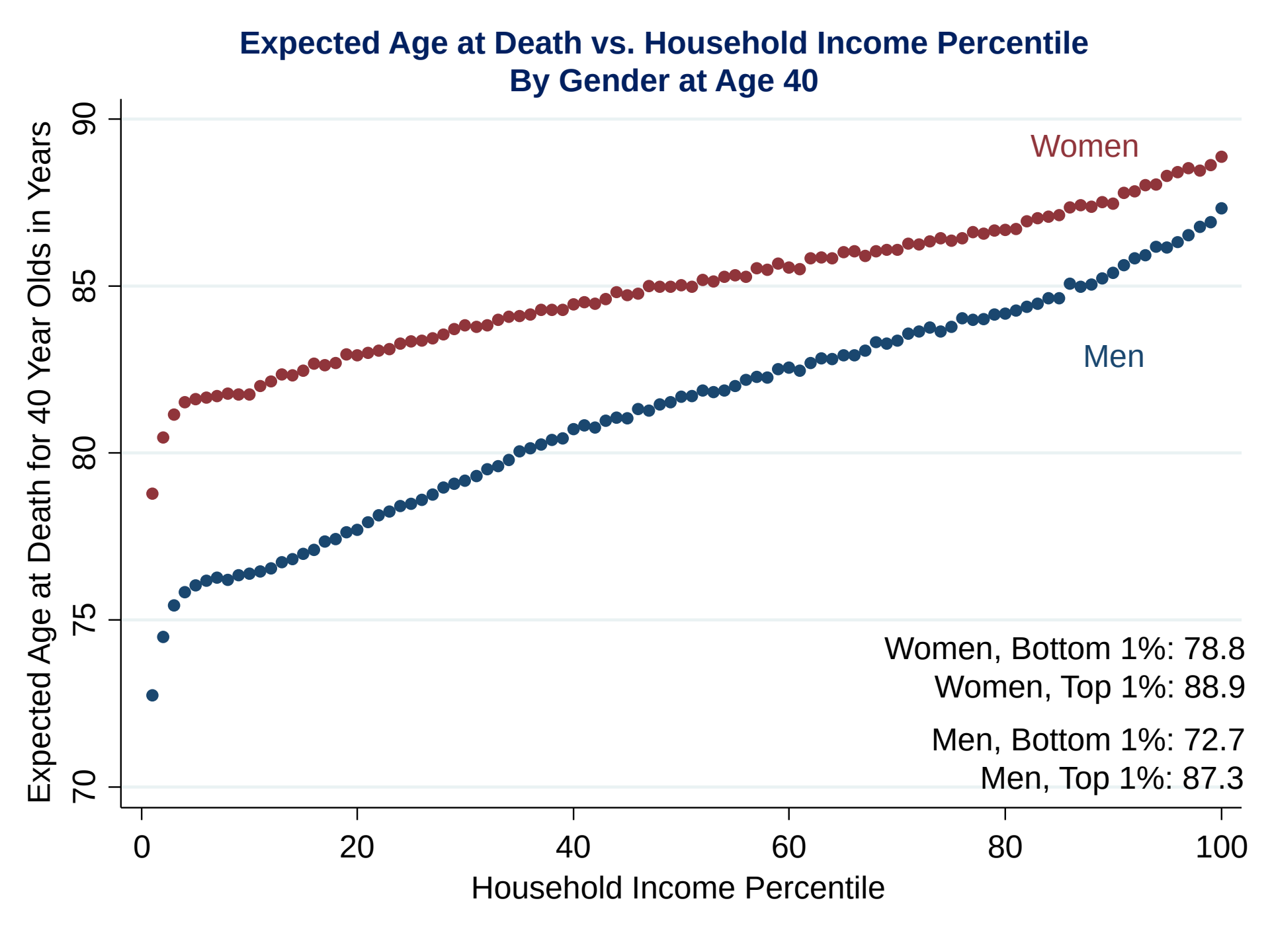
# Part 2: National Statistics on Income and Life Expectancy

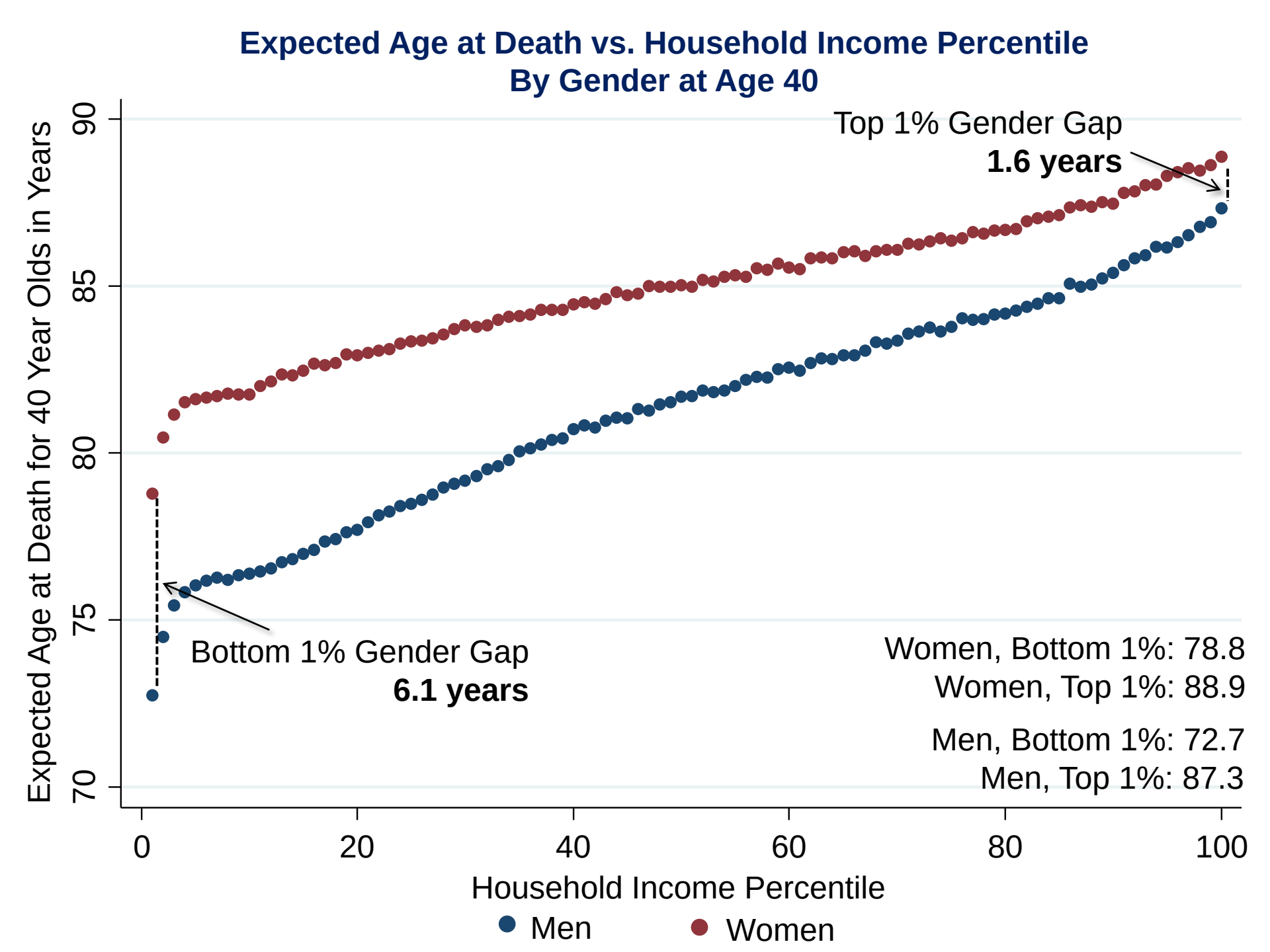

Expected Age at Death vs. Household Income Percentile
For Men at Age 40
Expected Age at Death for 40 Year Olds in Years
70
75
80
85
90
0
20
40
60
80
100
$25k
$47k
$74k
$115k
$2.0M
Household Income Percentile

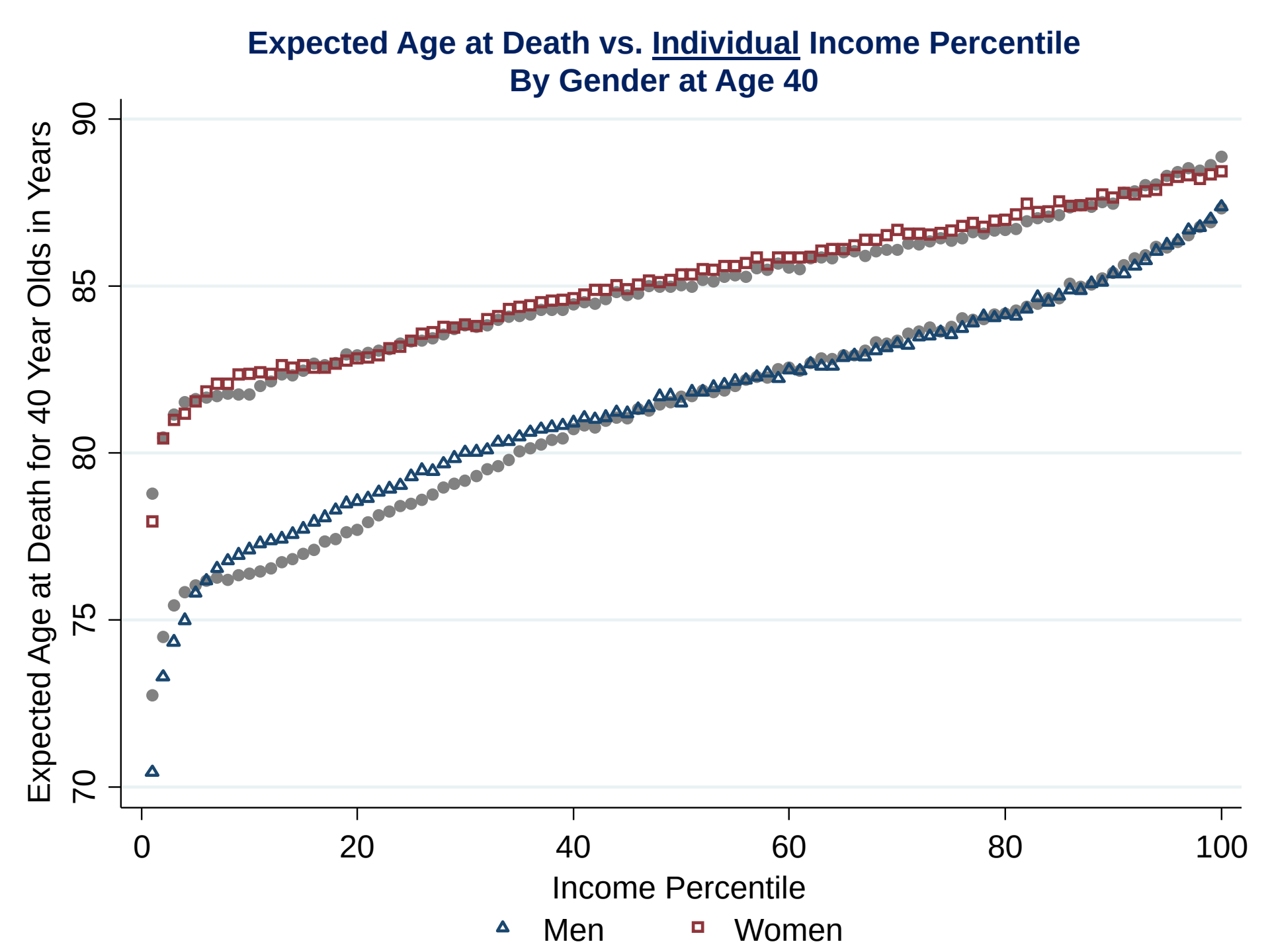

Expected Age at Death vs. Household Income Percentile
For Men at Age 40
Expected Age at Death for 40 Year Olds in Years
90
85
80
75
70
Top 1%:
87.3 Years
Bottom 1%:
72.7 Years
0
20
40
60
80
100
$25k
$47k
$74k
$115k
$2.0M
Household Income Percentile

# U.S. Life Expectancies by Percentile in Comparison to Mean Life Expectancies Across Countries



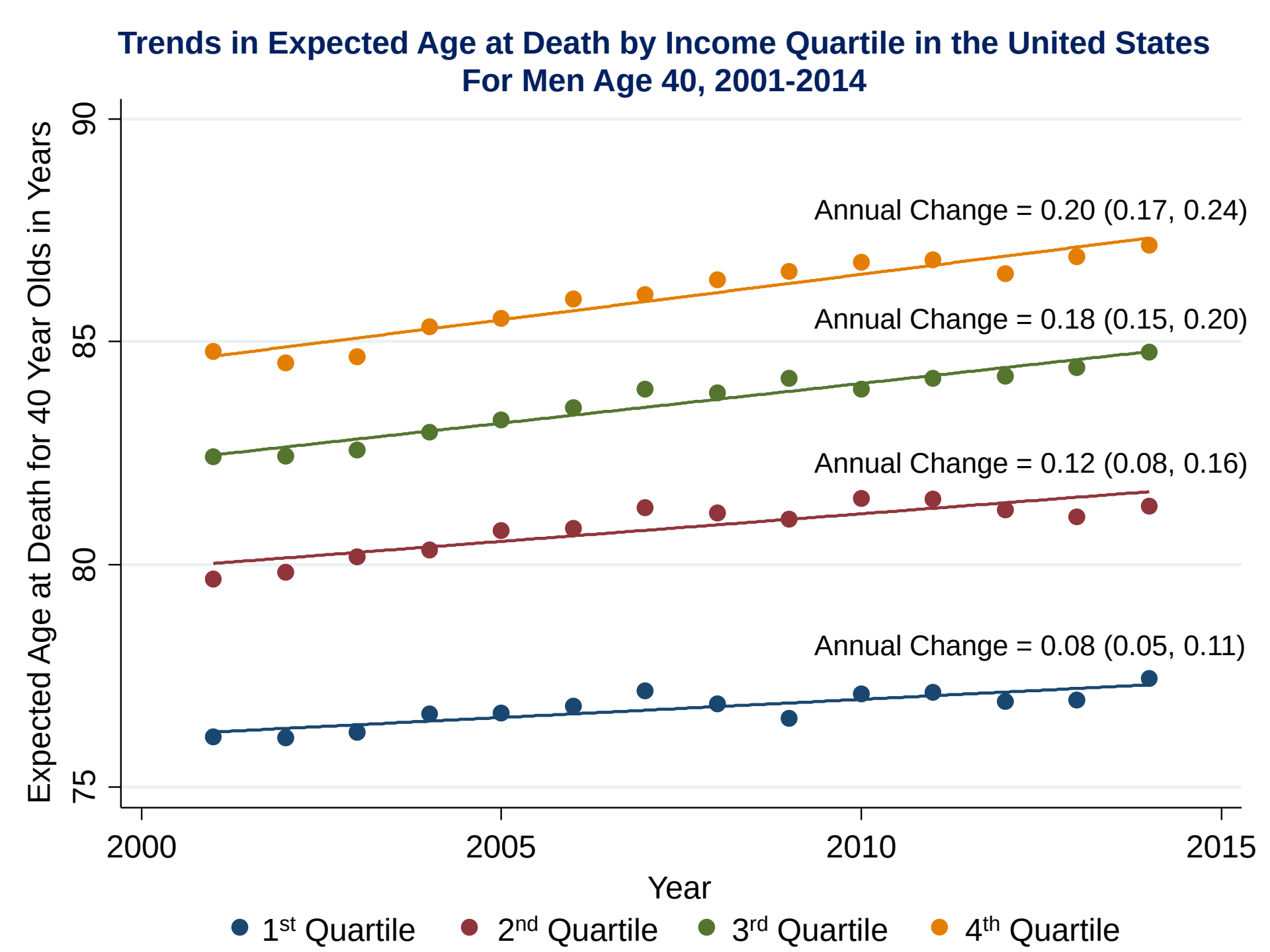

Expected Age at Death vs. Household Income Percentile
By Gender at Age 40
Expected Age at Death for 40 Year Olds in Years
70
75
80
85
90
Women
Men
Women, Bottom 1%: 78.8
Women, Top 1%: 88.9
Men, Bottom 1%: 72.7
Men, Top 1%: 87.3
0
20
40
60
80
100
Household Income Percentile

