Week 9 Lecture: Time

ECON 125: The Science of Population

Age, Period, and Cohort

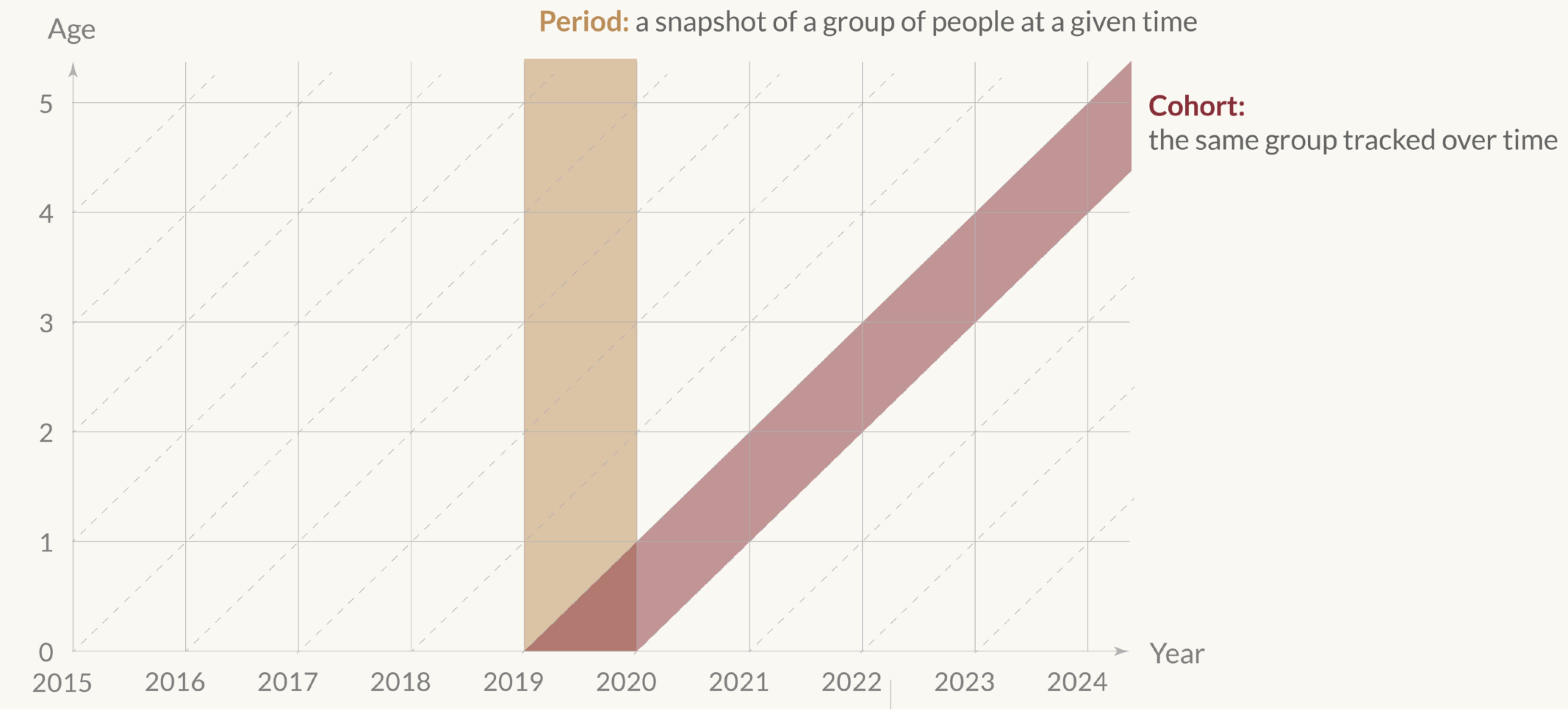
This lecture is about studying changes in outcomes...

- between people born at different times
- over time as a population experiences shared trends and fluctuations
- within people's lives as they get older

We will see that we generally cannot separate these forces in the data

The **age-period-cohort problem** comes up in MANY applications!

Ages, Periods, and Cohorts: The Lexis Diagram



Example 1: Life-Cycle **Consumption** Profiles

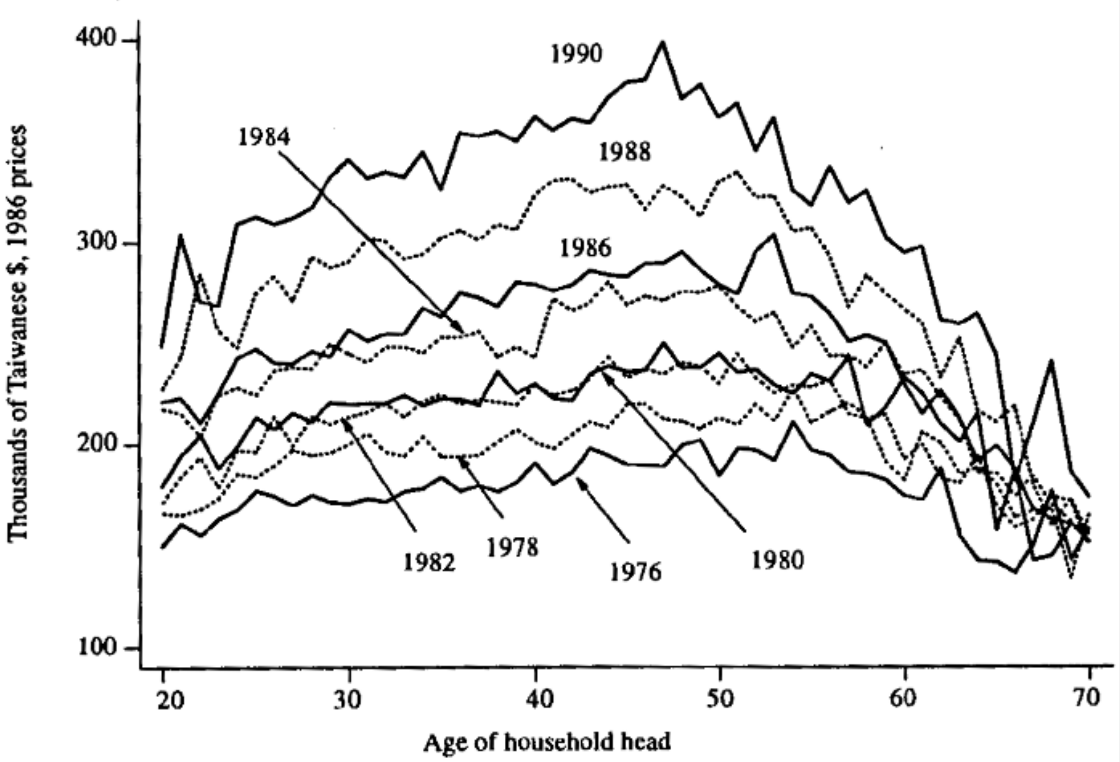
Econ majors may remember the Permanent Income Hypothesis (PIH)

- Due to Milton Friedman
- Predicted that people's consumption is constant over the life-cycle, equal to lifetime income divided by years lived
- Lots of simplification: no uncertainty, perfect credit markets
- Many alternatives and modifications (e.g., Life Cycle Hypothesis)
- But a provocative hypothesis to test

Is it true that consumption is constant over the life-cycle? We get very different answers from cross-sections and cohorts!

20th-century Taiwan

Figure 6.3. Cross-sectional consumption profiles, alternate years, Taiwan (China), 1976–90



Source: Author's calculations from Surveys of Personal Income Distribution, Taiwan (China).

Source: Deaton (1997)

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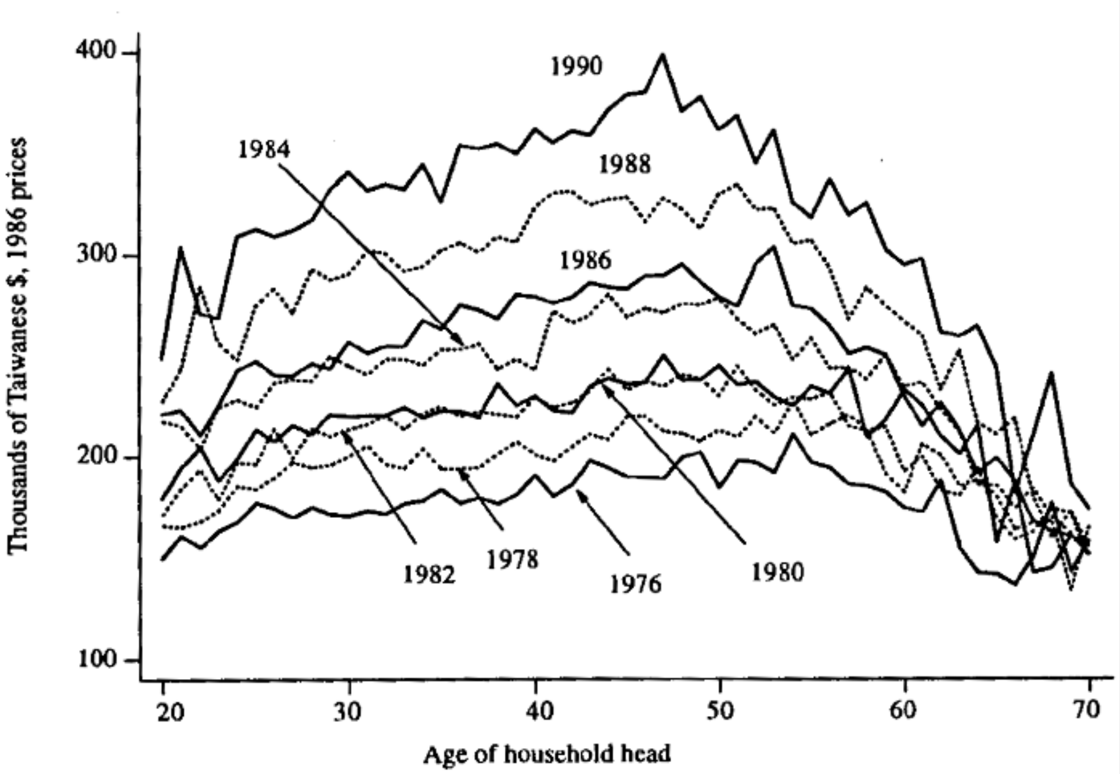
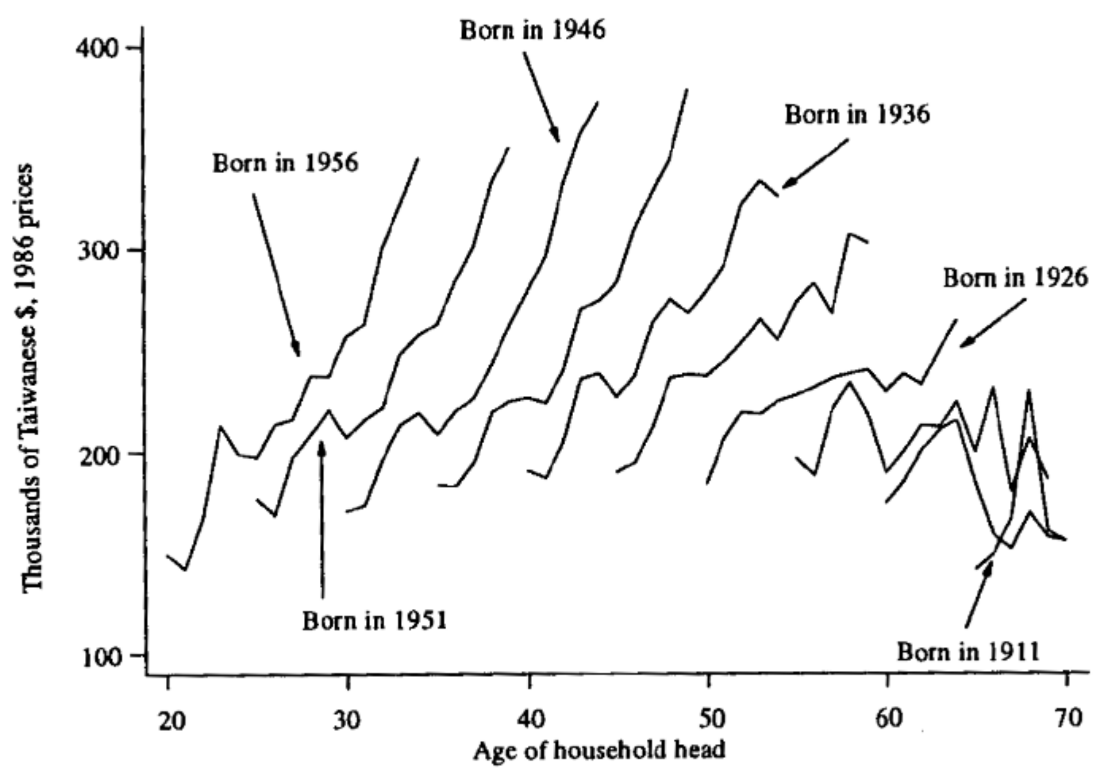


