Health dynamics and heterogeneous life expectancies

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January 2020

Motivation

- Health dynamics and health shocks is **a major source of risk** over the life cycle
- A negative health shock affects an individual's economic decisions through various channels:
  - Risk of large medical expenditures
  - Decreased earnings potential
  - Decreased life expectancy affects the effective discount factor
  - Direct effect on utility or on the marginal utility of consumption

$\Rightarrow$ A realistic health and survival process is crucial to properly quantify the risk an individual faces in an structural model

This paper

What we do:

- Use rich HRS data on the US elderly population
- Estimate health and death probabilities for different subsets of the population

What we get:

- An age-dependent yearly five-state Markov chain for health and death probabilities
  - Can be used in any life-cycle model
- Estimates of the life expectancy inequality in the population along the health gradient
- Quantification of the importance of current health status vs. future health dynamics for life expectancy inequality

Relation to previous estimates of health dynamics

Previous estimates restricted by data limitations:

- Based on HRS

  E.g., Pijoan-Mas and Ríos-Rull (2014), Amengual et al. (2017).

  - Estimate **biennial** transitions (due to biennial survey structure)
  - Many life-cycle applications need annual frequency

- Based on PSID

  E.g. French (2005), De Nardi et al. (2017).

  - Collapse health into **two states** (mainly due to too few observations to keep full level of detail)
  - Two states insufficient to capture heterogeneity and duration dependence for many application

$\Rightarrow$ In this paper we use the rich HRS data, but estimate an **annual five-state** Markov chain

Main results

- Strong health gradient for longevity
  - A 70-year old man in excellent health has a 75% probability of reaching his 80th birthday
  - Corresponding probability for a man in poor health is just below 40%
- Substantial inequality in life expectancy between educational groups as measured by life expectancy at the age of 50:
  - High-school dropouts: 75 years
  - College educated: 80 years
  - Main driver is the worse health dynamics after the age of 50 (not the health status at that age)

Data description

Health and Retirement Study

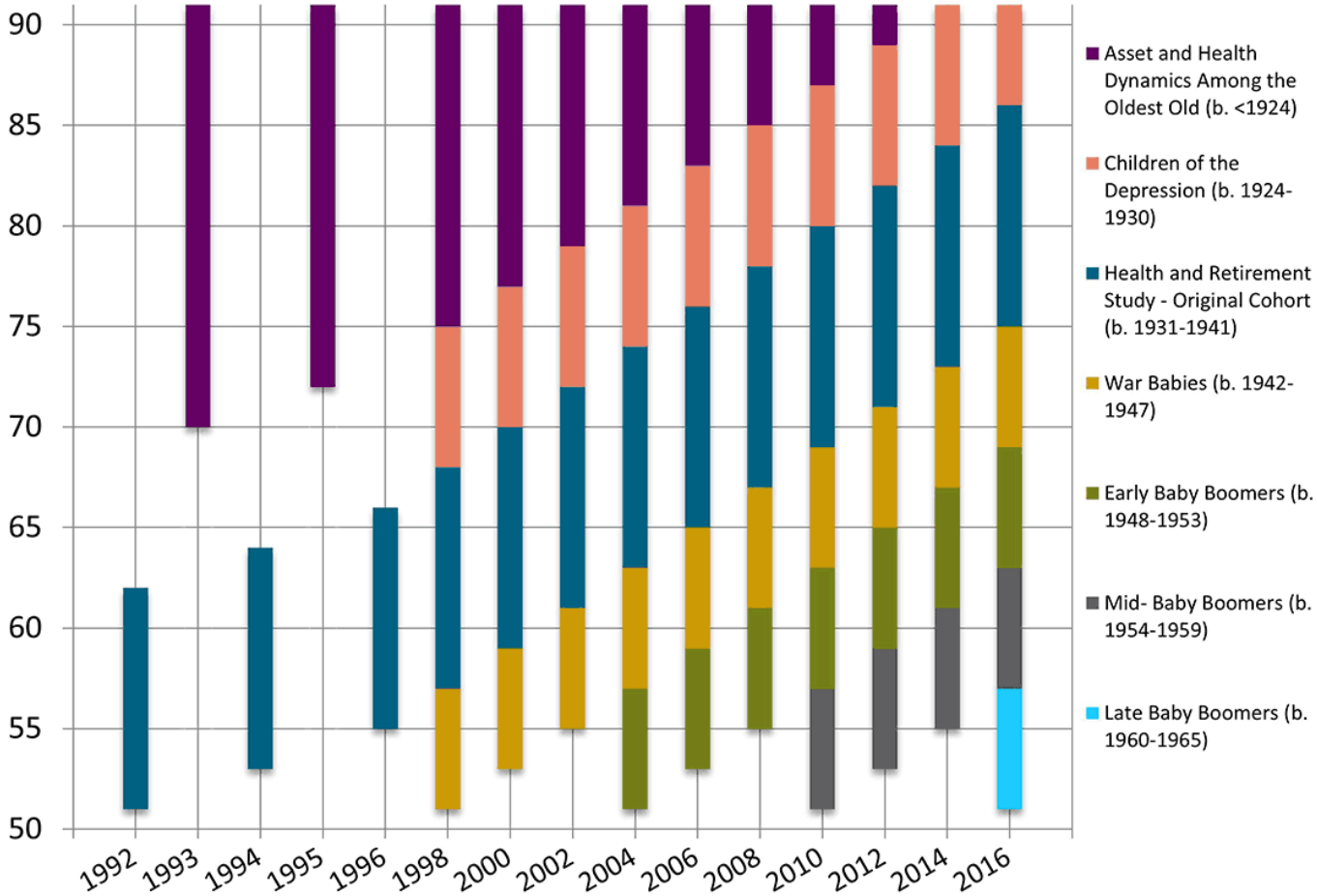
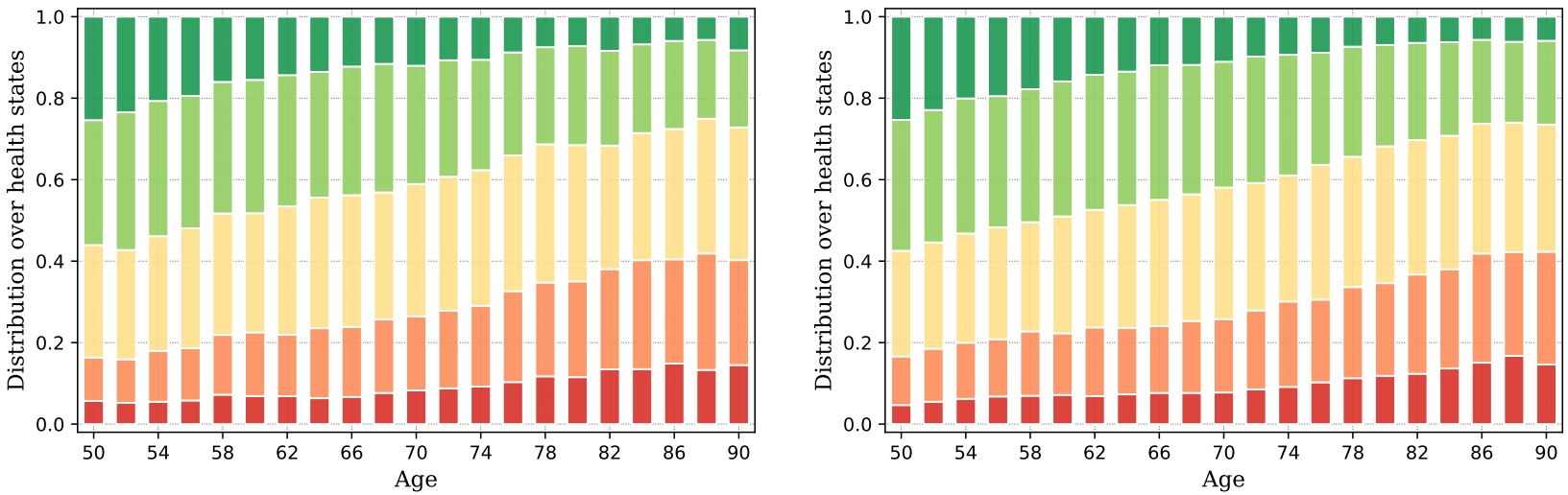