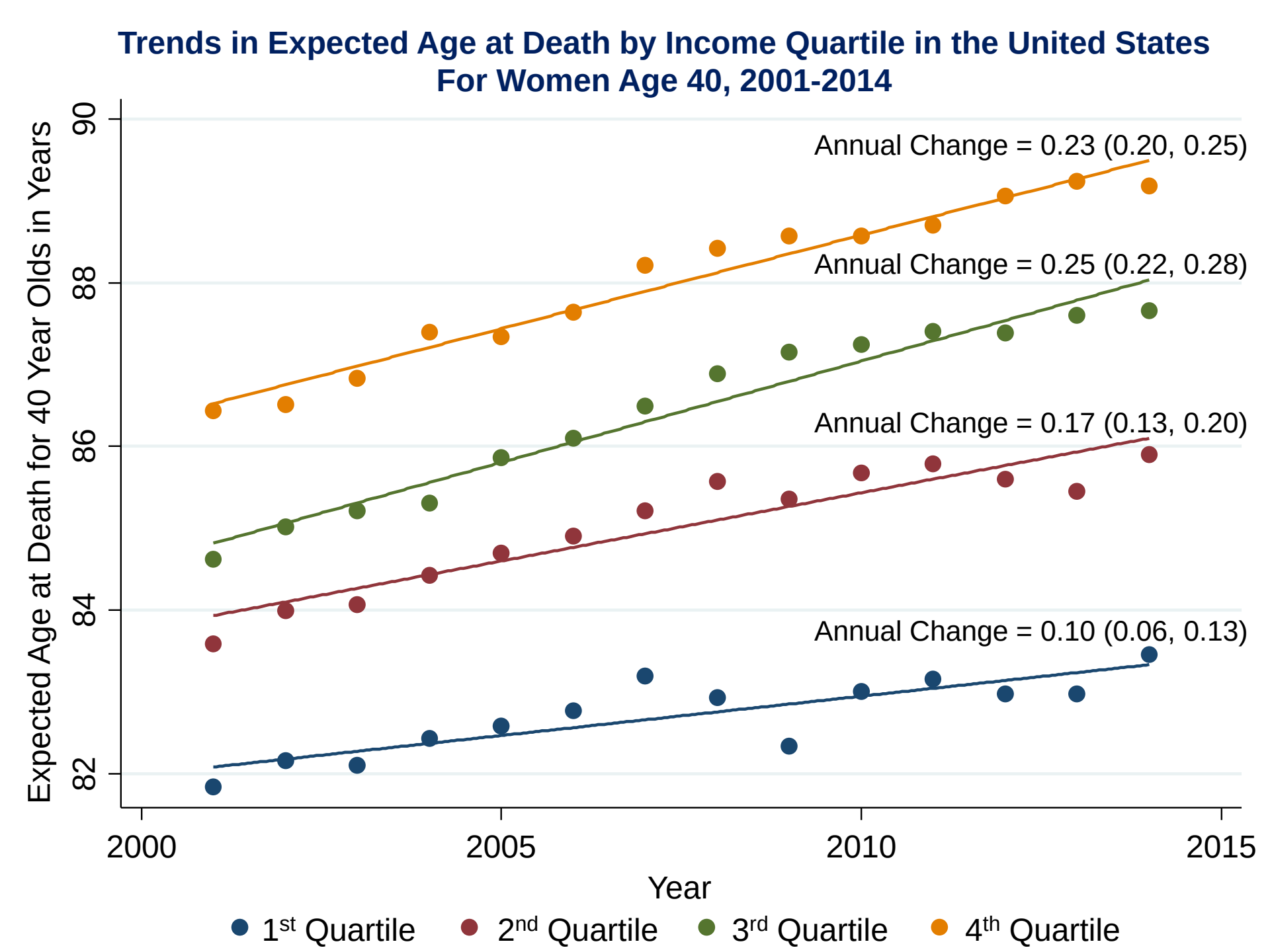

Expected Age at Death vs. Household Income Percentile
By Gender at Age 40
Expected Age at Death for 40 Year Olds in Years
70
75
80
85
90
0
20
40
60
80
100
Household Income Percentile
Top 1% Gender Gap
1.6 years
Bottom 1% Gender Gap
6.1 years
Women, Bottom 1%: 78.8
Women, Top 1%: 88.9
Men, Bottom 1%: 72.7
Men, Top 1%: 87.3
Men
Women

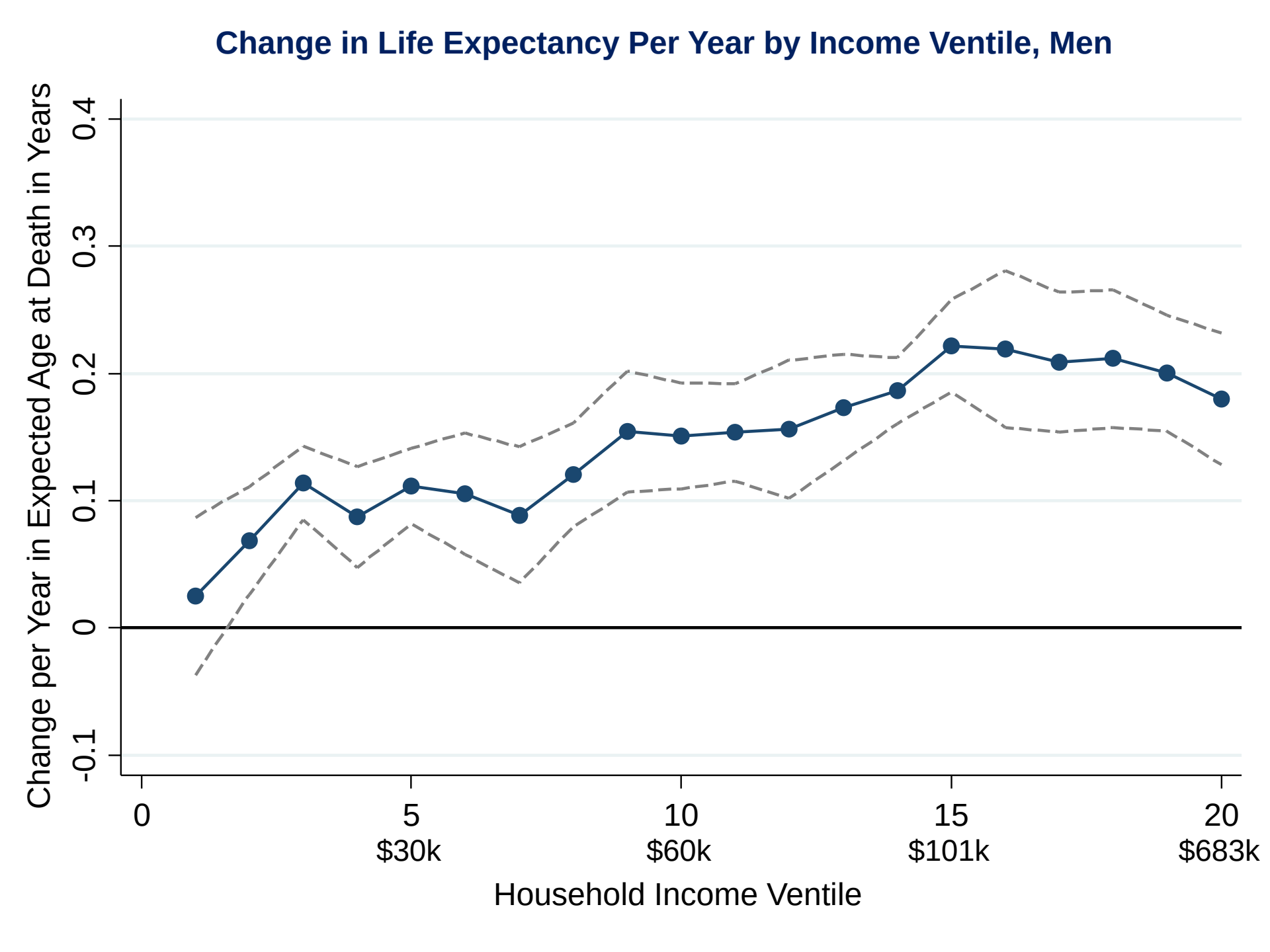

Expected Age at Death vs. Individual Income Percentile
By Gender at Age 40
Expected Age at Death for 40 Year Olds in Years
70
75
80
85
90
0
20
40
60
80
100
Income Percentile
Men
Women