Source: Author's calculations from Surveys of Personal Income Distribution, Taiwan (China).

Figure 6.4. Consumption profiles, selected cohorts, Taiwan (China)



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Source: Deaton (1997)

Example 1: Life-Cycle **Consumption** Profiles

Neither cross-sectional nor cohort age profiles seem consistent with PIH

But cohort age profiles seem particularly at odds with it!

$\rightarrow$ HH consumption per capita rises with head's age at most ages

Patterns for 20^{th}-century Taiwan; other fast-growing economies similar

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Patterns for 20th-century Taiwan; other fast-growing economies similar

Lots of insight about the life-cycle by following cohorts

We would miss them by comparing ages at a point in time

What did we assume about the influences of age, period, and cohort?

Example 2: Life-Cycle **Earnings** Profiles

Also interesting to consider earnings or wages over the life-cycle

- Related to the life-cycle evolution of skills, “return to experience”
- But less canonical in economic theory
- Same issues in comparing cross-sectional and cohort age profiles
- PS 5 will be about life-cycle wage profiles in US and Mexico
- Today, let’s look at US and China
- Again looking through the lens of age and cohort, ignoring period

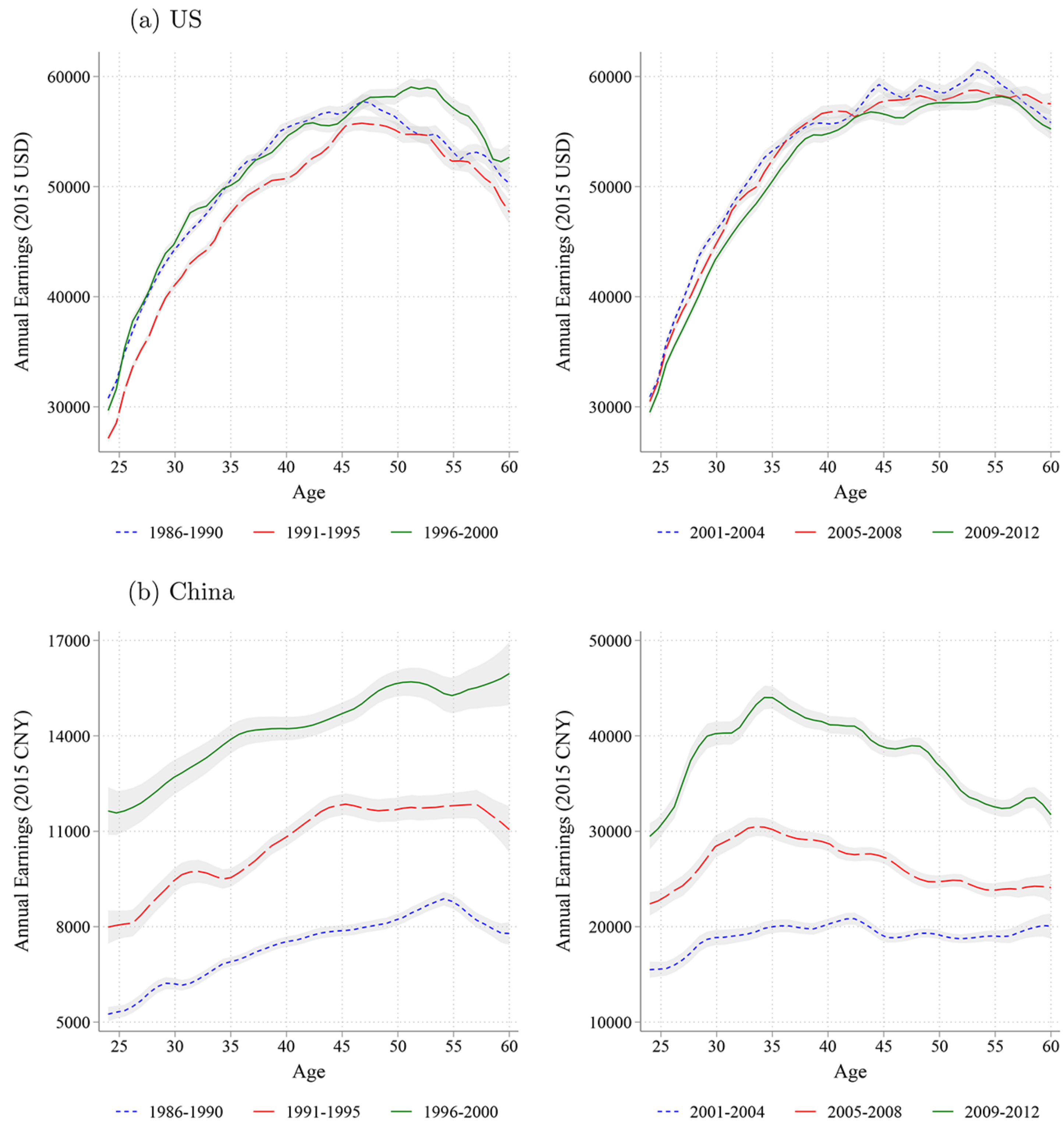

FIG. 1.—Cross-sectional age-earnings profiles. Panel *a* plots the cross-sectional age-earnings profiles of US male workers, using March CPS from 1986 to 2012. Panel *b* plots the cross-sectional age-earnings profiles of Chinese urban male workers, using UHS from 1986 to 2012. Each curve represents a cross section that pools adjacent years. The curves are kernel-smoothed values and the gray shaded areas are the 95% confidence intervals. Note that the vertical scale differs between the two graphs in panel *b*.

Source: Fang and Liu (2023)