Figure 1: HRS longitudinal cohort sample design. Source: HRS.

HRS data

- Self-reported health: 1 (excellent) to 5 (poor)
- Date of death (exactly coded from the National Death Index)



(a) Nonblack men **(b)** Nonblack women

Figure 2: Distribution of health states by age.

Estimation sample

		N. of indiv.	N. obs.	Avg. obs./indiv.	Age		
					Min.	Mean	Max.
Male	Non-black	12,765	77,612	6.1	50	67.7	106
	Black	2,397	12,252	5.1	50	65.9	103
Female	Non-black	15,485	99,455	6.4	50	68.4	110
	Black	3,556	19,556	5.5	50	66.4	111

Table 1: Estimation sample

Data structure in practice

- Approximately 20% of the transitions are *not* biennial
- Death dates are coded exactly, and do not follow the interview structure
- Even if all observations were perfectly biennial, they are overlapping
  - One person is observed at age a and $a + 2$
  - Another at age $a + 1$ and $a + 3$
  - Both should contribute to estimating transition probabilities between ages $a + 1$ and $a + 2$

$\Rightarrow$ Cannot take the "square root" of the two-year transitions

$\Rightarrow$ Solution: maximizing the probability of observing all *transition paths* in the data

Estimation

Estimation in a nut-shell

- Similar in spirit to Pijoan-Mas and Ríos-Rull (2014), but takes into account irregular and overlapping observations and estimates one-year probabilities
- Maximum-likelihood estimation: maximizing probability of observing the *transition paths* in the data
  - Includes rolling forward the Markov chain that is being estimated
- Nested logit puts structure on the Markov chain:
  - Survival probabilities given by binary-outcome logit model
  - Health transition probabilities conditional on survival given by multinomial logit

Illustrative example

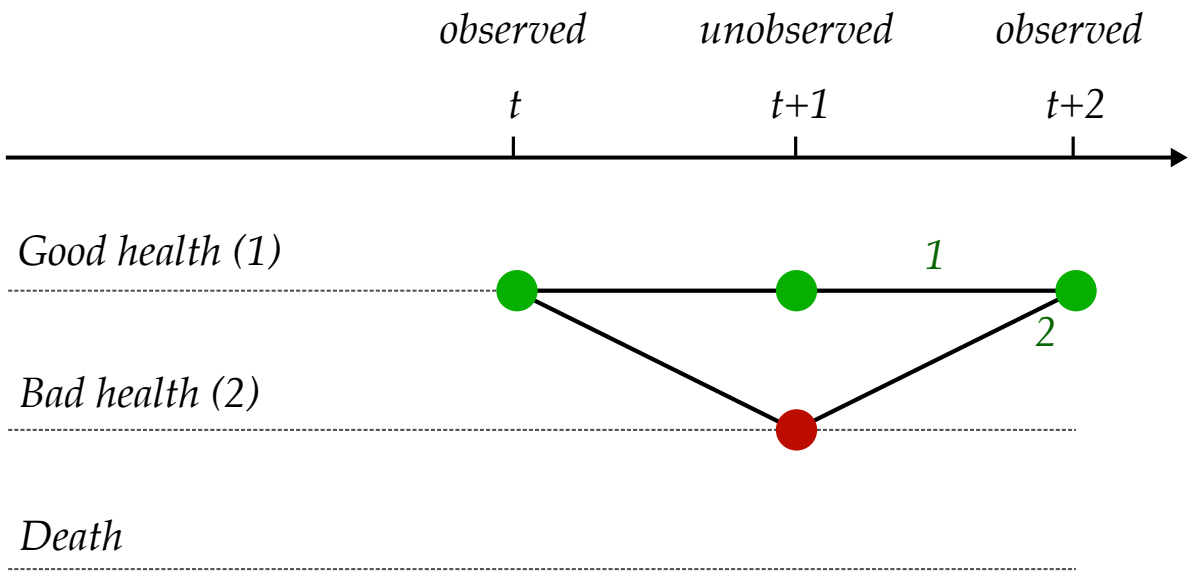
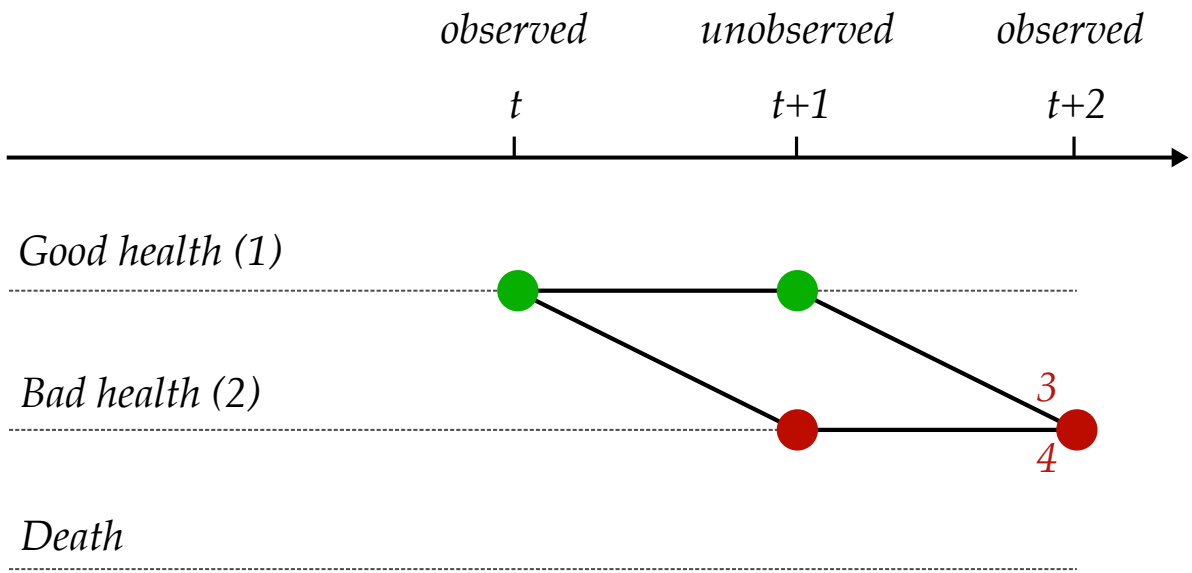