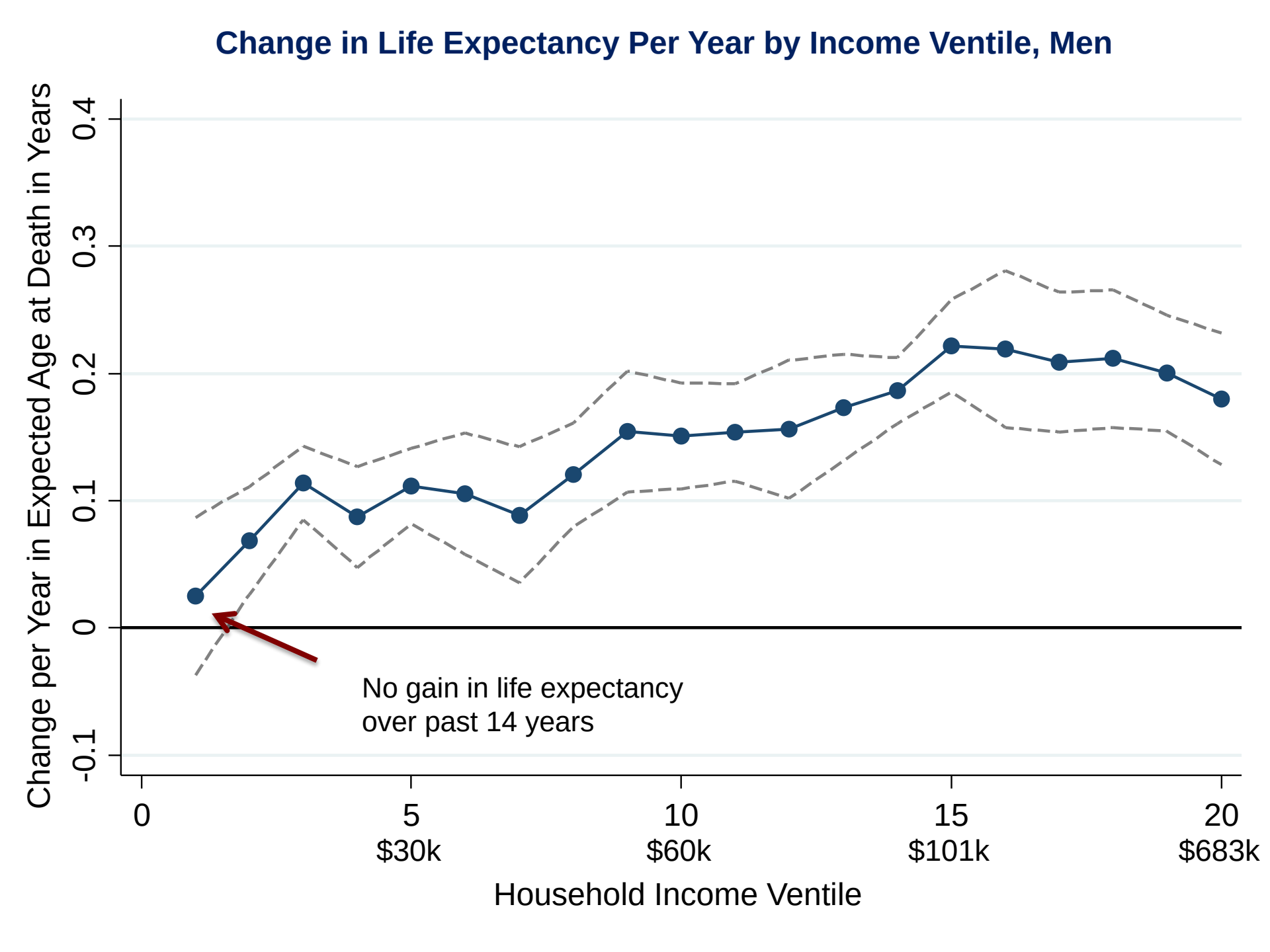
# Time Trends

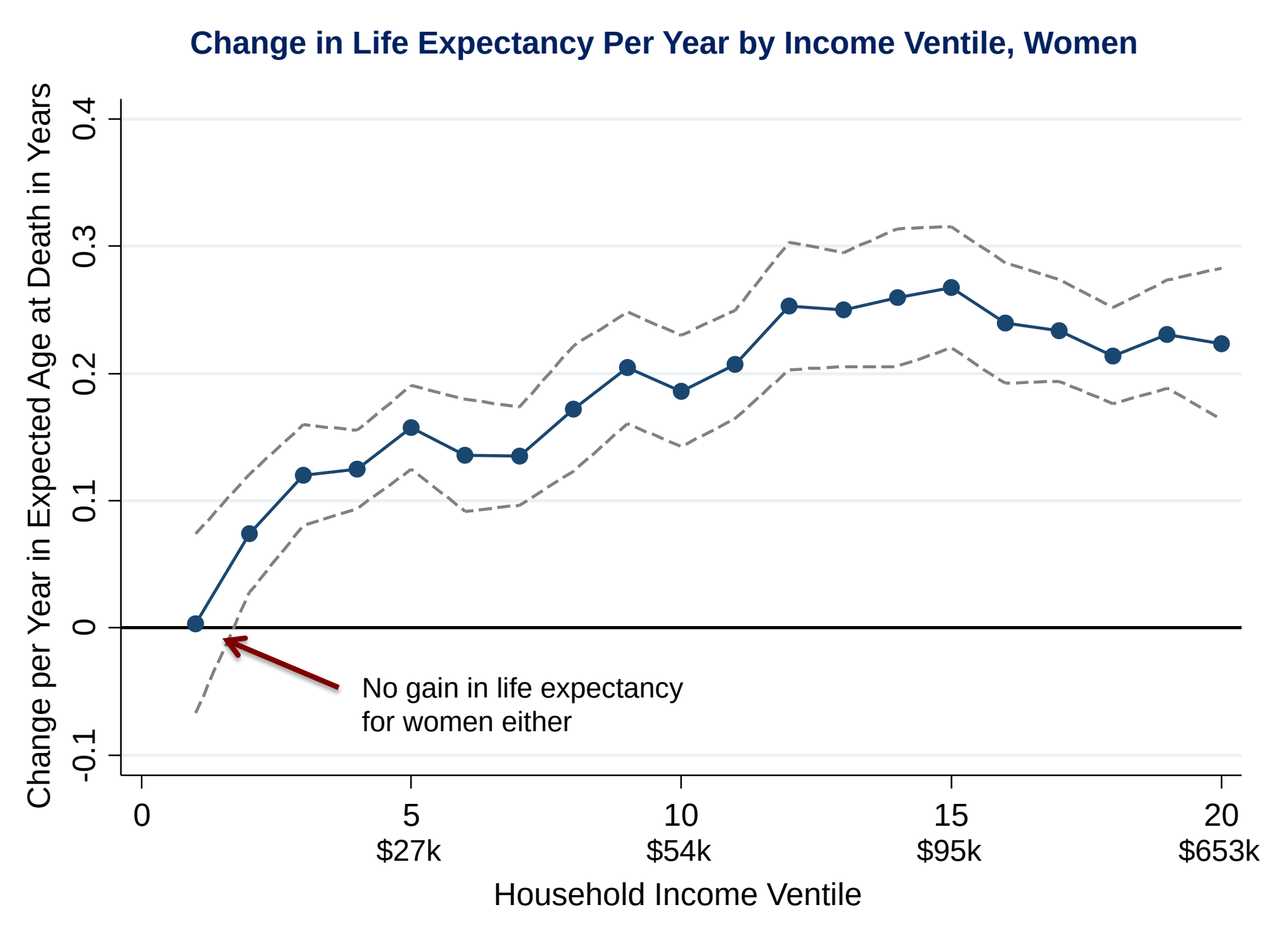
- How are gaps in life expectancy changing over time?
  - Relevant for understanding distributional consequences of various policies, e.g. increasing age of eligibility for social security
- Some studies have found that gap between low- and high-SES groups has grown [Waldron 2007, Meara et al. 2008, Goldring et al. 2015]
  - Some evidence of *declining* life expectancy for low-SES subgroups, but results debated [Olshansky et al. 2012, Bound et al 2015]


Trends in Expected Age at Death by Income Quartile in the United States
For Men Age 40, 2001-2014
Expected Age at Death for 40 Year Olds in Years
75
80
85
90
2000
2005
2010
2015
Year
Annual Change = 0.20 (0.17, 0.24)
Annual Change = 0.18 (0.15, 0.20)
Annual Change = 0.12 (0.08, 0.16)
Annual Change = 0.08 (0.05, 0.11)
1st Quartile
2nd Quartile
3rd Quartile
4th Quartile


Trends in Expected Age at Death by Income Quartile in the United States
For Women Age 40, 2001-2014
Annual Change = 0.23 (0.20, 0.25)
Annual Change = 0.25 (0.22, 0.28)
Annual Change = 0.17 (0.13, 0.20)
Annual Change = 0.10 (0.06, 0.13)
Expected Age at Death for 40 Year Olds in Years
82
84
86
88
90
2000
2005
2010
2015
Year
1st Quartile
2nd Quartile
3rd Quartile
4th Quartile


Change in Life Expectancy Per Year by Income Ventile, Men
Change per Year in Expected Age at Death in Years
-0.1
0
0.1
0.2
0.3
0.4
0
5
$30k
10
$60k
15
$101k
20
$683k
Household Income Ventile


Change in Life Expectancy Per Year by Income Ventile, Men
Change per Year in Expected Age at Death in Years
-0.1
0
0.1
0.2
0.3
0.4
No gain in life expectancy
over past 14 years
0
5
$30k
10
$60k
15
$101k
20
$683k
Household Income Ventile


Change in Life Expectancy Per Year by Income Ventile, Women
Change per Year in Expected Age at Death in Years
-0.1
0
0.1
0.2
0.3
0.4
No gain in life expectancy
for women either
0
5
$27k
10
$54k
15
$95k
20
$653k
Household Income Ventile

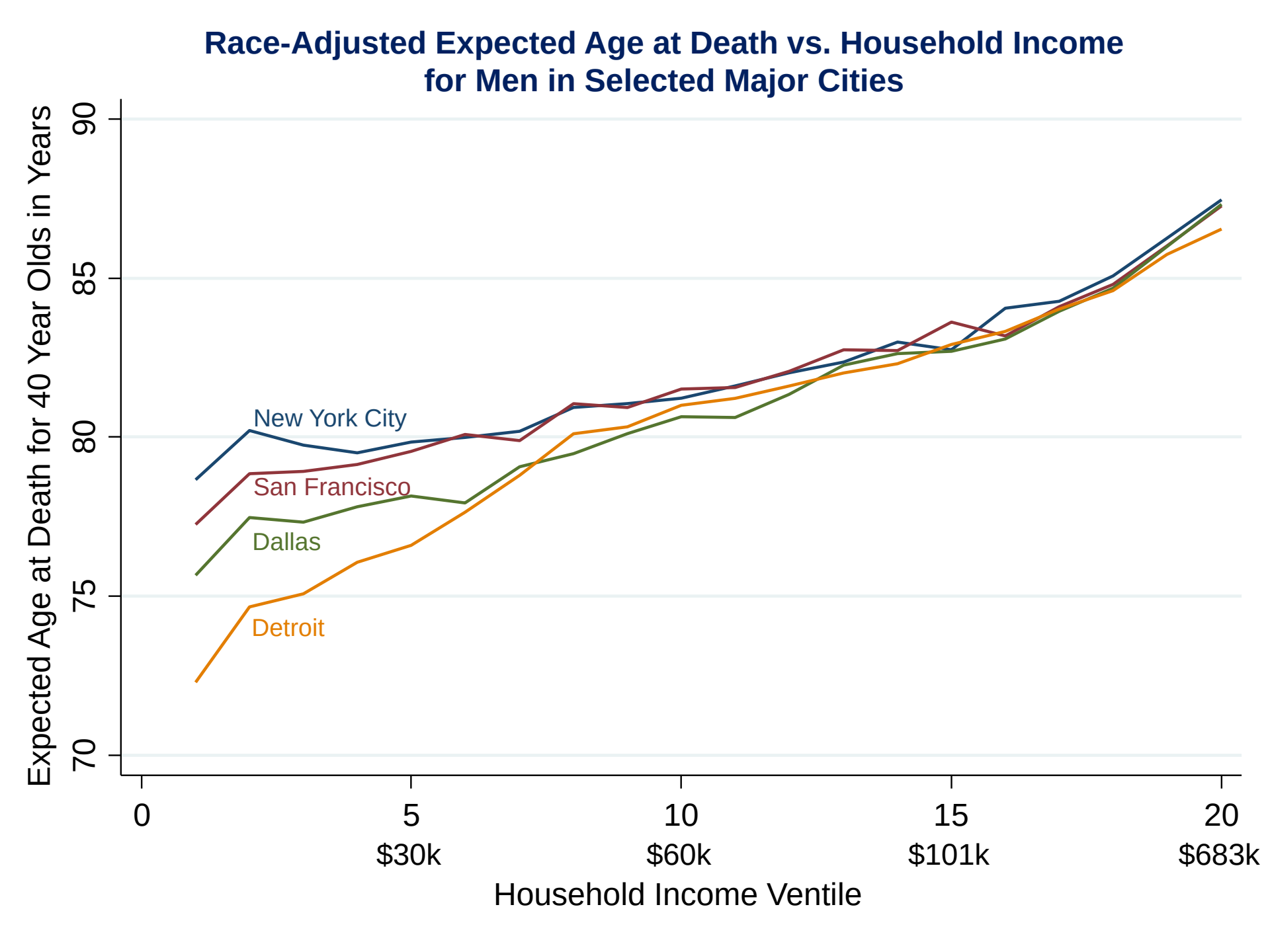
# Part 3: Local Area Variation

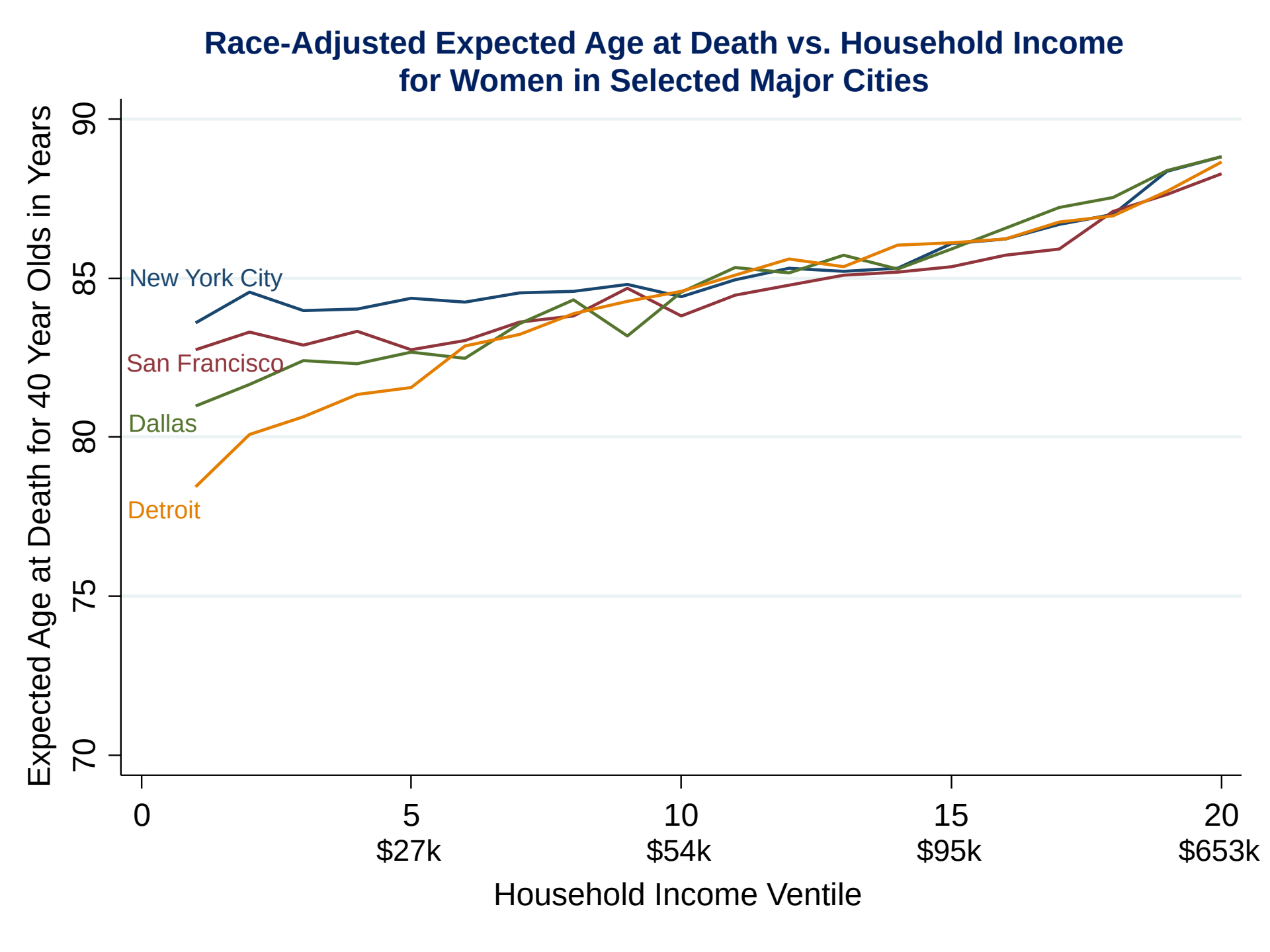
# Local Area Variation

- Long literature analyzing geographical differences in mortality
  [e.g., Fuchs (1974), Murray et al. 2006, Berkman et al 2014]