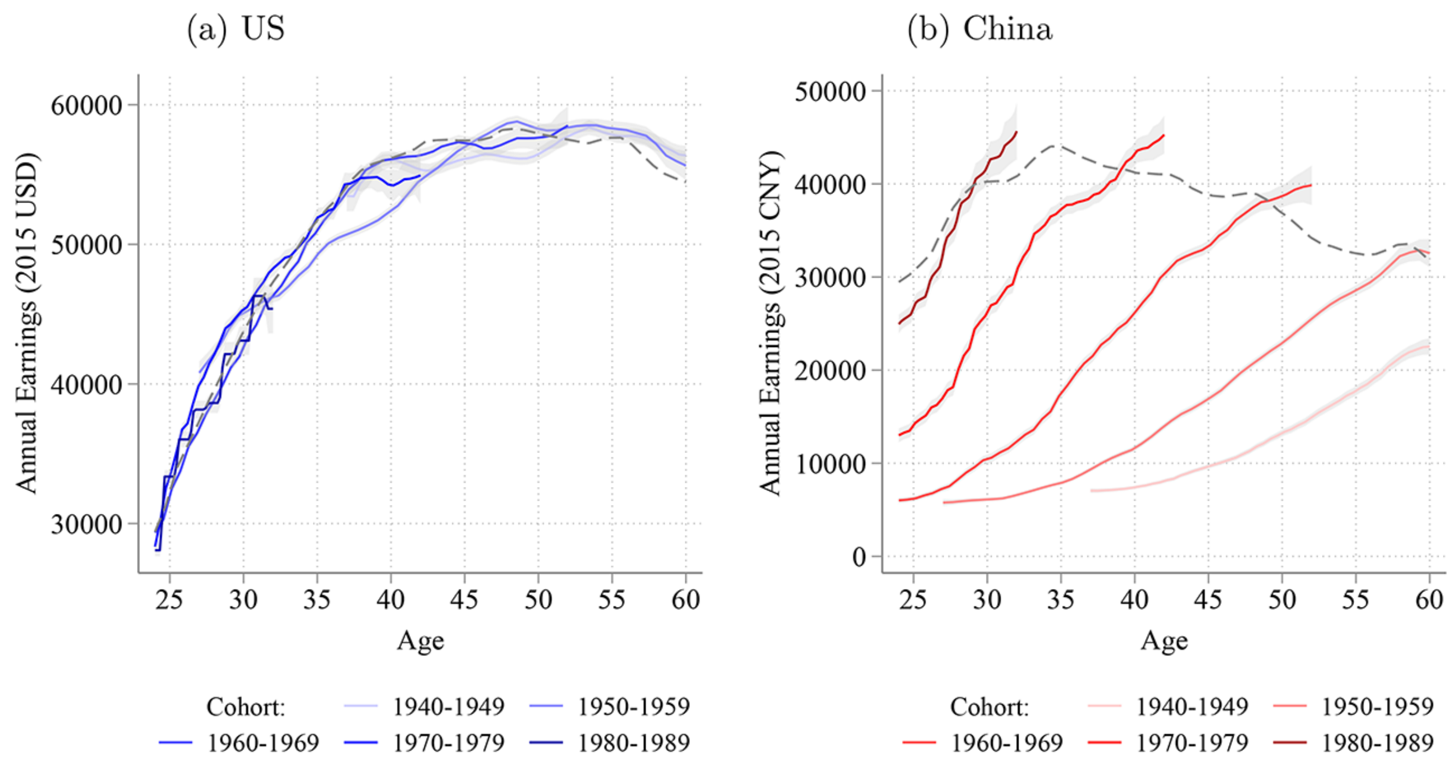

FIG. 3.—Life-cycle age-earnings profiles. Panel *a* plots the life-cycle age-earnings profiles for male workers of different birth cohorts in the United States, and panel *b* for urban China. Each solid line represents a 10-year cohort bin. Darker lines indicate more recent cohorts and lighter lines older cohorts. The gray dashed line in both panels reproduces the cross-sectional profile for 2009–12 from figure 1 for comparison.

Source: Fang and Liu (2023)

Example 2: Life-Cycle **Earnings** Profiles

US life-cycle earnings profiles are similar for all cohorts

- Steep at younger ages then flatten at older ages
- Not much increase between cohorts
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China life-cycle earnings profiles change **dramatically** across cohorts

- Rising with age for all cohorts (a bit more steeply at younger ages)
- Large increases between successive cohorts
- Cross-sectional profiles change from rising to flat to hump-shaped

Age, Period, and Cohort Effects

Theoretically useful concepts!

- Age effects: forces driving lifecycle profile
- Period effects: forces driving change over time
- Cohort effects: forces driving change across people born at diff. times

Many applications in economics and business: household consumption, worker earnings, factory productivity, project revenues

Many applications in health and population studies: mortality, disability, risk behaviors, fertility

Problem! Without restrictions, cannot separately identify A-P-C effects

Some methods address problem, but none solve it—key is to understand it

The Age-Period-Cohort Model

Suppose that outcome y is determined by forces that...

- change with age over a person's life
- evolve over time for the population
- vary across groups born at different times

Then we can write:

$$y_{abt} = \mu + f(a) + g(b) + h(t) + \varepsilon_{abt}$$

where a is age, b is birth year, t is time, and ε_{abt} represents randomness

The Age-Period-Cohort Identification Problem

So we have:

$$y_{abt} = \mu + f(a) + g(b) + h(t) + \varepsilon_{abt}$$

Problem is that a, b, and t and **linearly dependent**: $t = b + a$

In the language of econometrics (or statistics more broadly), a, b, and t are **collinear**, i.e., we cannot include all three in a regression

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Another way to look at it is to note that we can rewrite the model as:

$$y_{ab} = \mu + f(a) + g(b) + h(b + a) + \varepsilon_{ab}$$

So without additional assumptions (typically called “restrictions”), we cannot separately identify $h(\cdot)$ from $f(\cdot)$ and $g(\cdot)$

Restrictions

For some outcomes, we know some forces can be (mostly) excluded:

- Adult educational attainment: mainly cohort, little to no age/period
- Adult height: mainly cohort, some age, little to no period
- Child height: mainly age, some cohort, little period
- Balding: mainly age, little to no cohort/period

These restrictions are based on substantive or scientific knowledge

But for most outcomes, restrictions like these are not plausible

Is It a Problem?

Some researchers think of this vexing statistical challenge as a technical problem that needs to be fixed

I tend to think of it more as a basic property of how time works: as time passes, babies enter the population, and we all get older

This property makes it to study change over people's lives

But it is not a technical problem, and one-size-fits-all fixes will not work

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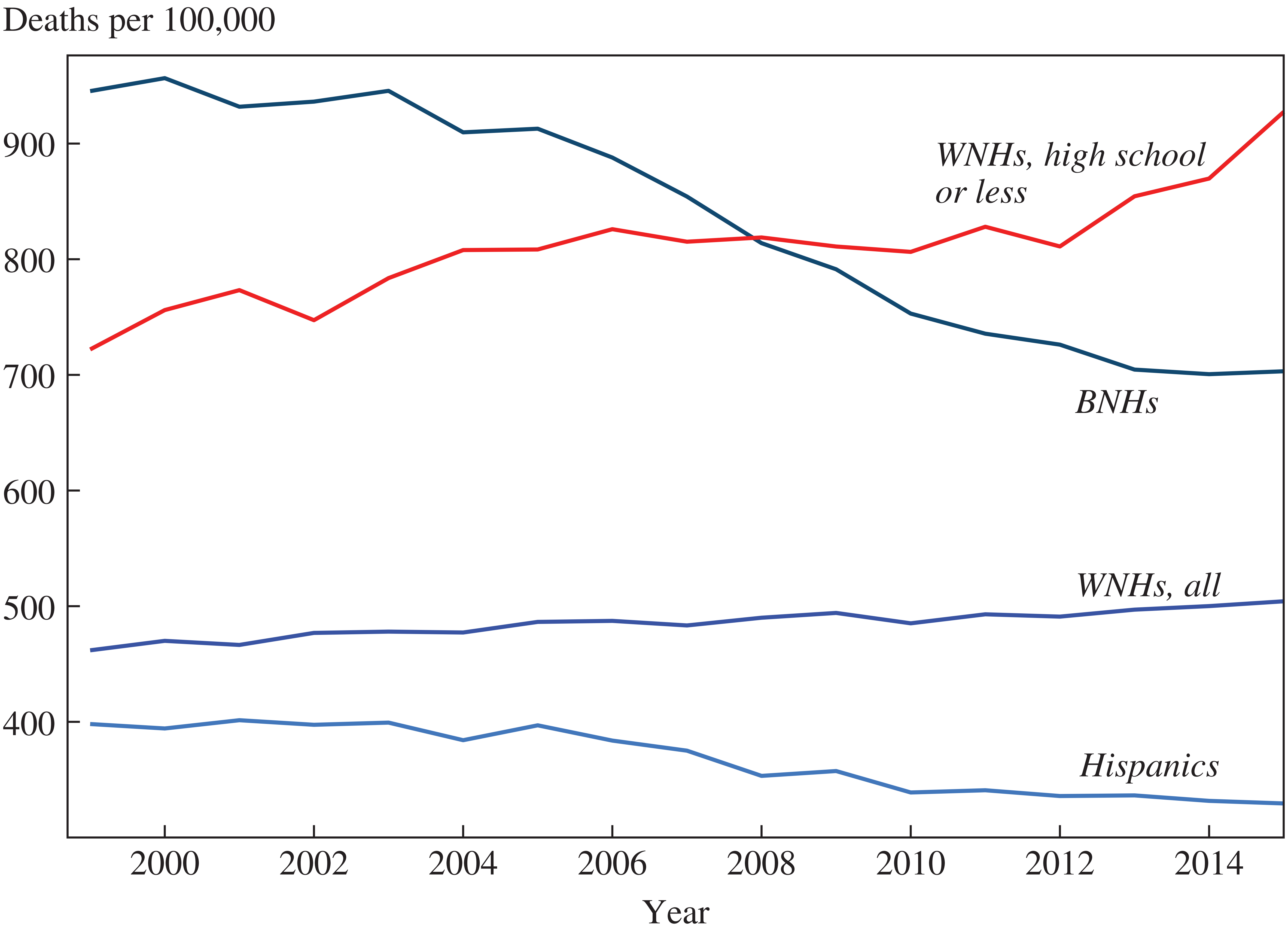
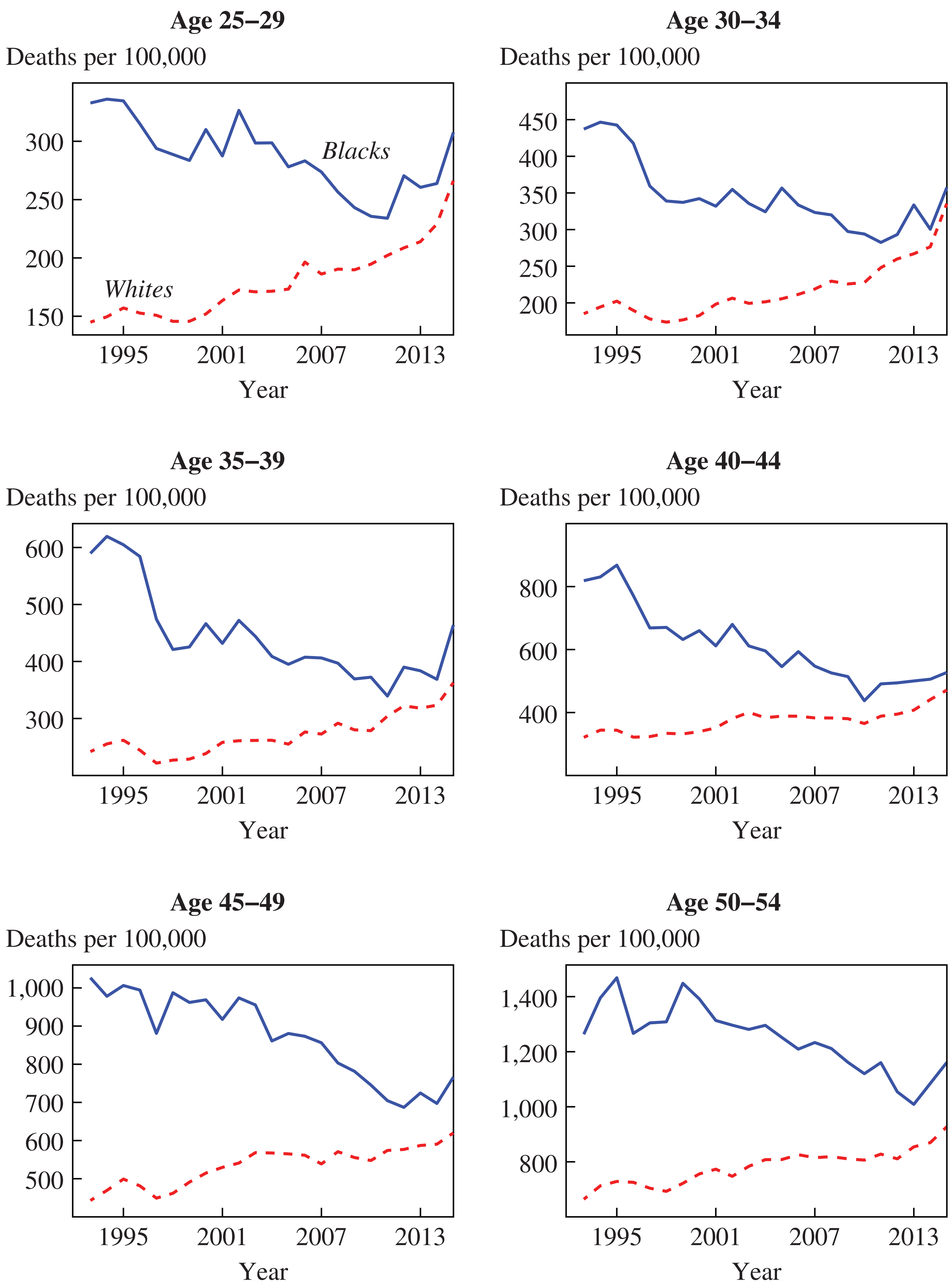
Mortality and Morbidity in the 21st Century