Figure 3: Simplified transition paths

Illustrative example



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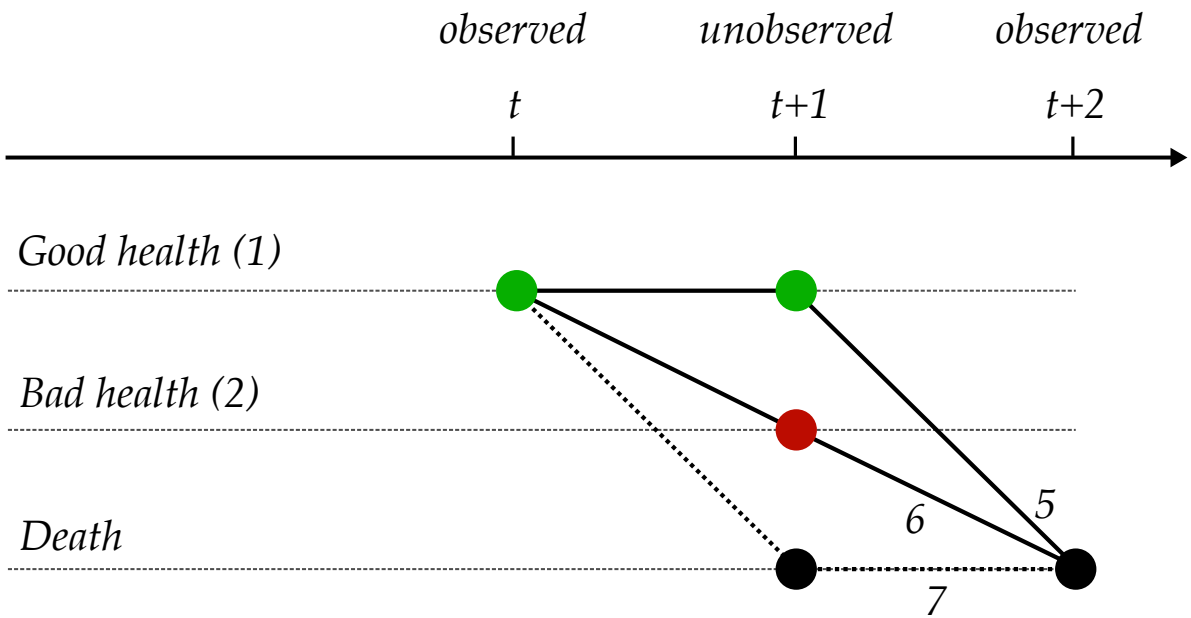

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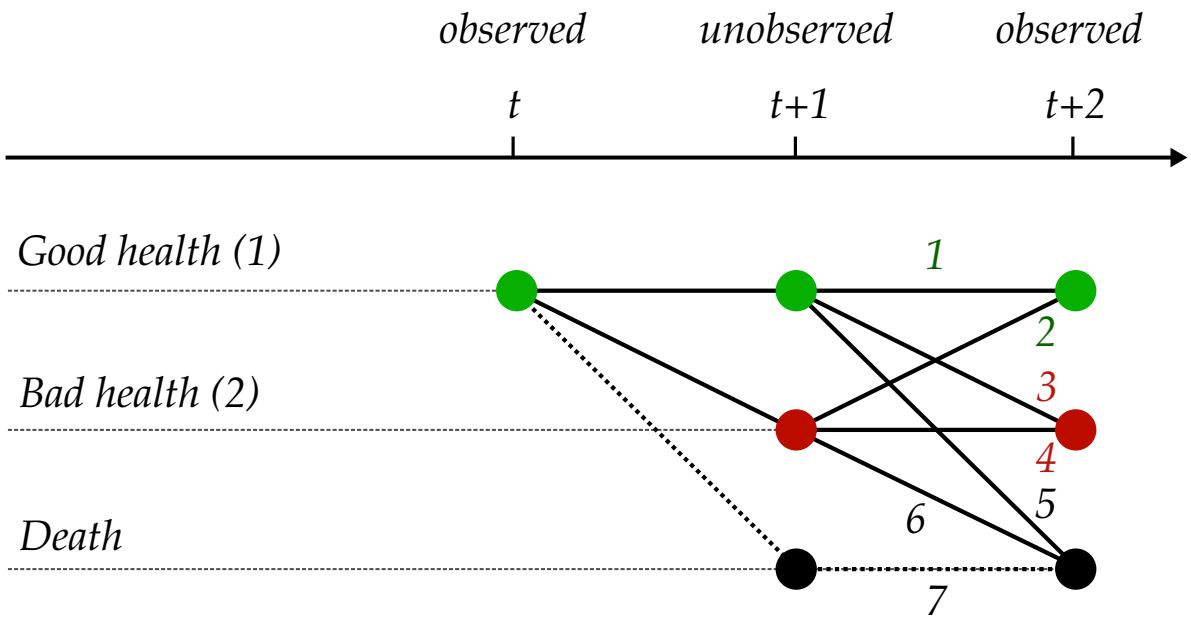