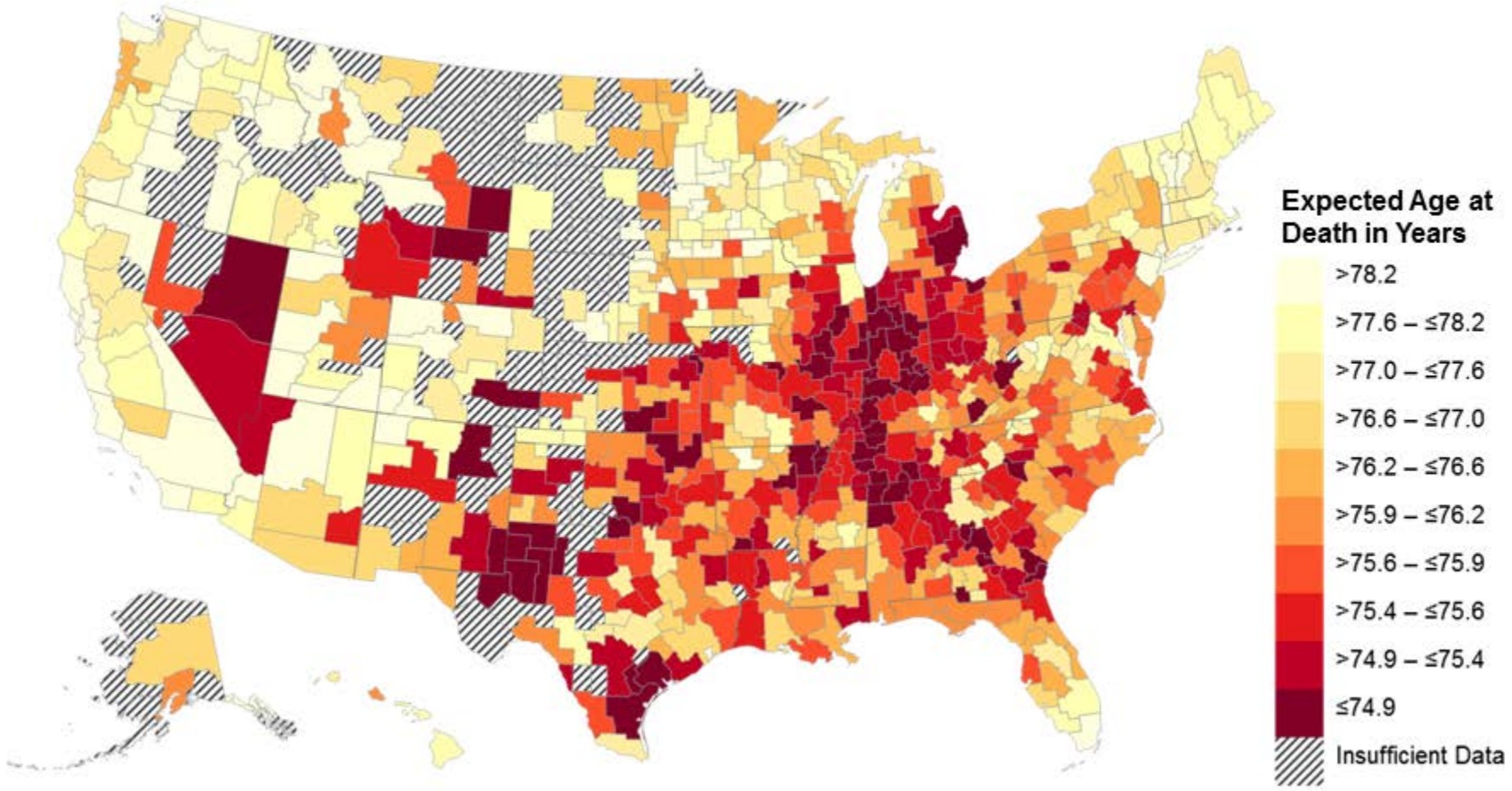
- We analyze geographic variation at the level of commuting zones
  - Commuting zones are aggregations of counties (analogous to metro areas)
  - Also report county-level results

- Prior work has not disaggregated geographical variation in mortality by income
  - This turns out to be quite important…


Race-Adjusted Expected Age at Death vs. Household Income
for Men in Selected Major Cities
Expected Age at Death for 40 Year Olds in Years
70
75
80
85
90
New York City
San Francisco
Dallas
Detroit
0
5
$30k
10
$60k
15
$101k
20
$683k
Household Income Ventile

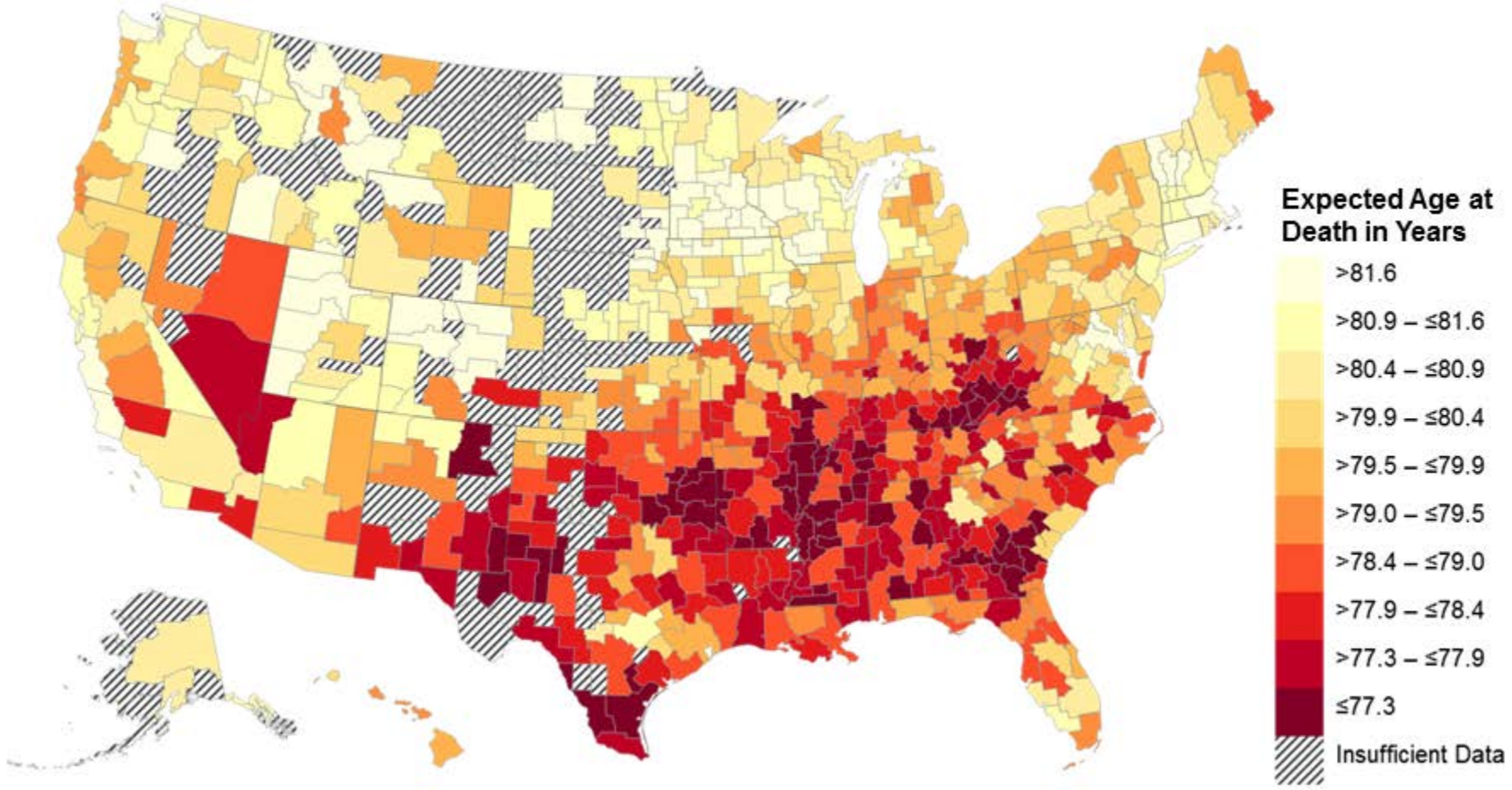

Race-Adjusted Expected Age at Death vs. Household Income
for Women in Selected Major Cities
Expected Age at Death for 40 Year Olds in Years
90
85
80
75
70
New York City
San Francisco
Dallas
Detroit
0
5
$27k
10
$54k
15
$95k
20
$653k
Household Income Ventile