Figure 1. All-Cause Mortality by Race and Ethnicity for Age 50–54, 1999–2015



Sources: CDC WONDER; National Vital Statistics System; authors' calculations.

Figure 2. All-Cause Mortality for Black Non-Hispanics and White Non-Hispanics with a High School Degree or Less, 1993–2015



Mortality Trends in Middle Age by Race, Ethnicity, and Education

Middle-age mortality among white non-Hispanics (WNHs) has risen, especially for those without college degrees

Opposite trend among Black non-Hispanics (BNHs) and among Hispanics, even for those without college degrees

Together, these facts imply falling racial inequality in mortality, for both good and bad reasons

Because WNHs are a large share of the population, middle-age mortality in the US started rising around 2000, departing from other rich countries

Figure 3. All-Cause Mortality by Country for Age 45–54, 1990–2015

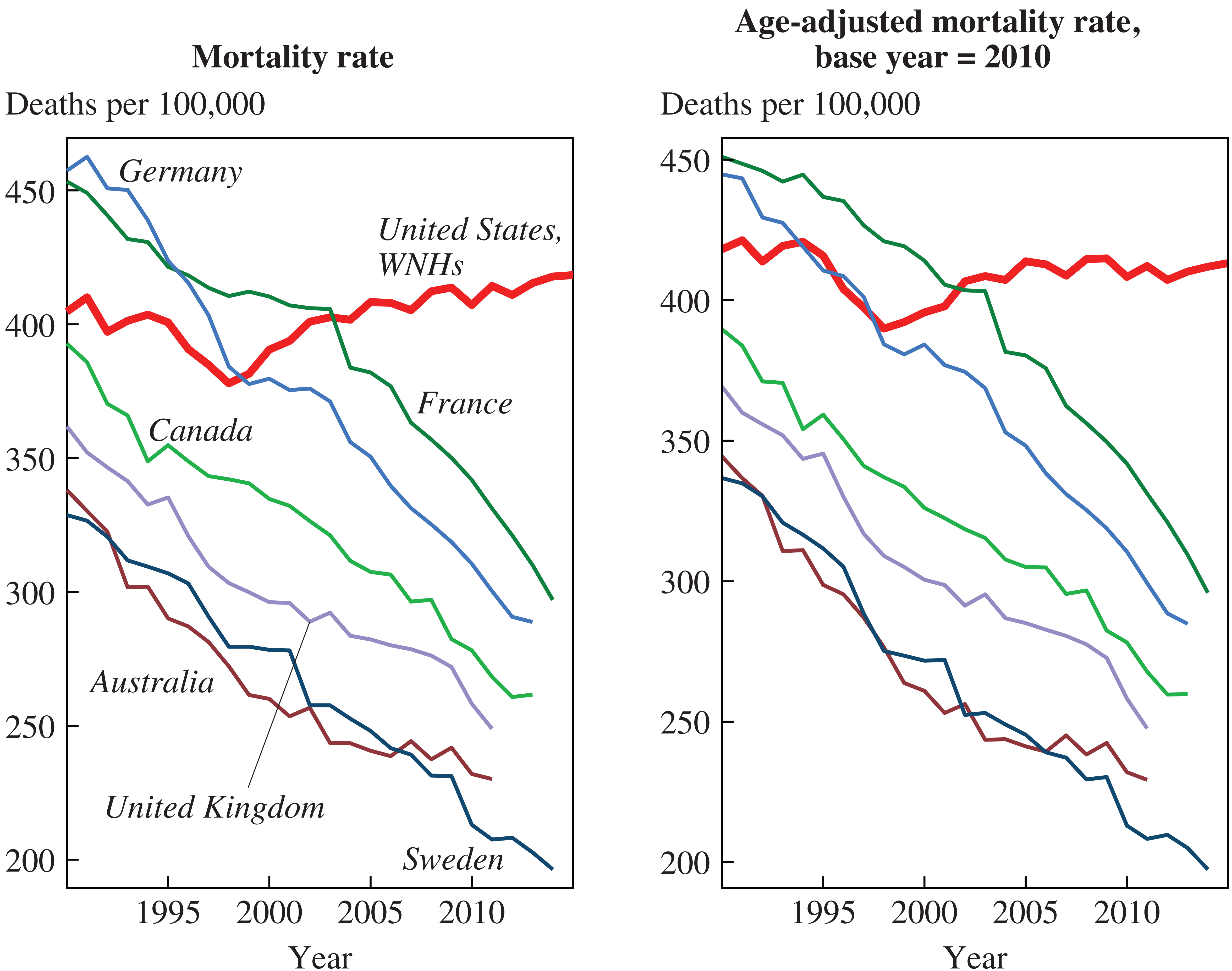
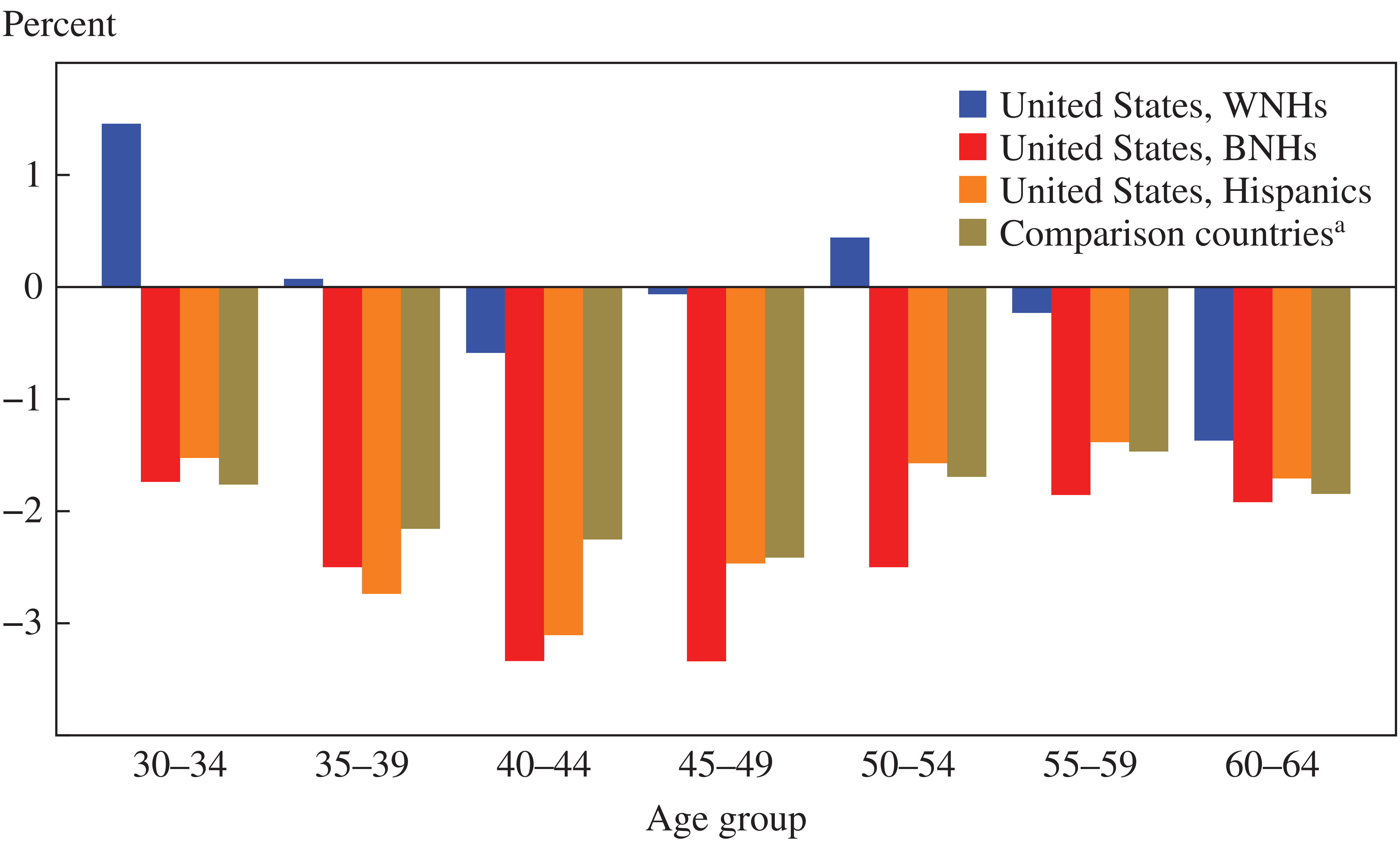
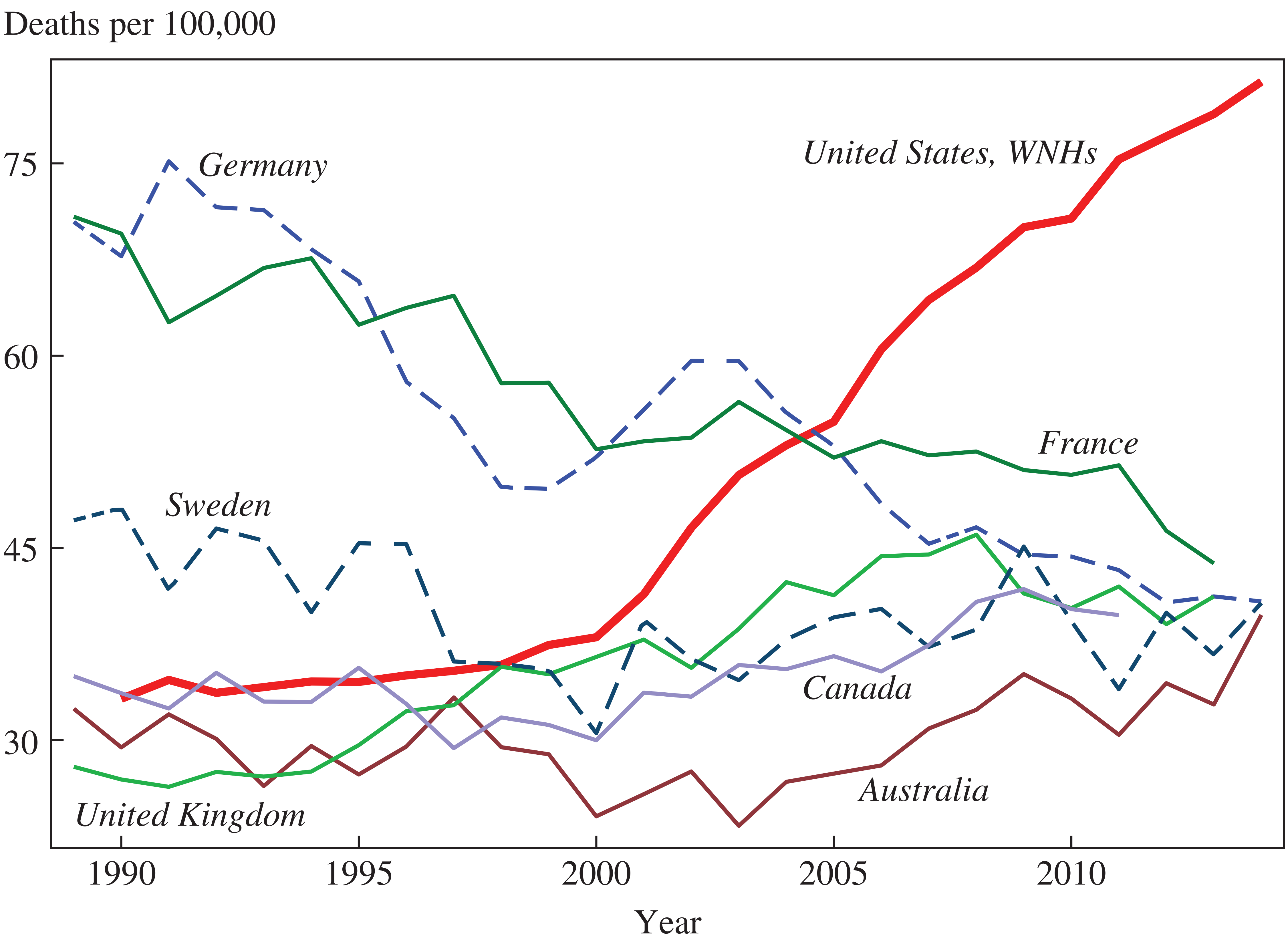