Figure 3: Simplified transition paths

Covariates

Baseline specification:

- Current health state
- Second-order polynomial in age
- Separate estimates for men/women and nonblack/black individuals

Extensions:

- Model permits the inclusion of time-invariant characteristics
- We will include education as an illustration

Results

Illustration of results

Baseline model:

- Transition probabilities (health and survival)
- Implied health dynamics
- Life expectancies

Extending the model with education:

- Comparison of life expectancy

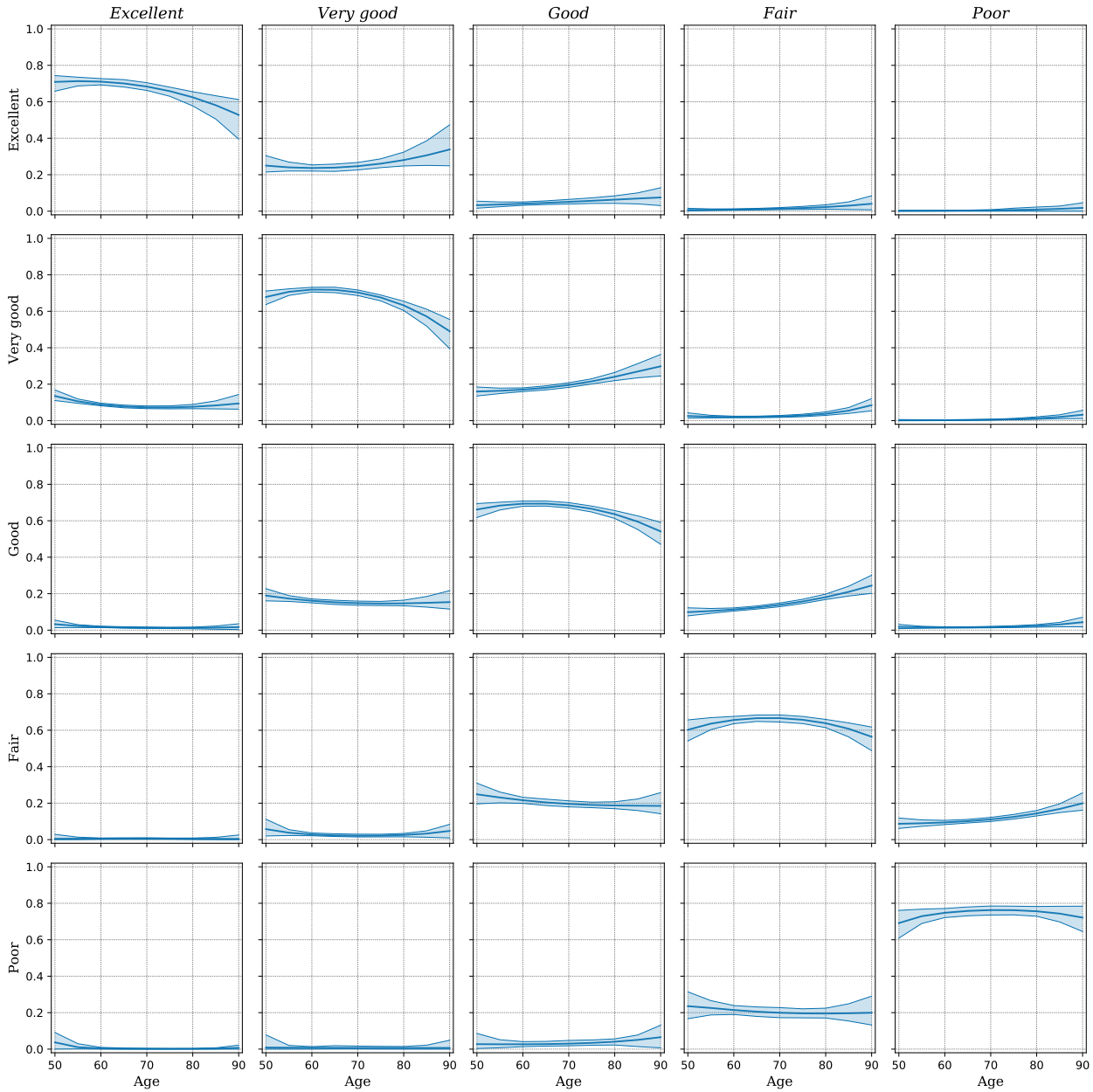
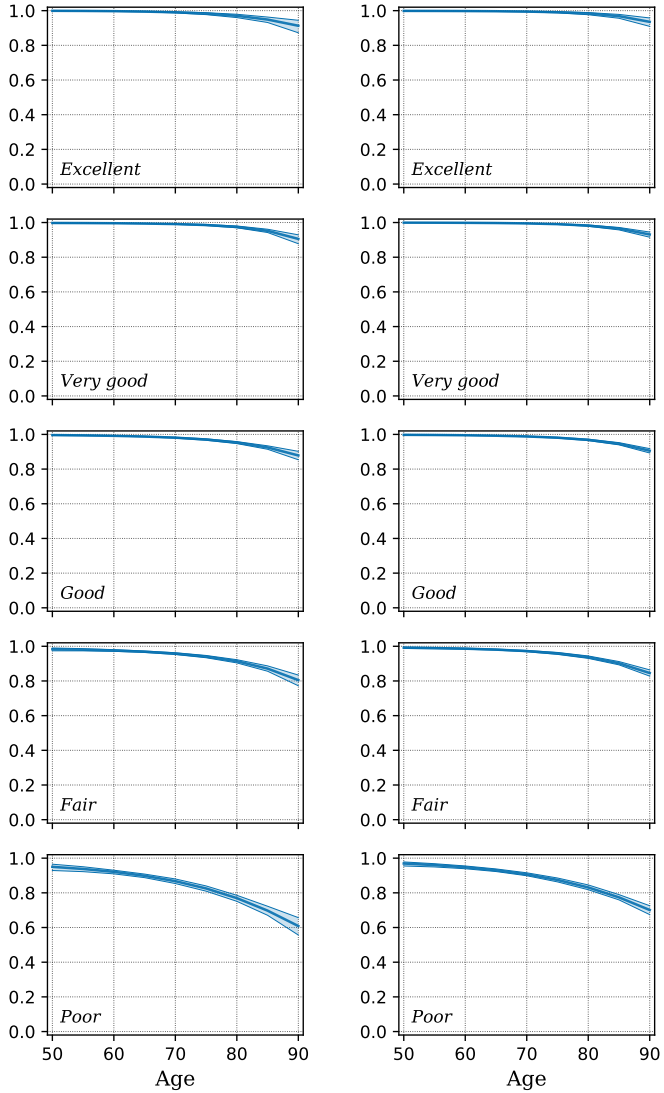