# Race-Adjusted Expected Age at Death for 40 Year Old Men
# Bottom Quartile of U.S. Income Distribution



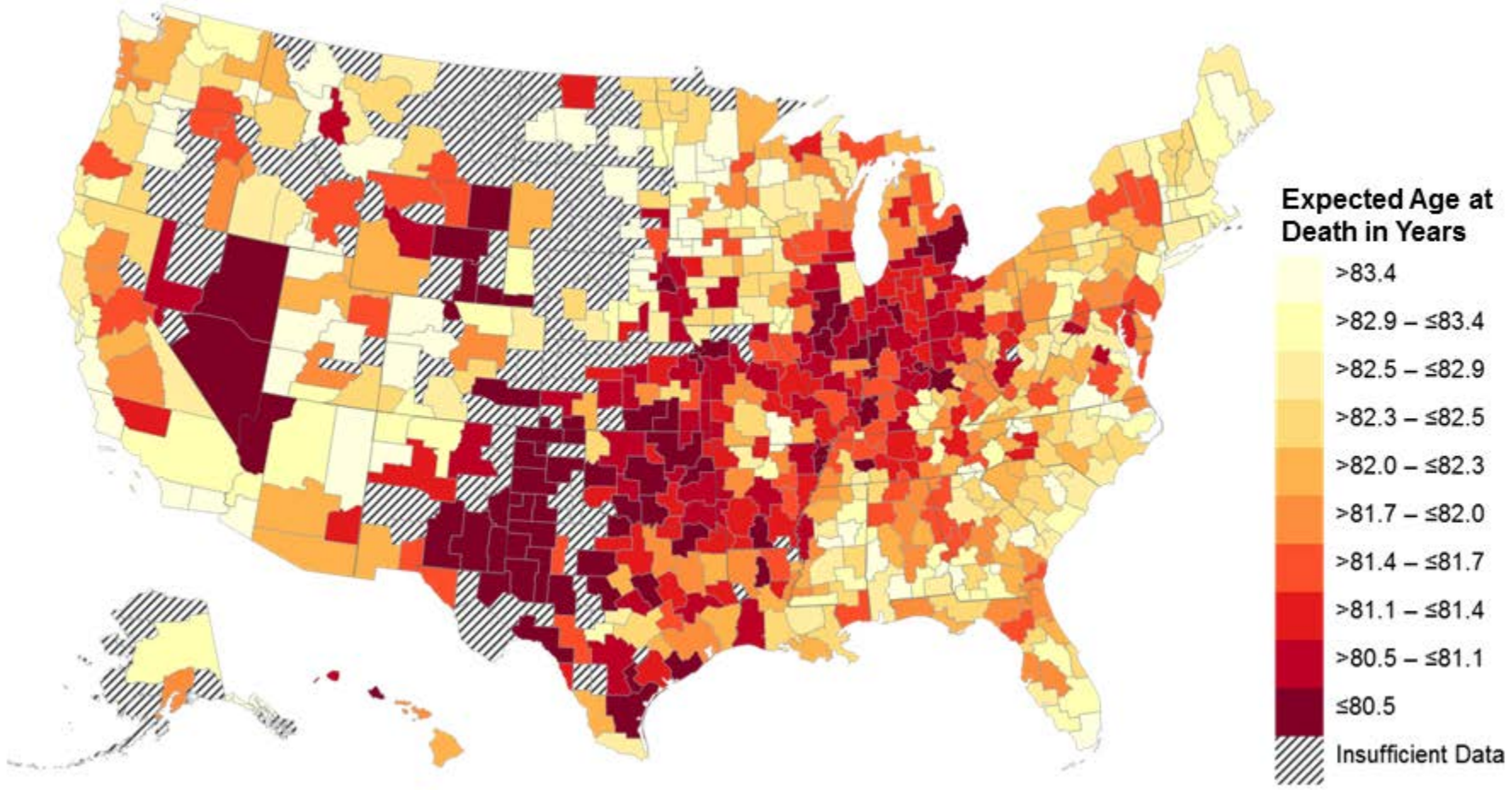

*Note: Lighter Colors Represent Areas with Higher Life Expectancy*

# Race-Adjusted Expected Age at Death for 40 Year Old Men
## Pooling All Income Groups



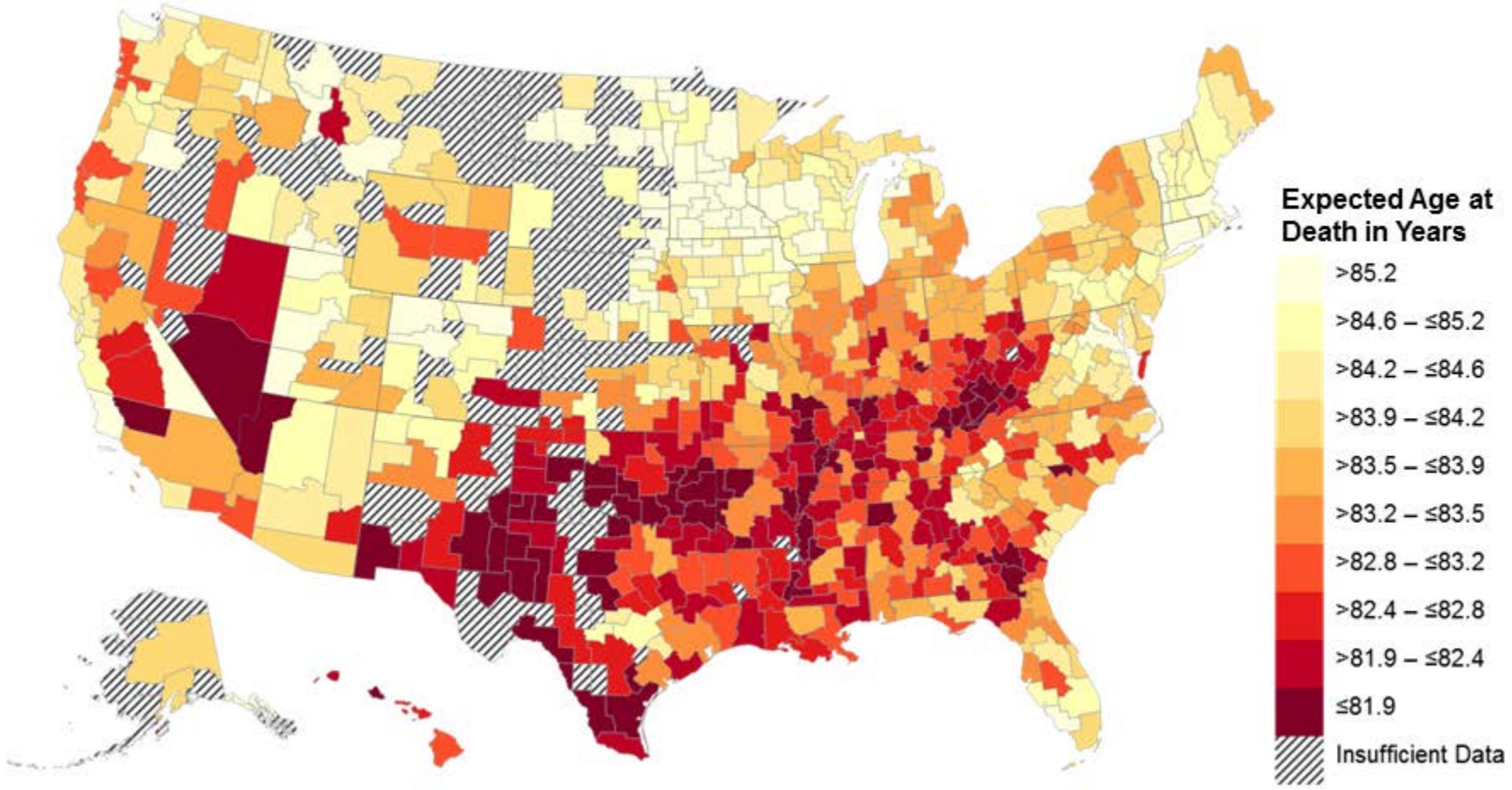

*Note: Lighter Colors Represent Areas with Higher Life Expectancy*

# Race-Adjusted Expected Age at Death for 40 Year Old Women
# Bottom Quartile of U.S. Income Distribution




*Note: Lighter Colors Represent Areas with Higher Life Expectancy*

# Race-Adjusted Expected Age at Death for 40 Year Old Women
## Pooling All Income Groups




*Note: Lighter Colors Represent Areas with Higher Life Expectancy*

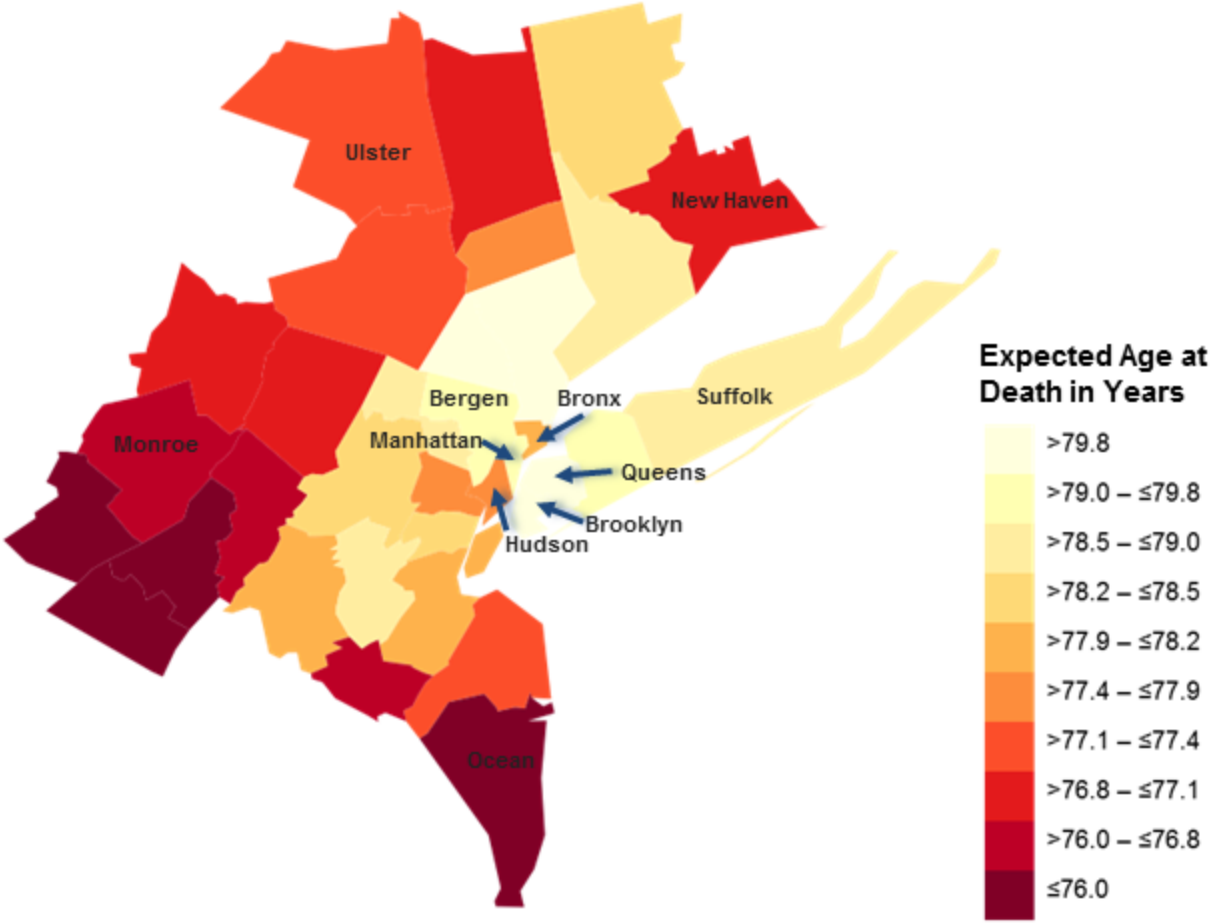
## Race-Adjusted Expected Age at Death for 40 Year Olds in Bottom Quartile

Top 10 and Bottom 10 CZs Among 100 Largest CZs

| Top 10 CZs | | | Bottom 10 CZs | | |
|---|---|---|---|---|---|
| Rank | CZ | Expected Age at Death | Rank | CZ | Expected Age at Death |
| 1 | New York, NY | 81.8 (81.6, 82.0) | 91 | San Antonio, TX | 78.0 (77.6, 78.4) |
| 2 | Santa Barbara, CA | 81.7 (81.3, 82.1) | 92 | Louisville, KY | 77.9 (77.7, 78.2) |
| 3 | San Jose, CA | 81.6 (81.2, 82.0) | 93 | Toledo, OH | 77.9 (77.6, 78.2) |
| 4 | Miami, FL | 81.2 (80.9, 81.6) | 94 | Cincinnati, OH | 77.9 (77.7, 78.1) |
| 5 | Los Angeles, CA | 81.1 (80.9, 81.4) | 95 | Detroit, MI | 77.7 (77.5, 77.8) |
| 6 | San Diego, CA | 81.1 (80.8, 81.4) | 96 | Tulsa, OK | 77.6 (77.4, 77.9) |
| 7 | San Francisco, CA | 80.9 (80.6, 81.3) | 97 | Indianapolis, IN | 77.6 (77.4, 77.8) |
| 8 | Santa Rosa, CA | 80.8 (80.5, 81.2) | 98 | Oklahoma City, OK | 77.6 (77.3, 77.8) |
| 9 | Newark, NJ | 80.7 (80.5, 80.9) | 99 | Las Vegas, NV | 77.6 (77.4, 77.8) |
| 10 | Port St. Lucie, FL | 80.7 (80.5, 80.9) | 100 | Gary, IN | 77.4 (77.1, 77.8) |