Figure 4. Mortality Trends by Five-Year Age Group, 2000–14



Sources: CDC WONDER; Human Mortality Database; WHO Mortality Database; authors' calculations.
a. The comparison countries are Australia, Canada, France, Germany, Sweden, and the United Kingdom.

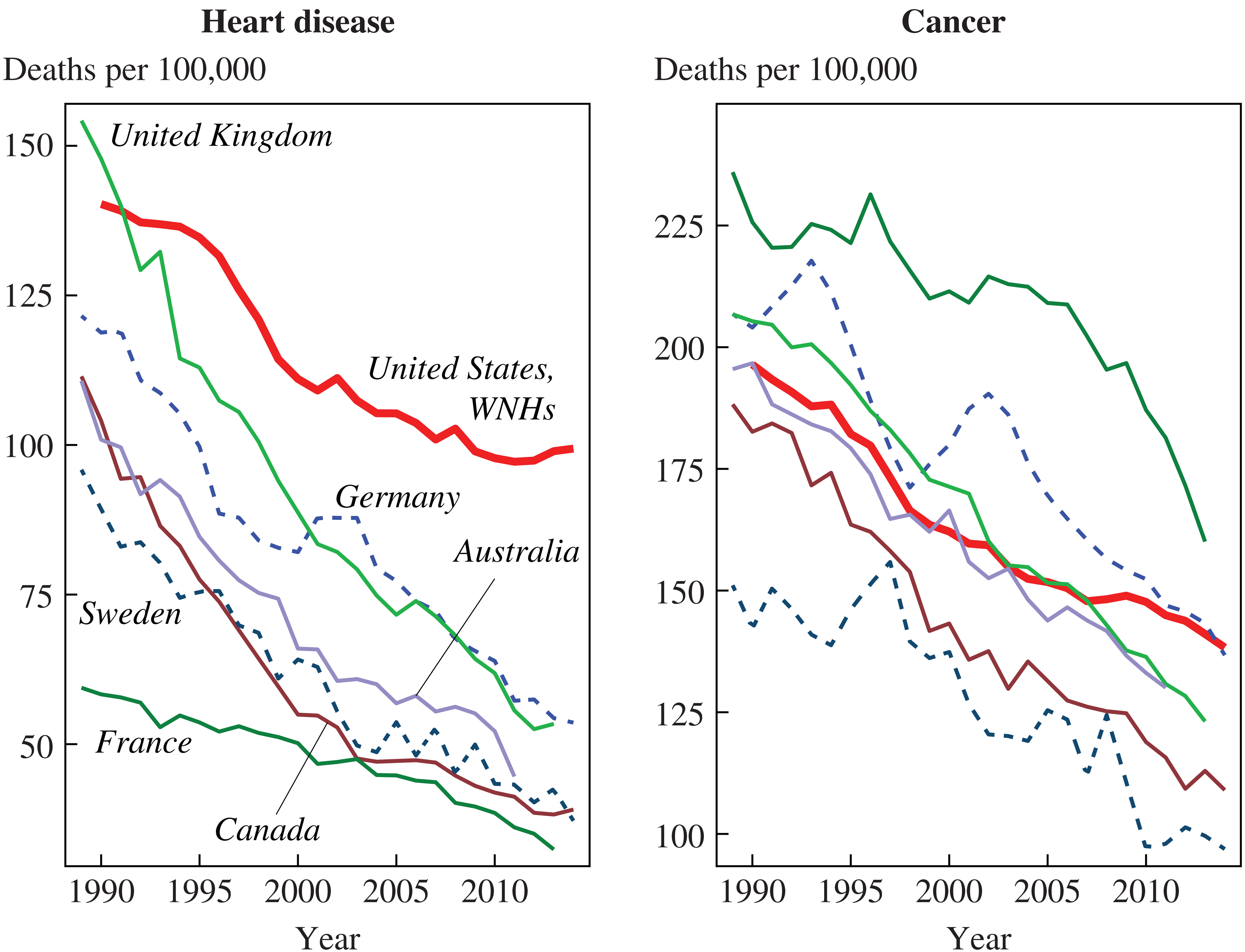
Figure 5. Deaths of Despair by Country for Age 50–54, 1989–2014[a]



Sources: National Vital Statistics System; Human Mortality Database; WHO Mortality Database; authors' calculations.

a. Deaths of despair refer to deaths by drugs, alcohol, or suicide.

Figure 8. Heart Disease and Cancer Mortality by Country for Age 50–54, 1989–2014



Sources: National Vital Statistics System; Human Mortality Database; WHO Mortality Database; authors' calculations.

Understanding the Rise of Midlife Mortality

Adverse trend in midlife mortality among US WNHs is partly due to slower declines in heart disease and cancer

But a big part of the story is rising "deaths of despair," from drugs, alcohol, or suicide

These are a US phenomenon, and much starker in whites than non-whites

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But what does this story have to do with age, period, and cohort?