Figure 4: One-year health-to-health trans. probabilities (nonblack men).



(a) Nonblack men

(b) Nonblack women

Figure 5: One-year survival probabilities.

Predicted health and survival probabilities

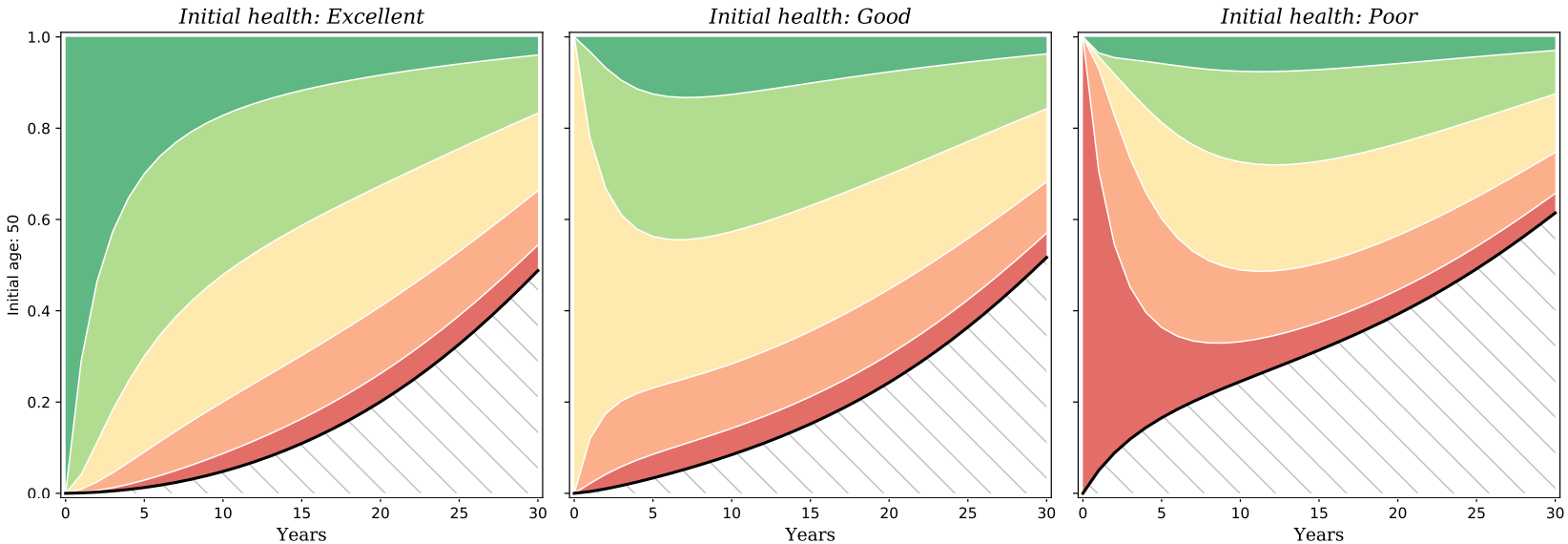


Figure 6: Evolution of probabilities, 50-year old nonblack males.

Comparing model predictions and data

- Compute two-year transition probabilities implied by our estimated annual model
  - Health-to-health transitions conditional on survival
  - Cumulative probability of having died within two years
- Compare these to the biennial transitions observed in the data (approx. 80% of all transitions)
- Remarkably good fit