*Note: 95% confidence intervals shown in parentheses*

# Race-Adjusted Expected Age at Death for 40 Year Old Men in Bottom Quartile By County in the New York Area

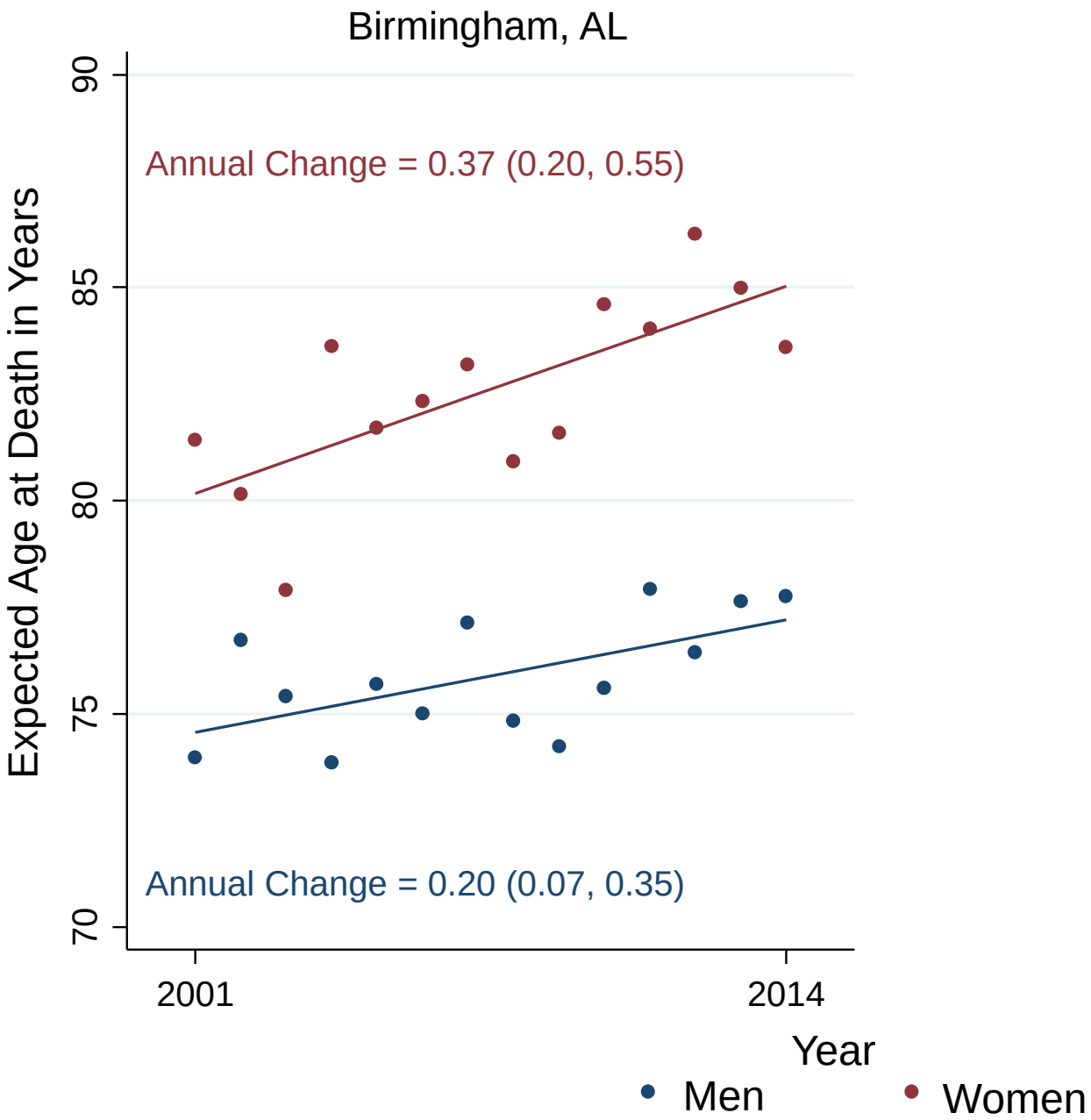


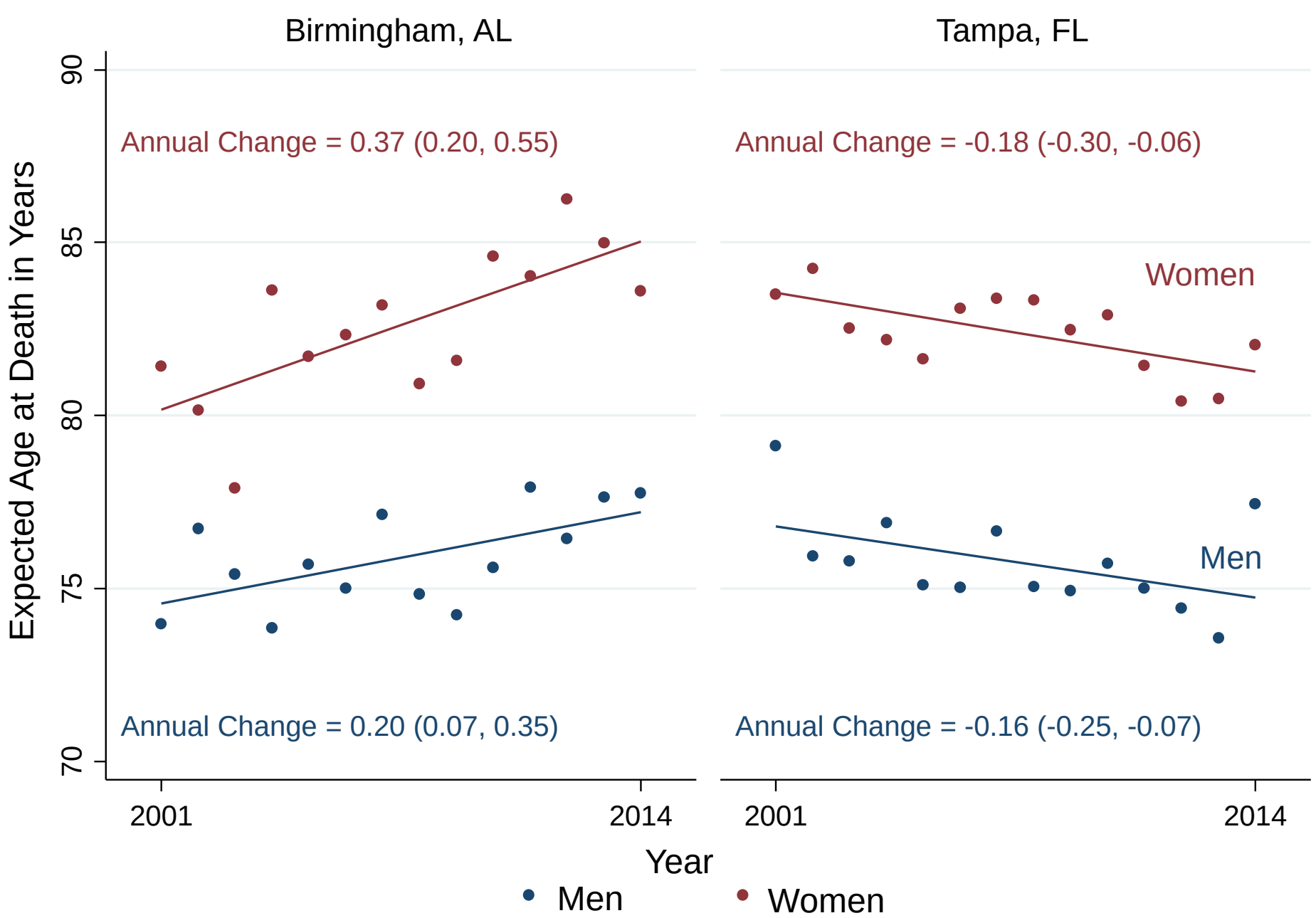

*Note: Lighter Colors Represent Areas with Higher Life Expectancy*

# Local Area Variation in Trends

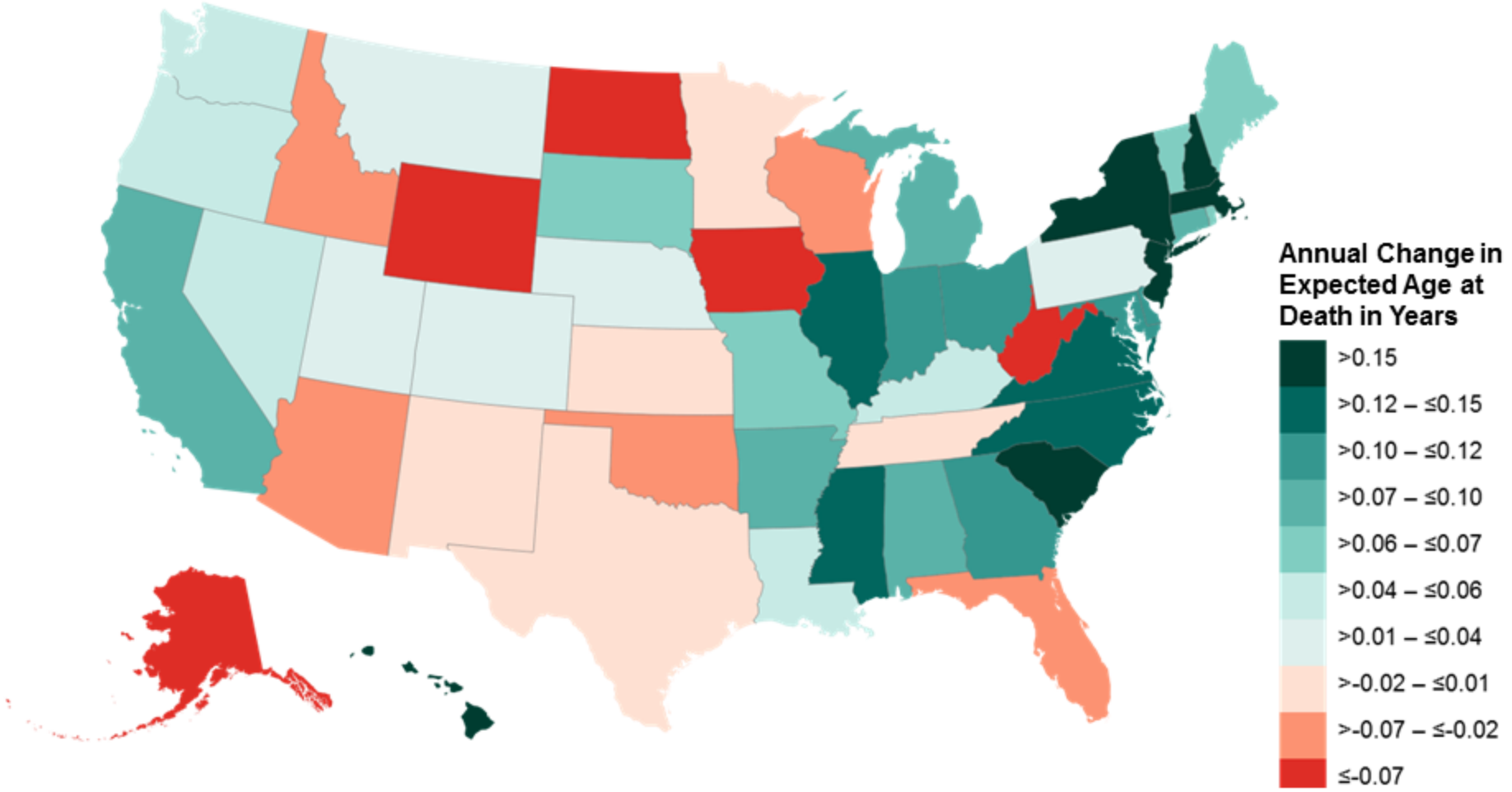
- Next, analyze how *trends* in life expectancy vary across areas

# Change in Race-Adjusted Expected Age at Death in Bottom Quartile



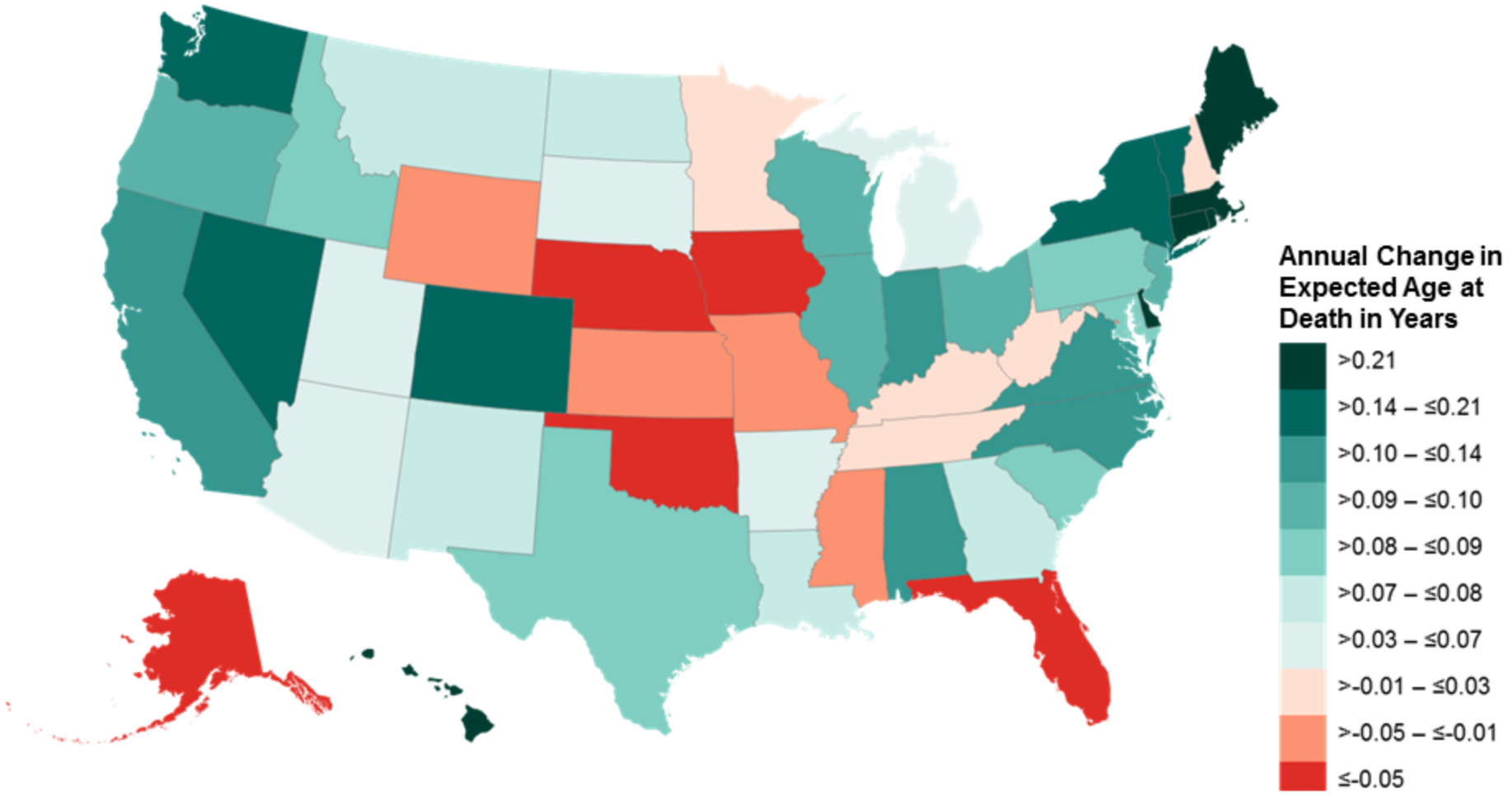

Change in Race-Adjusted Expected Age at Death in Bottom Quartile
Birmingham, AL
Tampa, FL
Annual Change = 0.37 (0.20, 0.55)
Annual Change = -0.18 (-0.30, -0.06)
Women
Men
Annual Change = 0.20 (0.07, 0.35)
Annual Change = -0.16 (-0.25, -0.07)
Expected Age at Death in Years
90
85
80
75
70
2001
2014
2001
2014
Year
Men
Women

# Annual Change in Race-Adjusted Expected Age at Death for Men in Bottom Quartile by State




*Note: Turquoise represents rising life expectancy; red represents falling life expectancy*

# Annual Change in Race-Adjusted Expected Age at Death for Women in Bottom Quartile by State




*Note: Turquoise represents rising life expectancy; red represents falling life expectancy*

## Change in Race-Adjusted Expected Age at Death in Bottom Quartile

Top 10 and Bottom 10 CZs Among 100 Largest CZs

| Top 10 CZs | | | Bottom 10 CZs | | |
|---|---|---|---|---|---|
| Rank | CZ | Change over Decade | Rank | CZ | Change over Decade |
| 1 | Toms River, NJ | 3.8 (2.4, 5.2) | 91 | Cape Coral, FL | -0.7 (-2.1, 0.6) |
| 2 | Birmingham, AL | 2.9 (1.8, 4.1) | 92 | Miami, FL | -0.7 (-1.4, -0.1) |
| 3 | Richmond, VA | 2.6 (1.3, 3.9) | 93 | Tucson, AZ | -0.7 (-2.0, 0.5) |
| 4 | Syracuse, NY | 2.5 (1.1, 4.0) | 94 | Albuquerque, NM | -0.8 (-2.2, 0.6) |
| 5 | Cincinnati, OH | 2.4 (1.5, 3.4) | 95 | Sarasota, FL | -0.8 (-2.0, 0.3) |
| 6 | Fayetteville, NC | 2.4 (1.0, 3.8) | 96 | Des Moines, IA | -1.0 (-3.0, 0.8) |
| 7 | Springfield, MA | 2.3 (0.6, 4.1) | 97 | Bakersfield, CA | -1.2 (-2.8, 0.3) |
| 8 | Gary, IN | 2.2 (0.8, 3.8) | 98 | Knoxville, TN | -1.2 (-2.6, 0.1) |
| 9 | Scranton, PA | 2.1 (0.8, 3.4) | 99 | Pensacola, FL | -1.5 (-3.0, -0.2) |
| 10 | Honolulu, HI | 2.1 (0.5, 3.8) | 100 | Tampa, FL | -1.7 (-2.5, -0.9) |

*Note: 95% confidence intervals shown in parentheses*

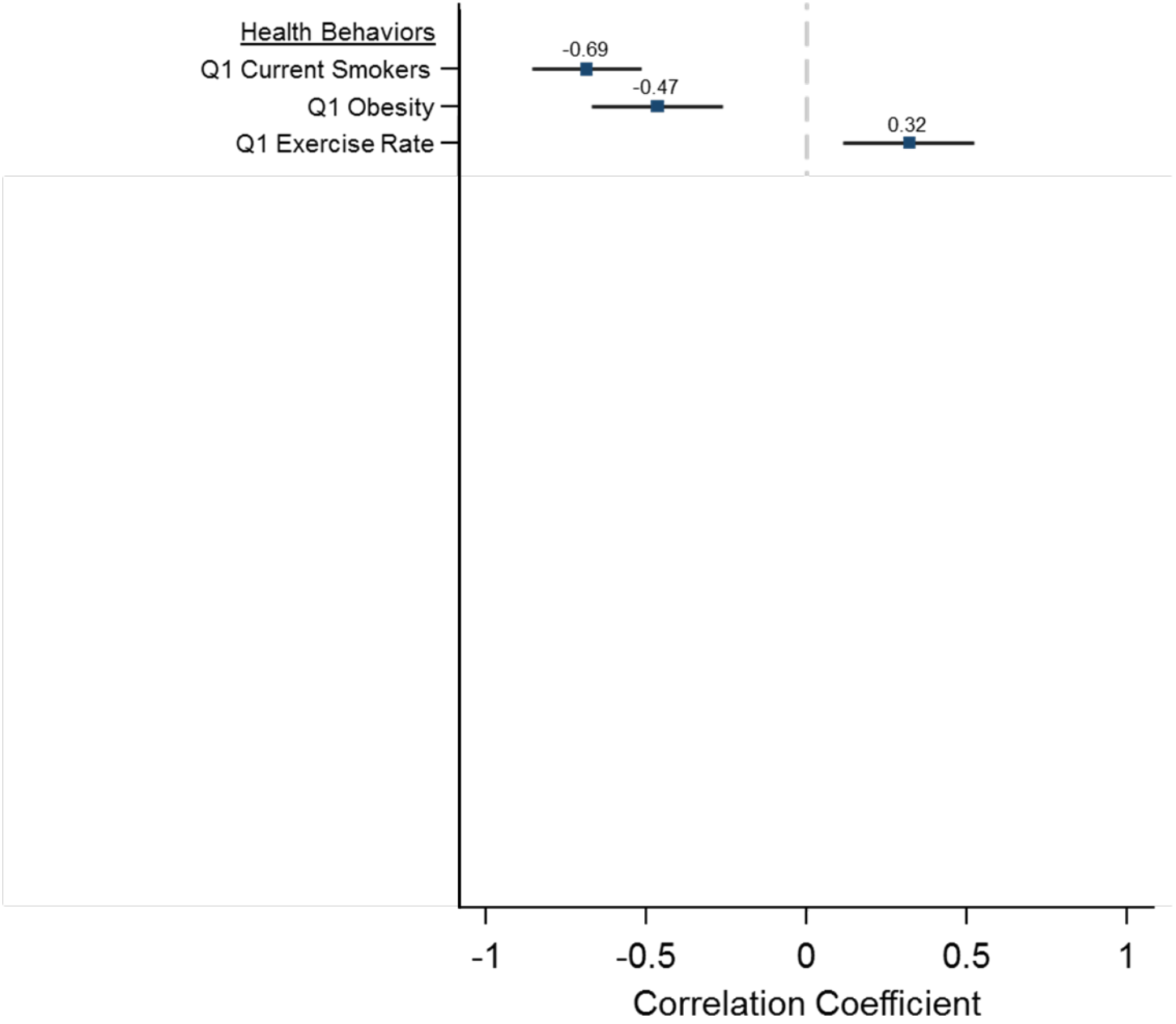
# Part 4: Correlates of Spatial Variation in Mortality