- Case and Deaton show how this **period** phenomenon can be traced through the lives of **cohorts**
- They jump back and forth between these concepts in the second half
- A little confusing, but highlights how age, period, cohort are intertwined

Figure 7. Deaths of Despair for White Non-Hispanics with Less Than a Bachelor's Degree, by Birth Cohort

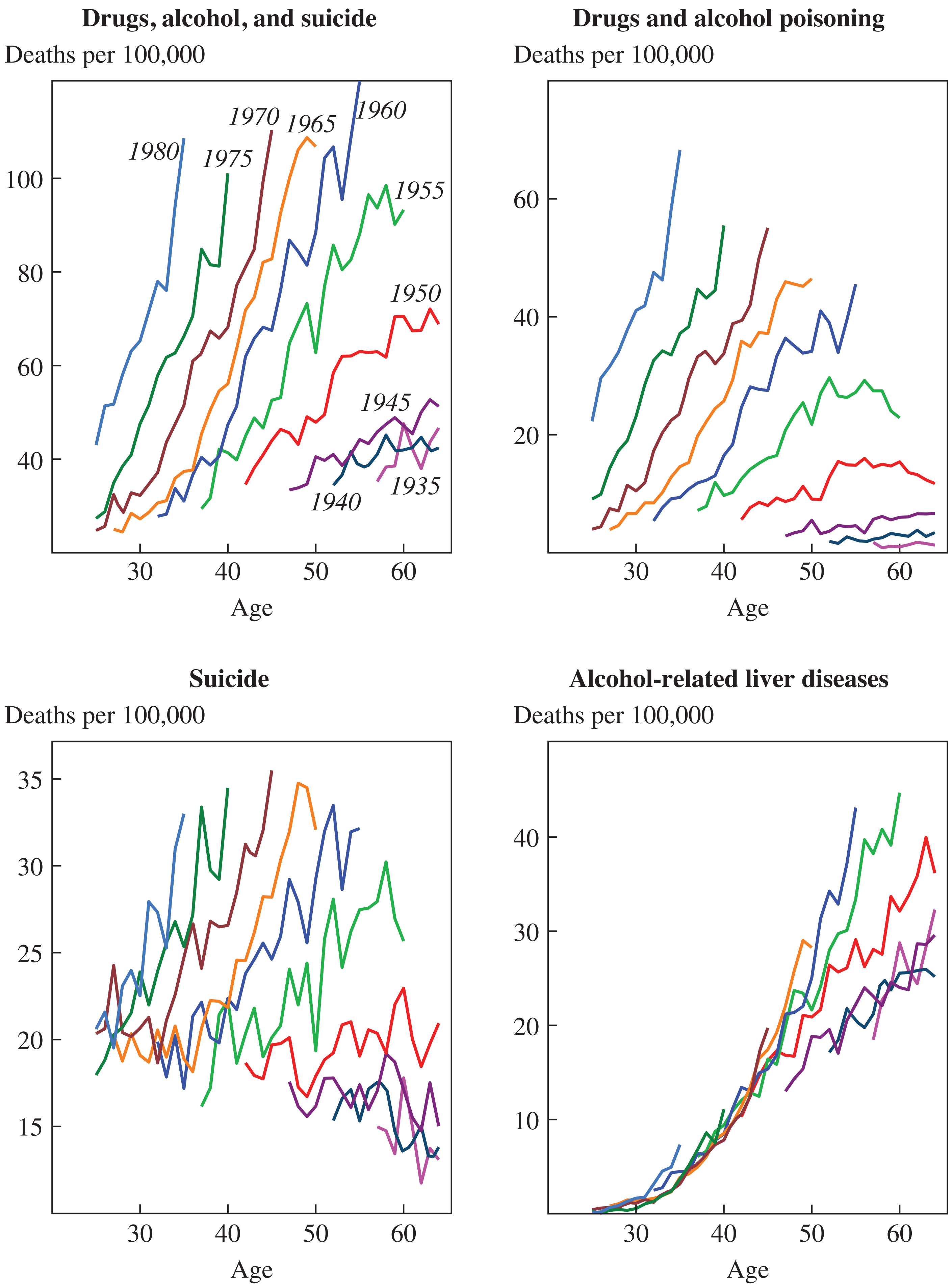
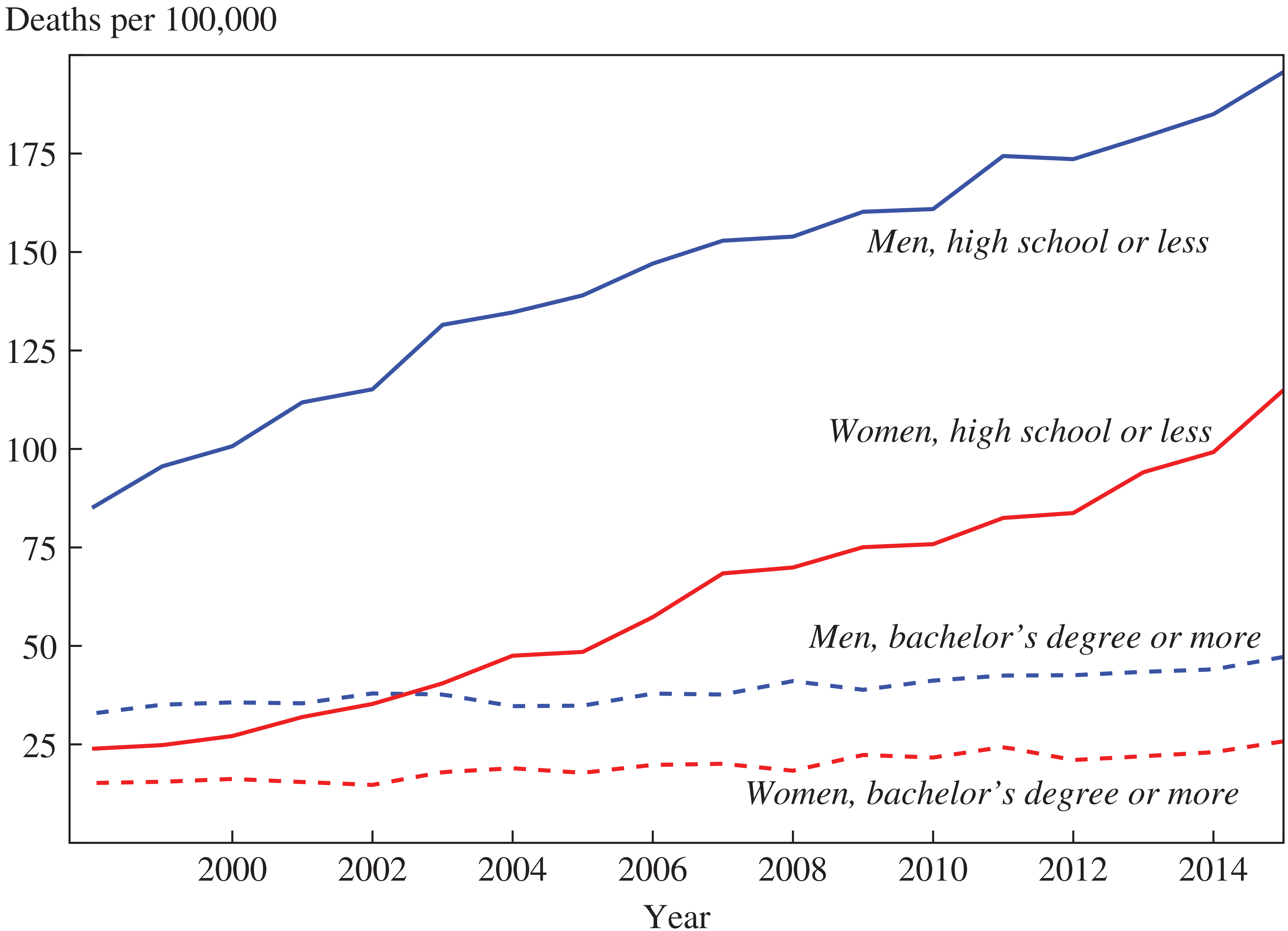
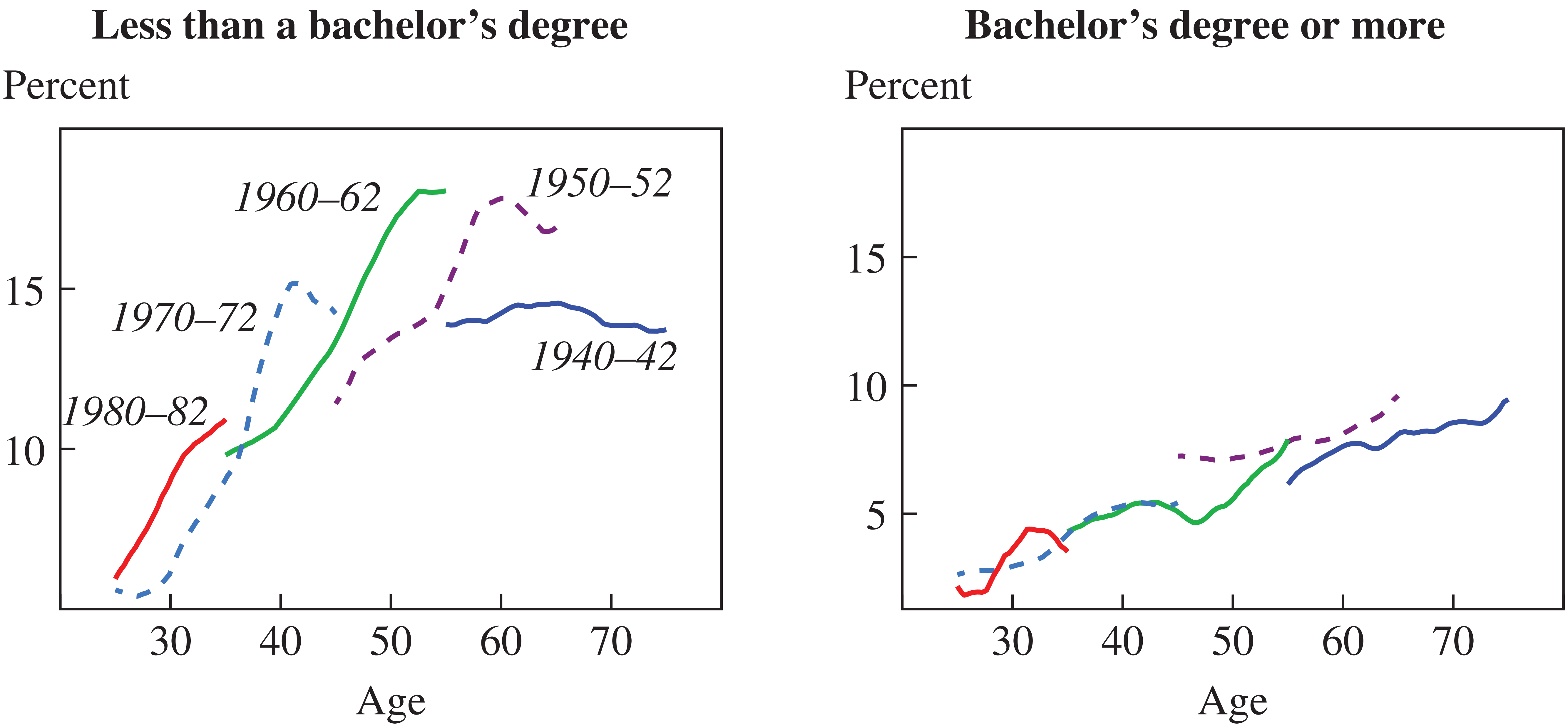


Figure 11. Deaths of Despair for White Non-Hispanics Age 50–54, by Level of Education, 1998–2015[a]



Sources: National Vital Statistics System; authors' calculations.
a. Deaths of despair refer to deaths by drugs, alcohol, or suicide.