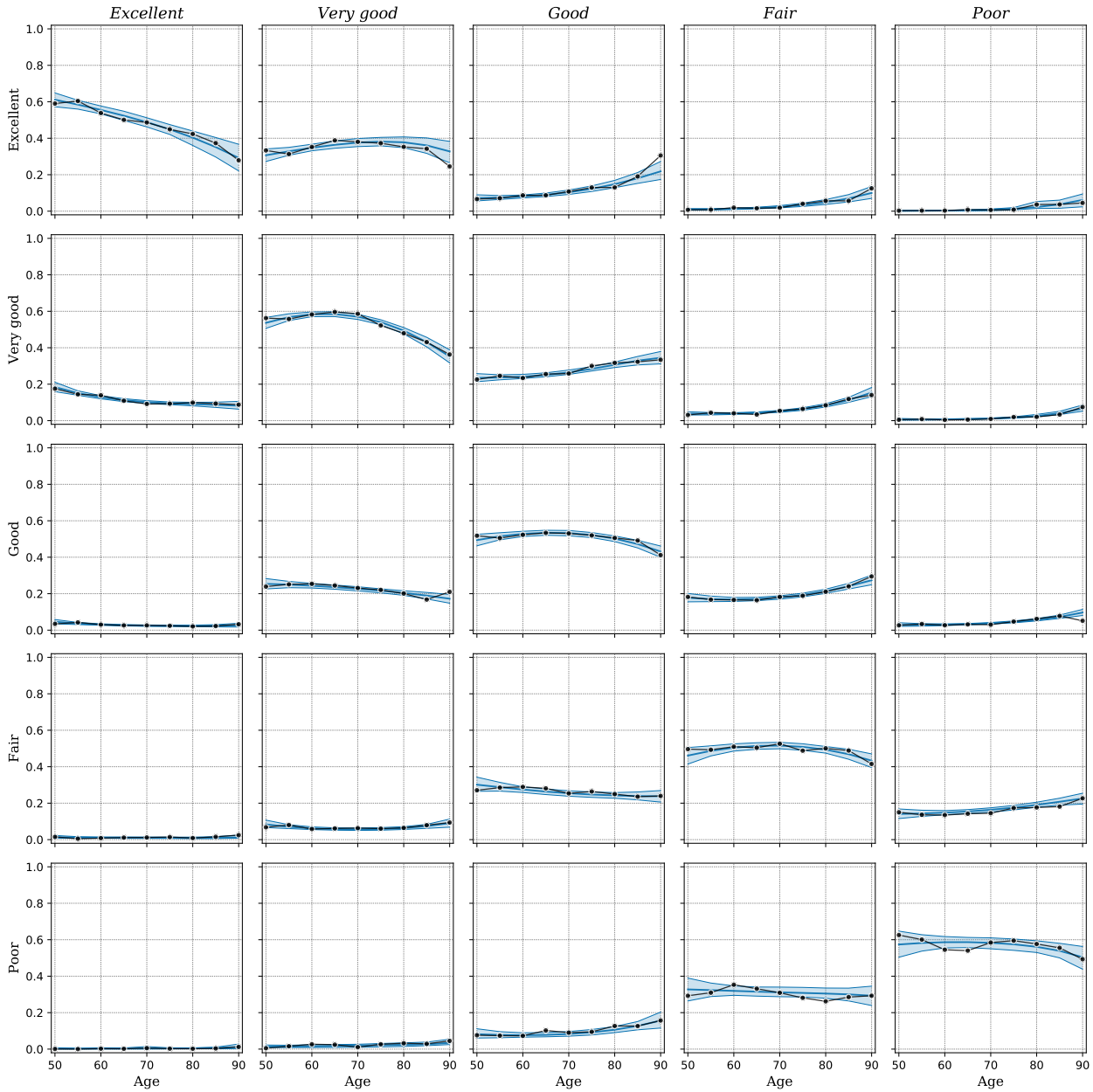
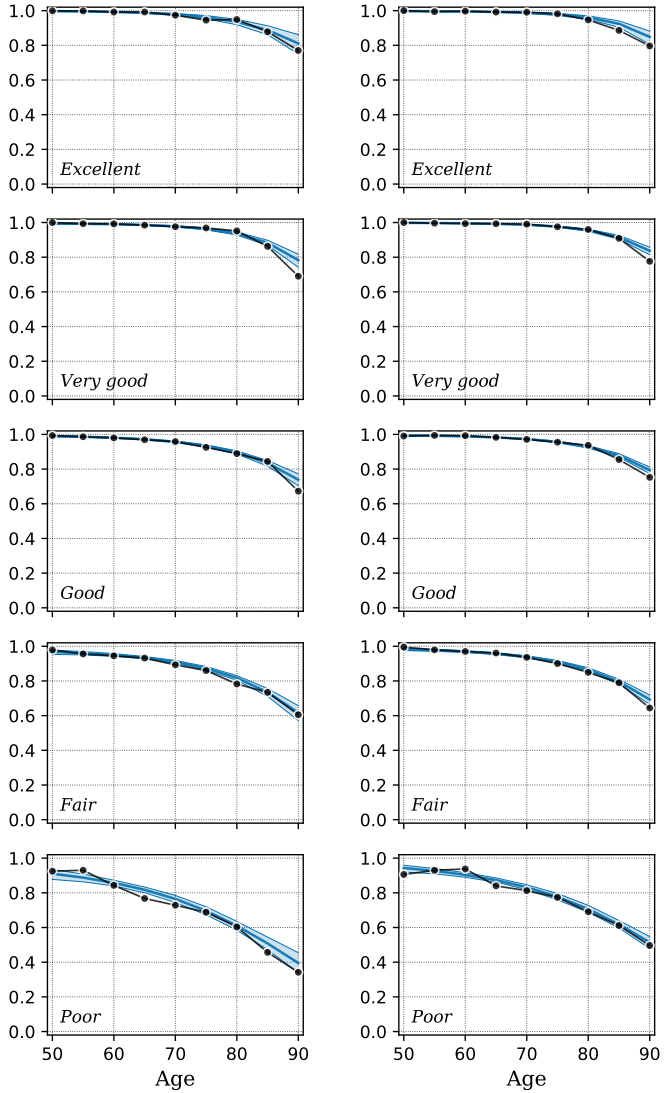


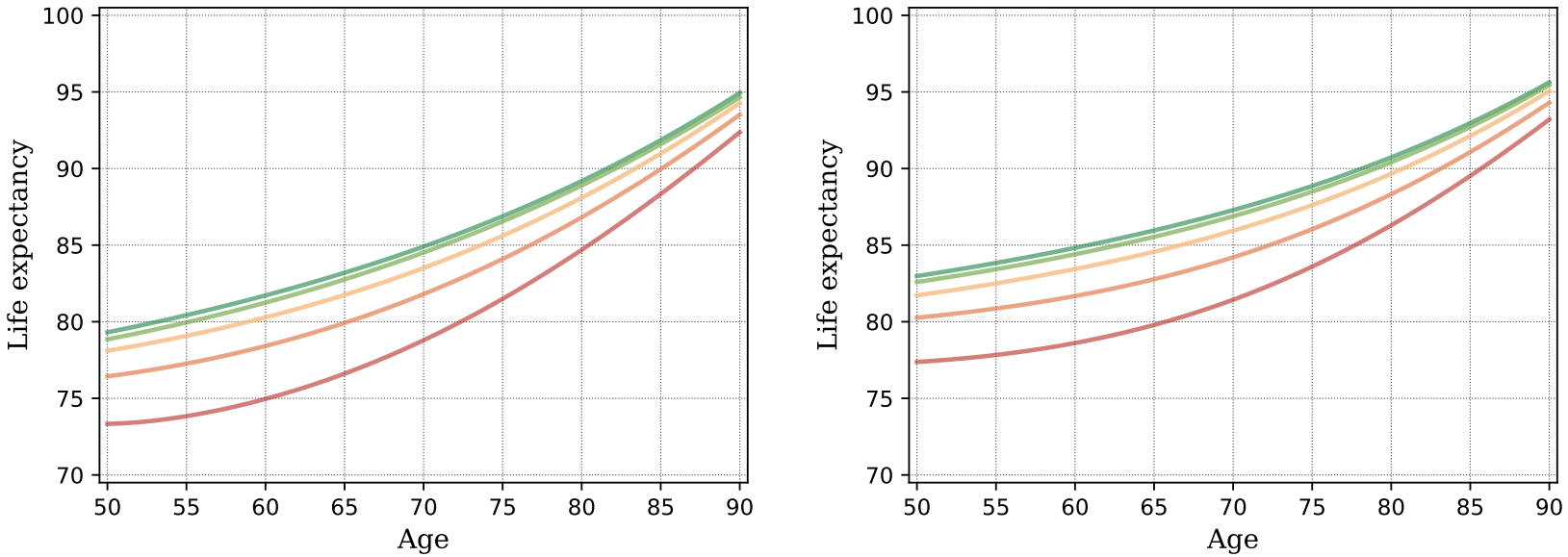
Figure 7: Two-year health-to-h. trans nonblack women: data vs. model.