# Why Does Life Expectancy Vary Across Areas?

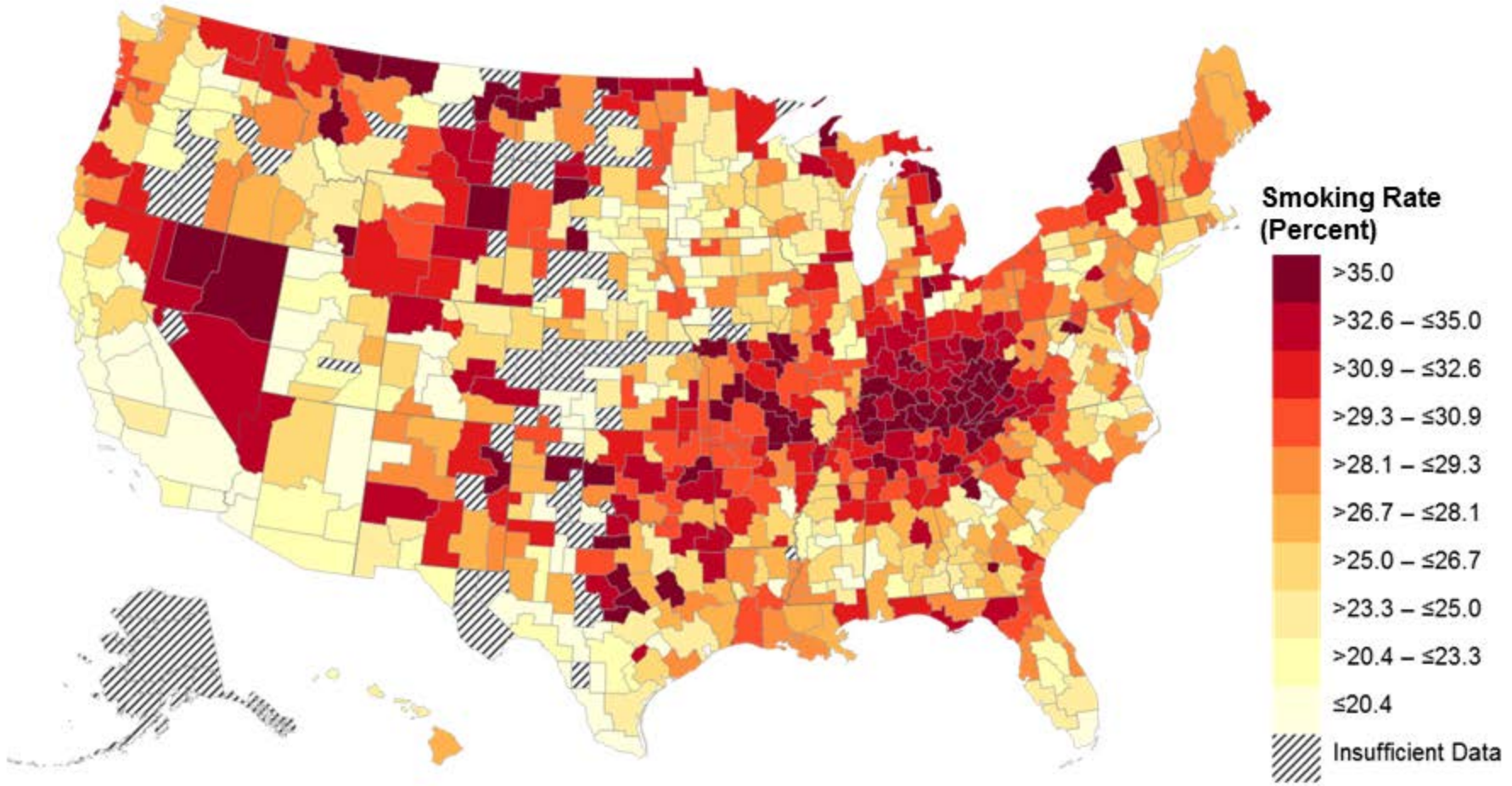
- Finally, we characterize the features of areas with high vs. low life expectancy conditional on income
  - Analysis is purely correlational: does not directly identify causal pathways that can be manipulated to change mortality
- Begin by assessing measures of health behavior using data from the BRFSS [Fuchs 1974]

# Correlations of Expected Age at Death with Health and Social Factors

For Individuals in Bottom Quartile of Income Distribution



# Smoking Rates by Commuting Zone
in Bottom Quartile




*Note: Lighter Colors Represent Areas Lower Smoking Rates*

# Why Does Life Expectancy Vary Across Areas?

- Variation in life expectancy among low income individuals is strongly related to variation in health behaviors

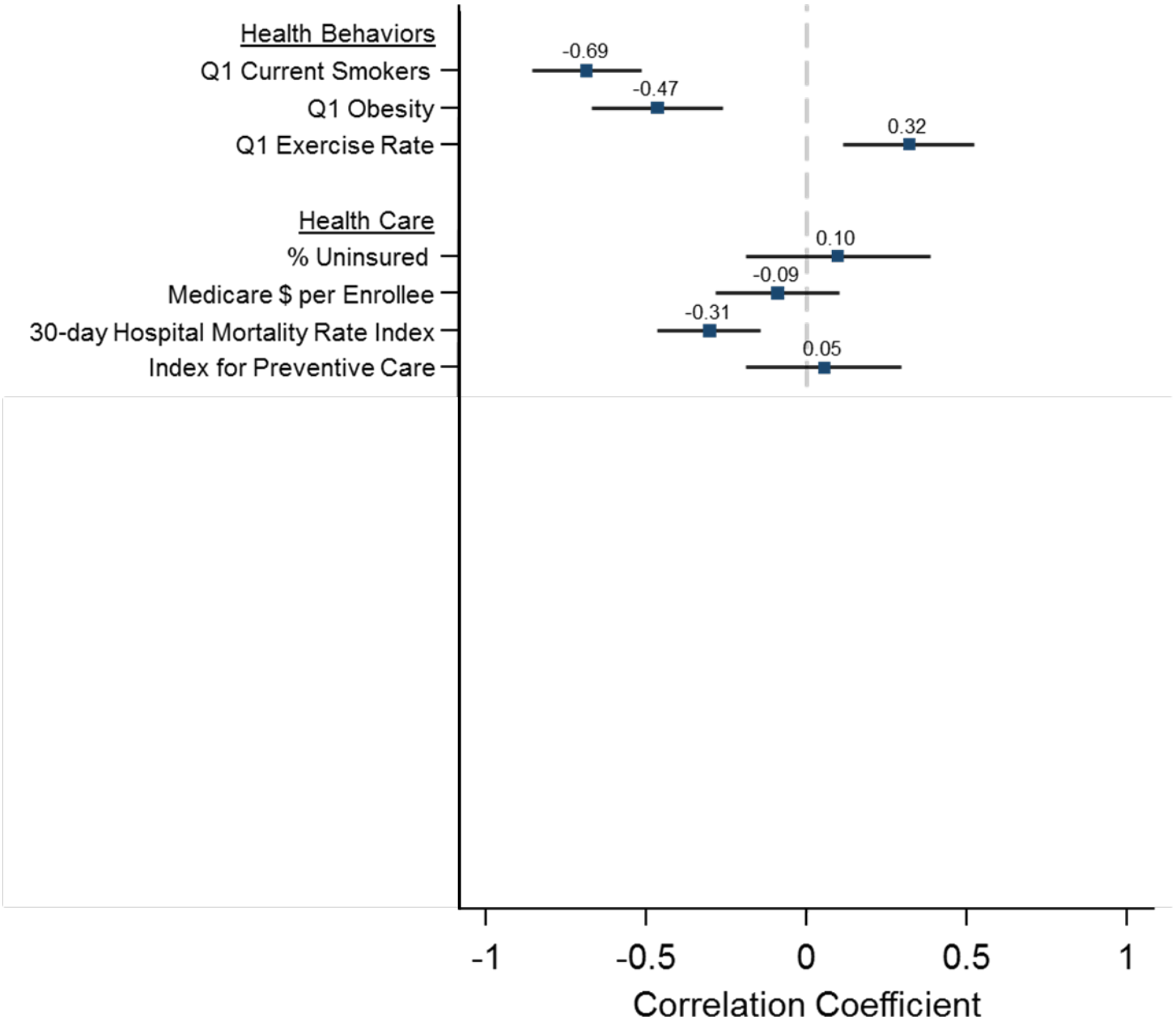
- What generates spatial variation in health behaviors and outcomes?

- We focus here on four theories discussed widely in literature:

  1. Health care [Fisher et al. 1993, Almond et al. 2010, Doyle et al. 2015]
  2. Environmental factors [Dockery et al. 1993, Currie and Neidell 2005]
  3. Income inequality [Lynch et al.1998, Deaton and Lubotsky 2001, Wilkinson 2005]
  4. Economic decline [Ruhm 2000, Sullivan and von Wachter 2009]

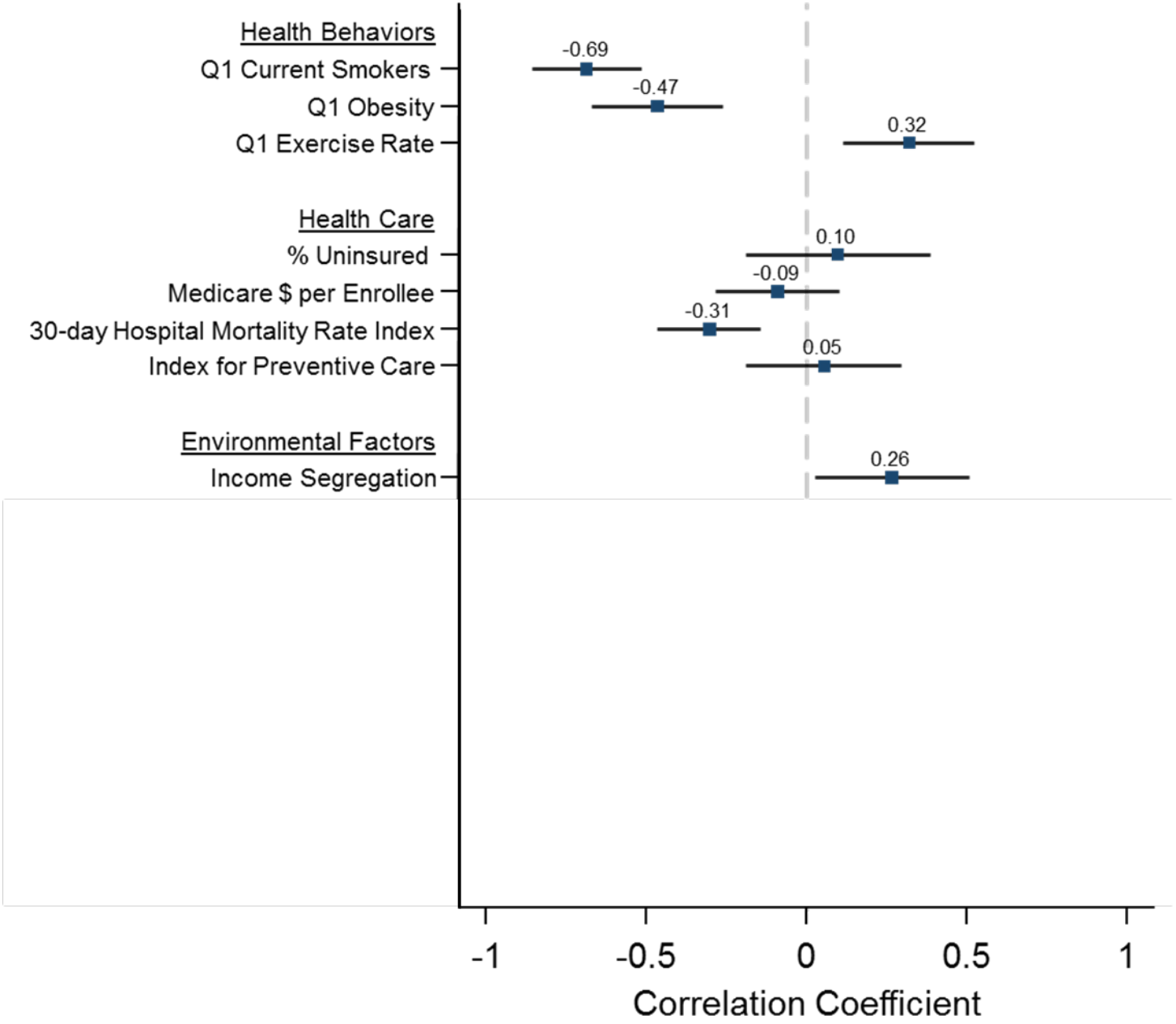
# Correlations of Expected Age at Death with Health and Social Factors

For Individuals in Bottom Quartile of Income Distribution



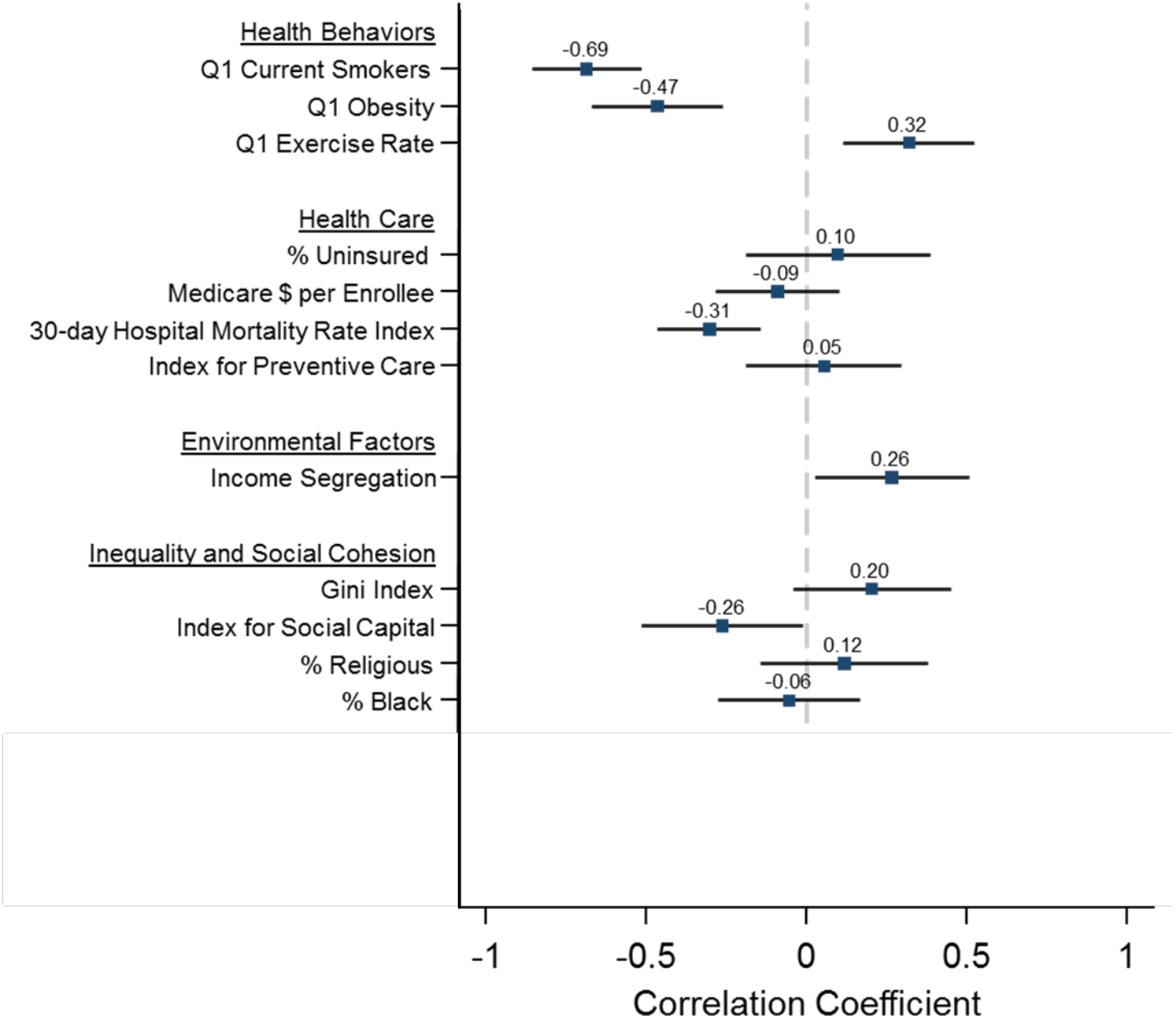
# Correlations of Expected Age at Death with Health and Social Factors