Figure 13. Reports of Sciatic Pain for White Non-Hispanics, by Birth Year



Sources: CDC National Health Interview Survey; authors' calculations.

Figure 18. Percent of White Non-Hispanic Men Not in the Labor Force, by Birth Cohort

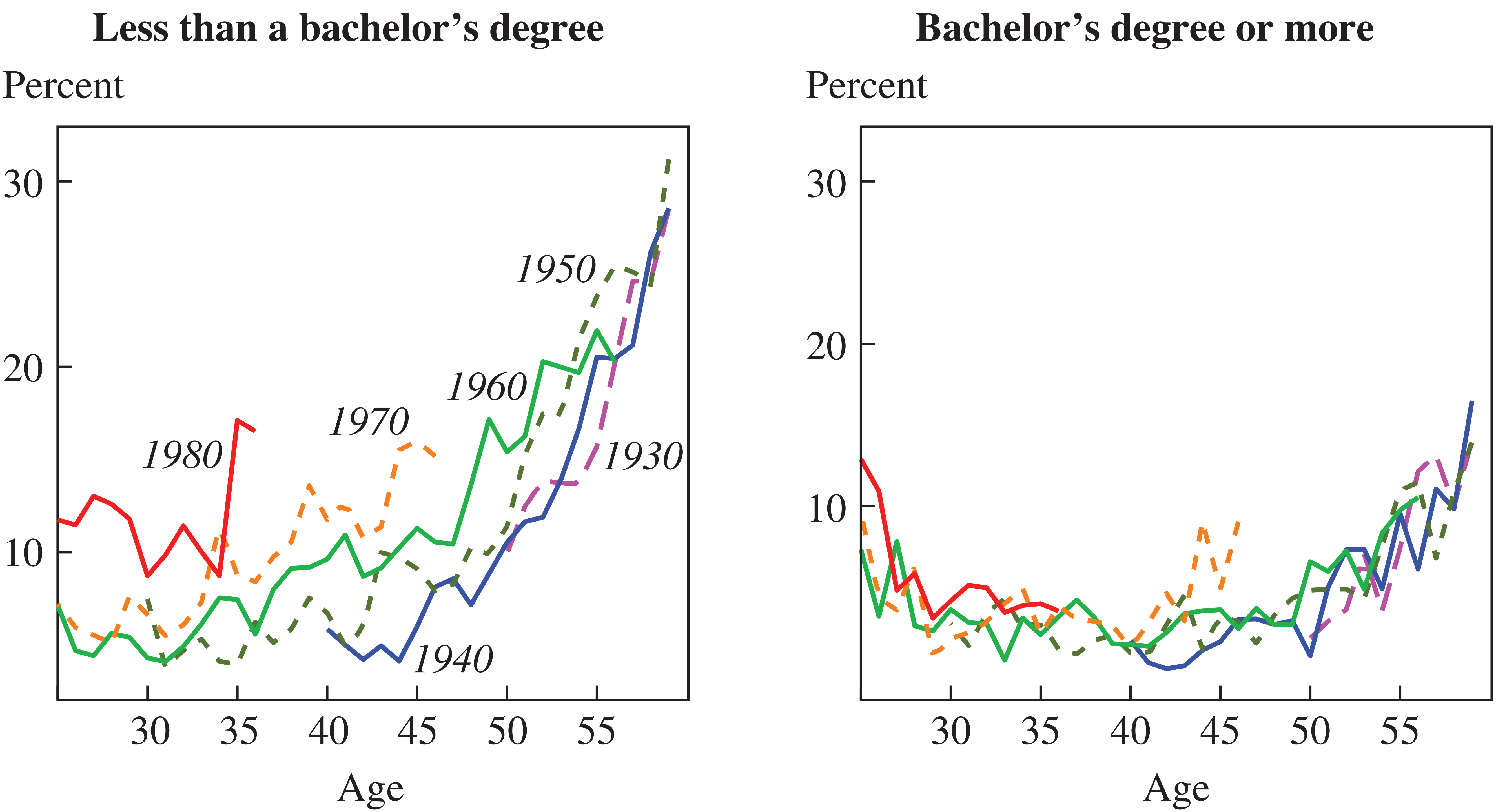
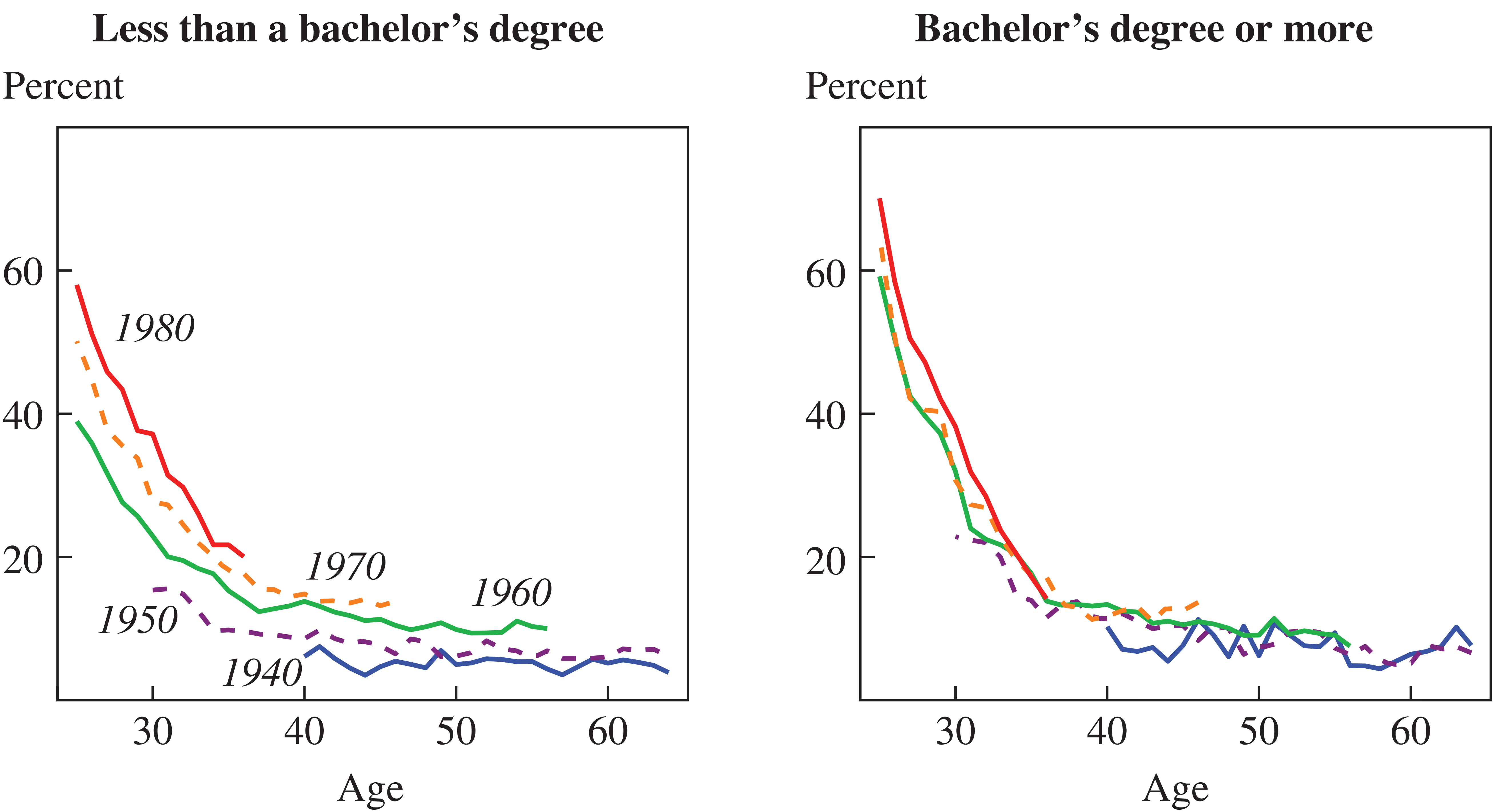
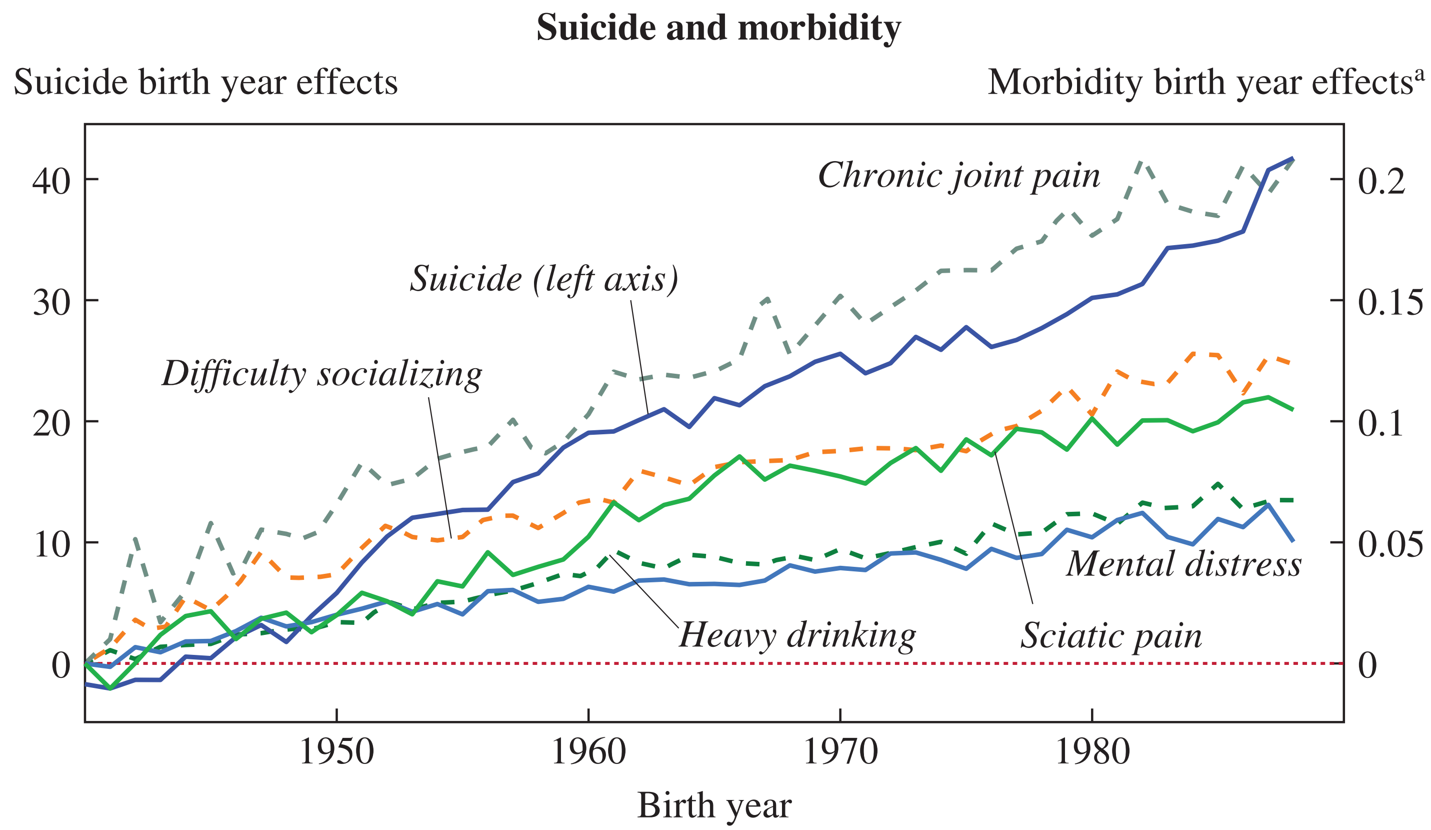