(a) Nonblack men **(b)** Nonblack women

Figure 8: Two-year survival probability: data vs. model.

Inequality in life expectancy

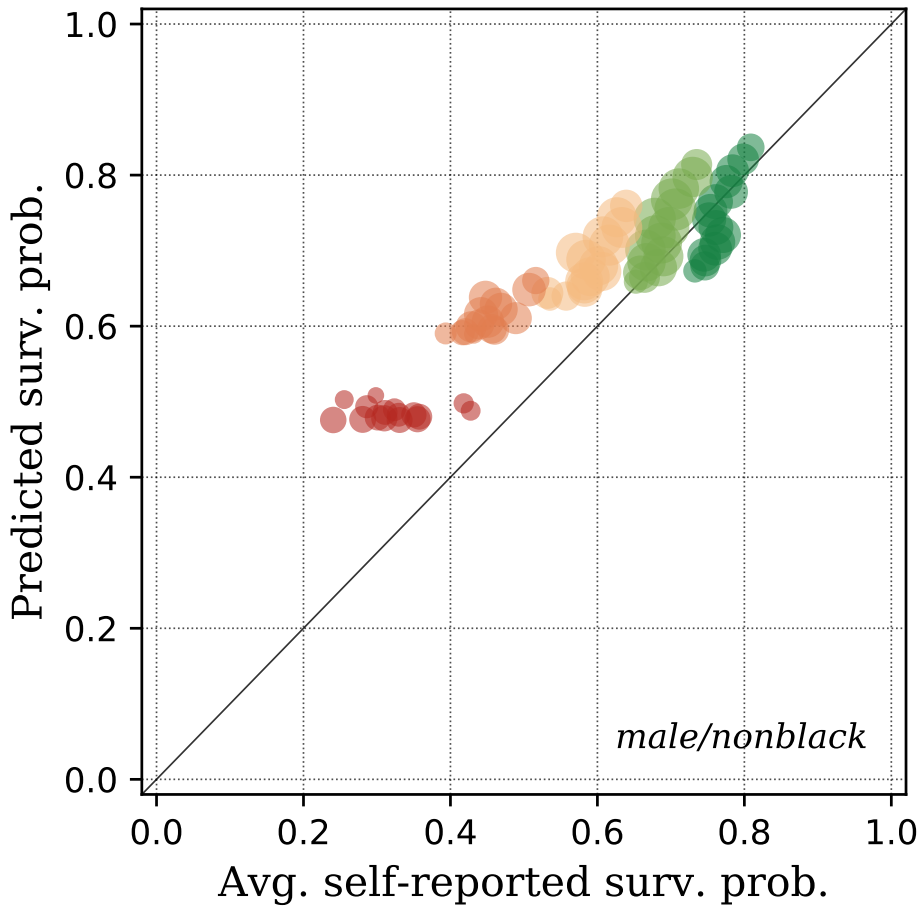


(a) Nonblack men **(b)** Nonblack women

Figure 9: Life expectancy by age and health state.