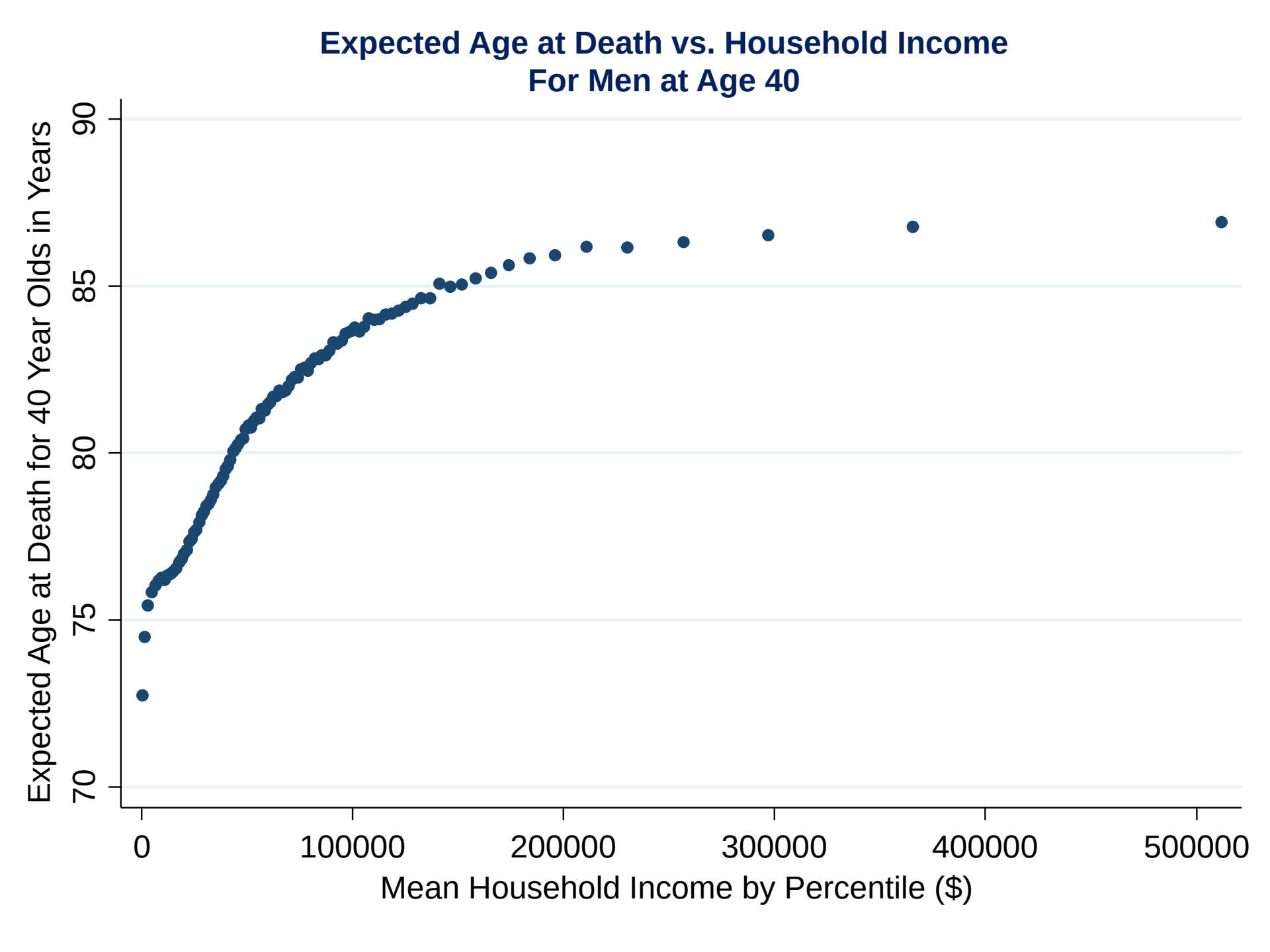
For Individuals in Bottom Quartile of Income Distribution



# Correlations of Expected Age at Death with Health and Social Factors

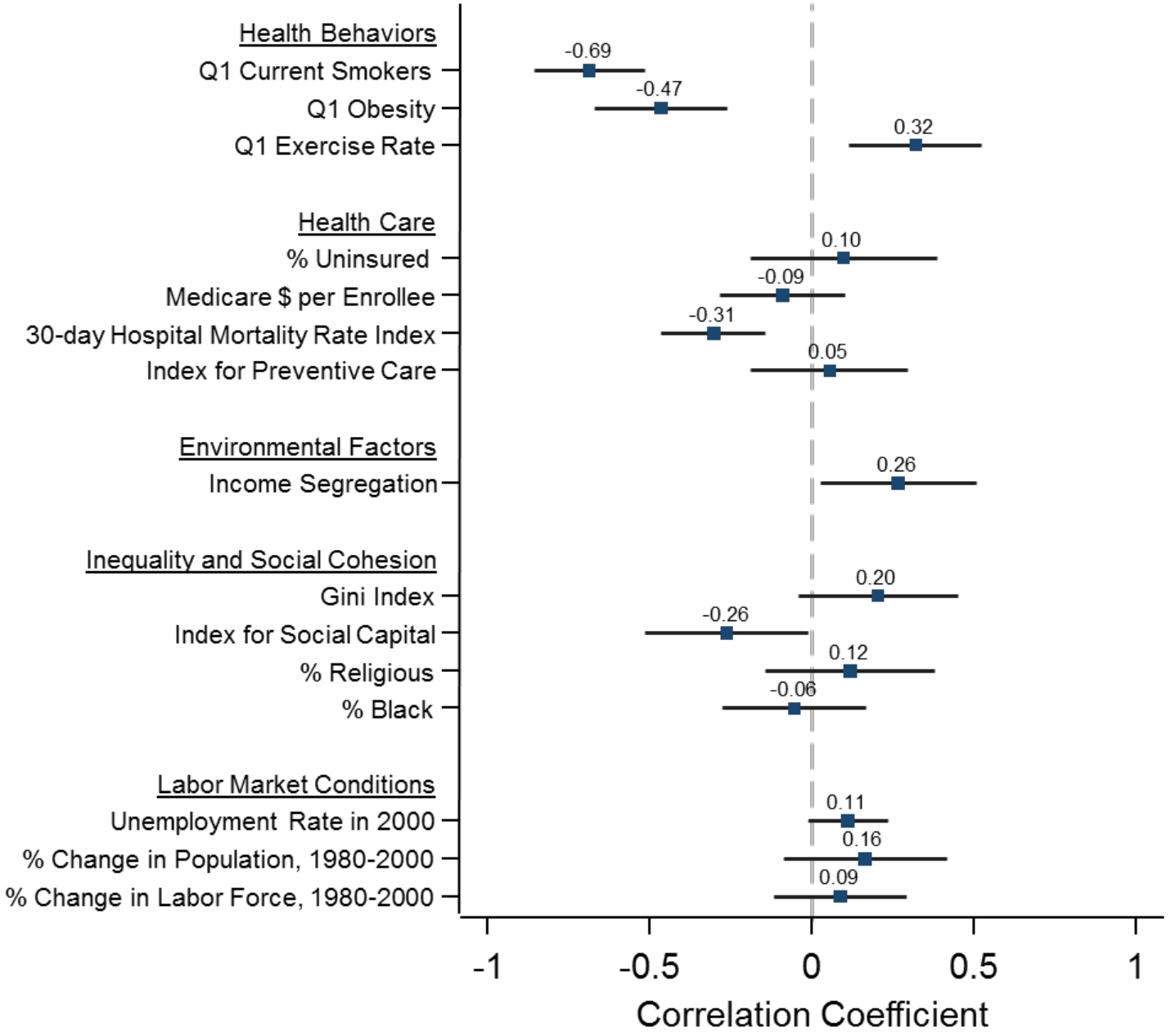
For Individuals in Bottom Quartile of Income Distribution




Expected Age at Death vs. Household Income
For Men at Age 40
Expected Age at Death for 40 Year Olds in Years
70
75
80
85
90
0
100000
200000
300000
400000
500000
Mean Household Income by Percentile ($)

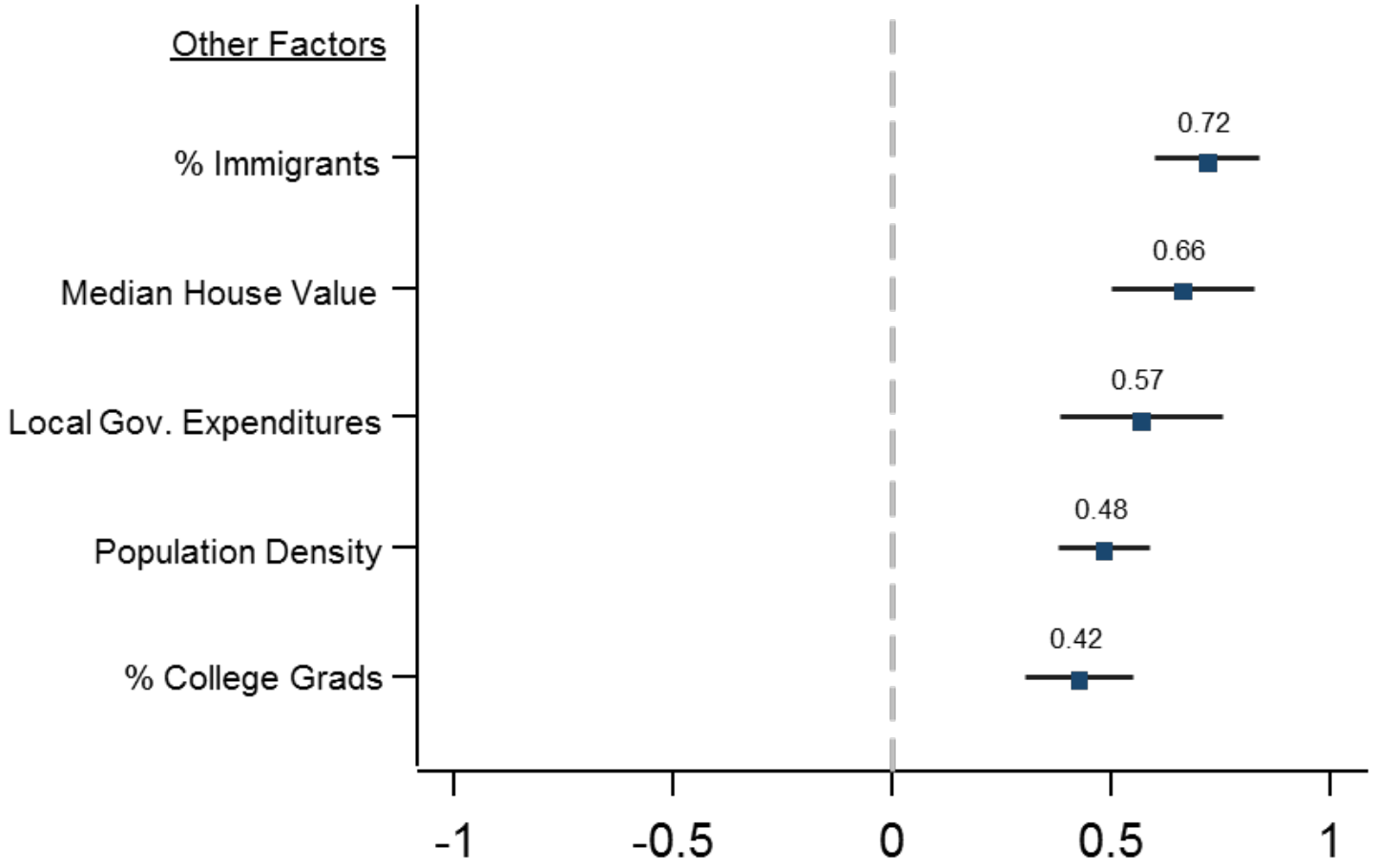
# Correlations of Expected Age at Death with Health and Social Factors

## For Individuals in Bottom Quartile of Income Distribution



# Correlations of Expected Age at Death with Other Factors

For Individuals in Bottom Quartile of Income Distribution



# Correlations: Summary

- General pattern: Low-income people in affluent, educated cities live longer (and have healthier behaviors)

- Why is this the case?
  - Spillovers from rich to poor: regulation, public revenues/transfers
  - Exposure to people with healthier behaviors
  - Sorting: low-income people who live in expensive cities are a selected group with different characteristics
  - Ongoing work by other researchers will shed light on these alternative mechanisms

# Conclusion

- Inequality in life expectancy is large and growing, but not immutable: some areas in the U.S. have relatively small and shrinking gaps
- Differential trends imply that indexing eligibility for Social Security and Medicare to mean life expectancy will affect progressivity
- Reducing health disparities likely to require local policy interventions
  - Ex: targeted efforts to improve health among low-income individuals in Las Vegas, Tulsa, and Oklahoma City
  - Changing health behaviors at local level likely to be important
- Statistics constructed here (available at www.healthinequality.org) provide a tool to monitor local progress and identify solutions