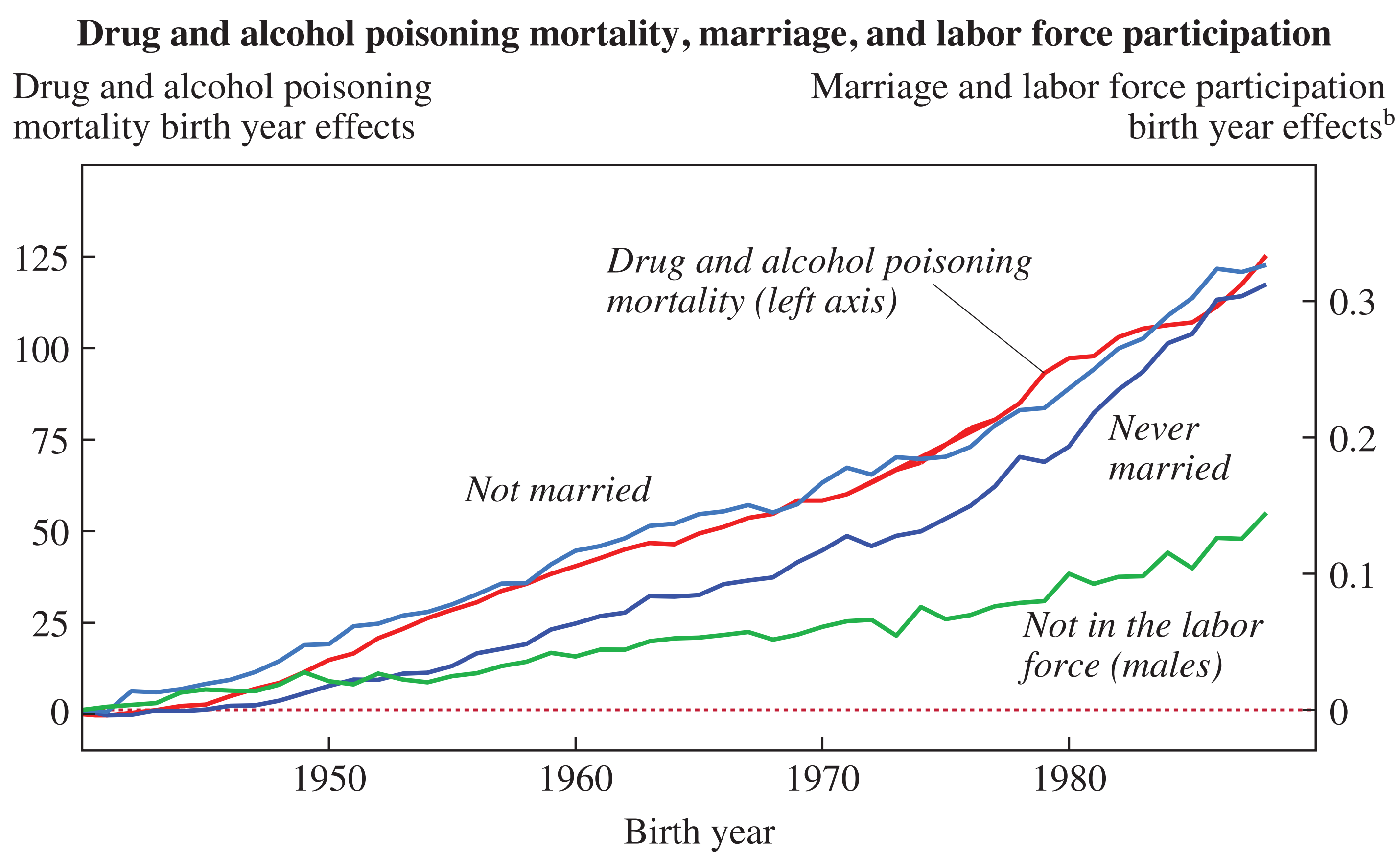
Figure 19. Percent of White Non-Hispanics Never Married, by Birth Cohort



Intercept Shifts in Cohort Age Profiles for WNHs Without College

(Regression-Based, Not on Exam)





A Cohort Explanation for Rising Midlife Mortality Among WNHs

Deaths of despair, pain, social isolation, non-marriage, male joblessness have all been rising across successive cohorts of WNHs

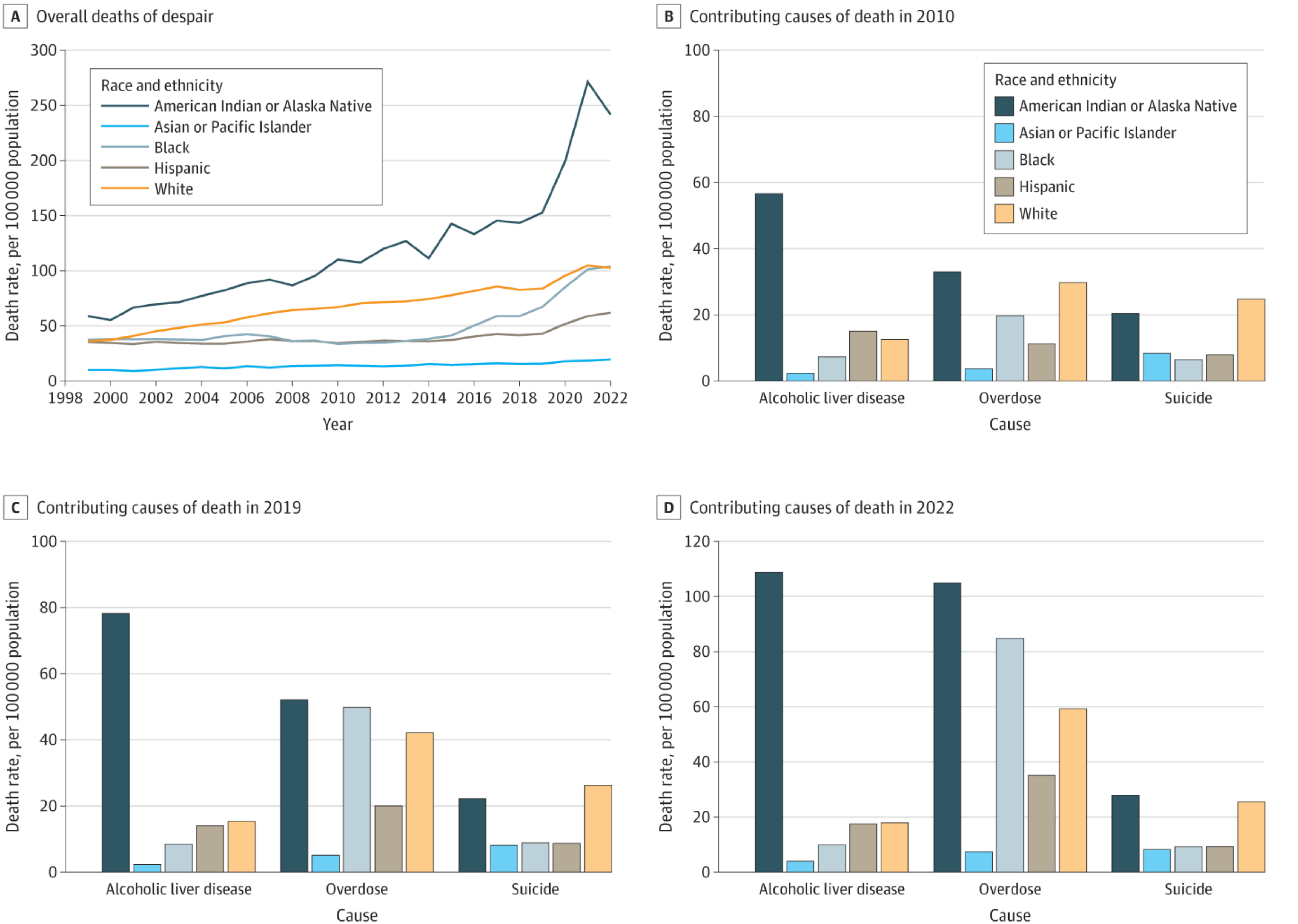
- Intercept of cohort age profile shifting upward
- Time series of age-specific outcome trending upward over time

These changes are especially stark for WNHs without college degrees

Case and Deaton argue that the cumulation of hopelessness and pain are related to increases in deaths from drugs, alcohol, and suicide

If you are interested in these issues, you should check out their book: *Deaths of Despair and the Future of Capitalism*

Like the current article, the book preceded the COVID-19 pandemic



Deaths of despair among individuals aged 45 to 54 years. Data representing American Indian or Alaska Native, Asian or Pacific Islander, Black, and White groups refer to non-Hispanic individuals in each group.

Friedman and Hansen. JAMA Psychiatry. 2024; 81(7): 731-732.