Objective vs. subjective survival probability

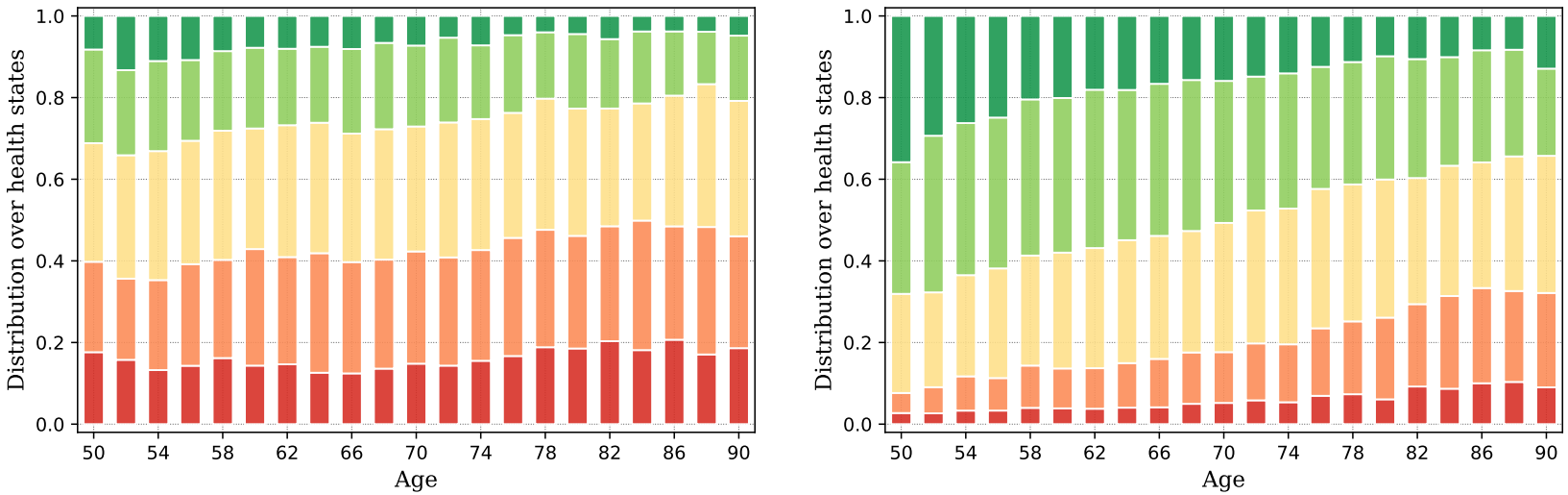
Probability of surviving until age 75



Health and survival for different education groups

- We add education level (fully interacted with age and health)
  1. Less than high school
  2. High school
  3. (Some) college or more
- As is well-known, highly educated individuals are healthier
- Average life expectancy for nonblack men in lowest education group is 5 years lower than for those in the highest education group
- The worse health dynamics after the age of 50 is more important than the worse health state at the age of 50

Lower educated have worse health



(a) Less than high school **(b)** (Some) college

Figure 10: Distribution by health state among nonblack men.

Life expectancy by education and health state

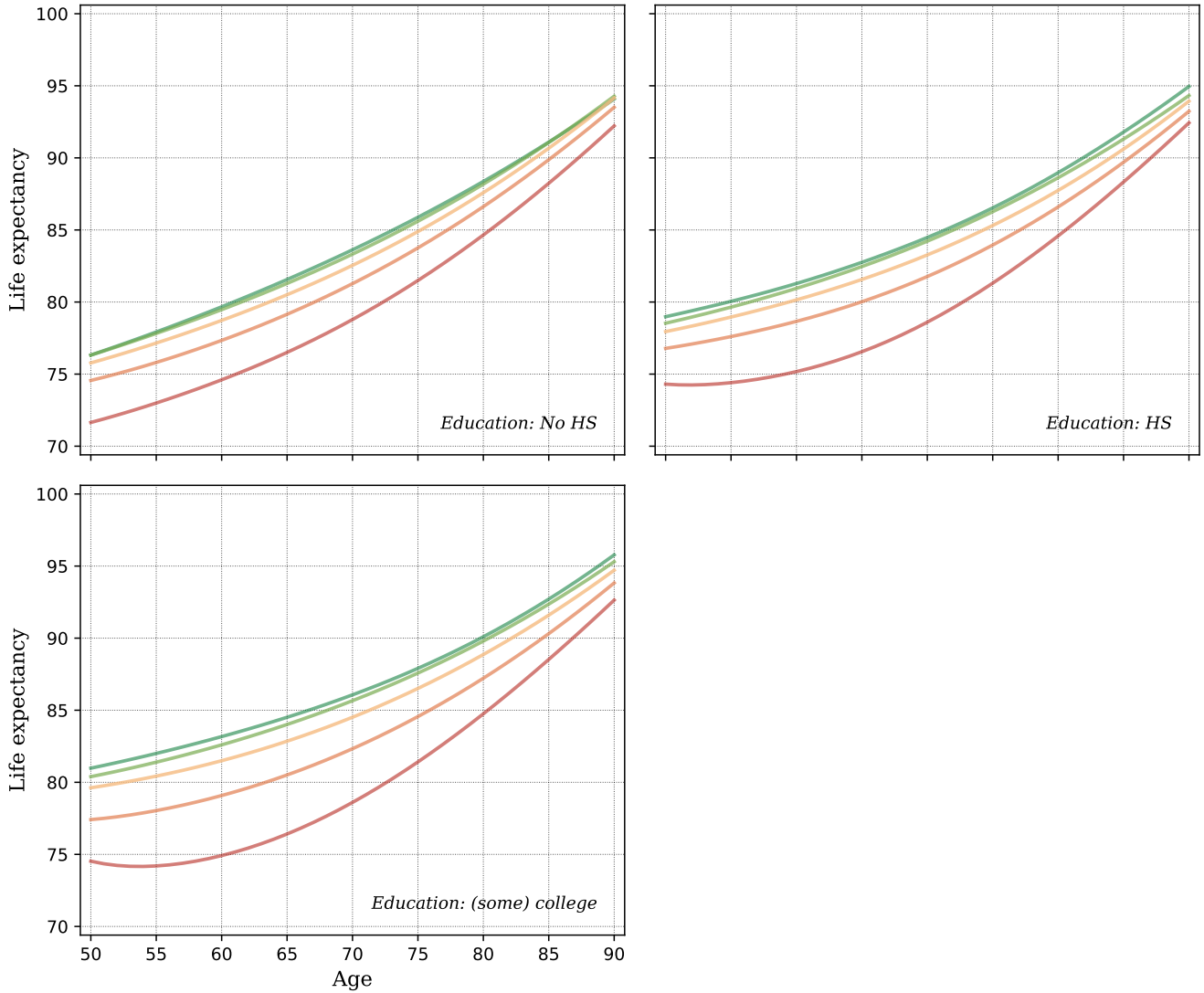


Figure 11: Life expectancy by education, age, and health (nonblack men).

Assessing the impact of current health distribution vs. health dynamics

Counterfactual exercise

- Take as given estimated health dynamics and survival probabilities for each education group
- Vary initial distribution over health states at age 50
- Example: giving group with less than high school the health distr. of college educated increases their life expectancy by 1.1 years.

	Using health distr. of		
	No HS	HS	(some) col.
No HS	74.9	75.7	76.0
HS	77.3	78.0	78.3
(some) col.	78.5	79.6	80.1

Table 2: Average life expectancy for nonblack men at the age of 50, by education level and initial health distribution.

Conclusions

- Health shocks and survival dynamics are a major source of risk over the life cycle – a realistic description of the underlying process is crucial
- We provide improved estimates for an age-dependent annual five-state Markov chain for health and survival probabilities
  - Can be used in any life-cycle model
- Estimates can be used to assess life expectancy inequality in the population

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Amengual, D., J. Bueren, and J. Crego (2017). Endogenous health groups and heterogeneous dynamics of the elderly. Technical report, HEDG, c/o Department of Economics, University of York.

De Nardi, M., S. Pashchenko, and P. Porapakkarm (2017). The lifetime costs of bad health. Technical report, National Bureau of Economic Research.

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