

# Healthy Habits and Inequality

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# INTRODUCTION

- In recent decades, there has been an **increase in inequalities**  
(*wealth, consumption, income, health outcomes*)
- Two important facts:
  - a) Strong connection between **economic and health inequality**  
*Kitagawa, Hauser (1973); Pijoan-Mas, Rios-Rull (2014); Chetty et al. (2016)*
  - b) **Growing educational gradients** of health inequality  
*Preston, Elo (1995); Meara et al. (2009); Montez et al. (2011); Case, Deaton (2015)*

→ Reasons not well-understood
- We study to which extent **differences in lifestyles** across education groups can account for these facts
  - Lifestyles are an important driver of health outcomes  
*McGinnis, Foege (1993); Li et al. (2018); Zaninotto et al. (2020)*
  - More educated individuals tend to adopt healthier lifestyles  
*Lantz et al. (1998); Cutler, Lleras-Muney (2010); Polvinen et al. (2013)*

# OBJECTIVES

- 1 Measure the impact of lifestyles on health dynamics and economic outcomes
- 2 Understand the joint determination of education and lifestyles
  - Why is there an education gradient of lifestyles?
- 3 Understand the increase in the education gradient of life expectancy
  - Quantify the role played by the increase in the education wage premium
    - a) Income effect on lifestyle choices
    - b) Selection: different composition of education groups

## LITERATURE ON HEALTH AND ECONOMIC INEQUALITY

- Models with *exogenous health dynamics*

De Nardi et al. (2010); Ameriks et al. (2020); Bueren (2023); Nakajima, Telyukova (2023)  
Capatina (2015); Braun et al (2019); Hosseini et al (2021); De Nardi et al. (2023)

→ We model endogenous health dynamics

- Models with *endogenous monetary health investments*

Fonseca et al. (2023); Ozkan (2023); Hong, Pijoan-Mas, Ríos-Rull (2024)

→ Scarce causal evidence of effects of money on health

→ We focus on health-related behaviour

- Models with *endogenous health behaviour investments*

Cole et al. (2019); Mahler, Yum (2023); Margaritis, Wallenius (2023)

→ Joint decision of education and lifestyle: deal with selection

→ Effect of lifestyle identified by long-run health dynamics

Hai, Heckman (2024)

→ We model different channels

→ We study long-run changes of economic and health inequality

# Health Dynamics and Health Behavior

## THE DATA

- HRS and PSID
  - Unbalanced panels of individuals  $i = 1, \dots, N$  followed  $t = 1, \dots, T$  periods
- Demographic information: birth cohort ( $c$ ), sex ( $s$ ), education ( $e$ ), age ( $a_t$ )
- Wide array of information on health status and health behavior
  - Health state  $h_t$ : self-reported health (good/bad) + death
  - Health behavior  $z_{mt} \in \{0, 1\}$ :
    - 1 Preventive cancer tests (mammography / prostate check)
    - 2 Cholesterol test
    - 3 Flu shot
    - 4 Heavy drinking (2+ drinks on the day they drink)
    - 5 Smoking
    - 6 Exercise

## HEALTH BEHAVIOR AND HEALTH OUTCOMES

- Across demographic groups: **health behaviors** associated w/ health outcomes
  - But, at individual level:
    - Different **health behaviors** imperfectly correlated across individuals and over time  
[\[See data\]](#)
    - Hard to identify their long-run effect on health outcomes
    - Curse of dimensionality if you want to put them in a model
  - Objective: identify latent types in lifestyle behavior based on:
    - Cross-sectional and panel variation of health behavior
    - Health dynamics
- Types are permanent, but health behaviors change with age and health status

## LATENT TYPES

- We assume that observed **health behavior** is the (noisy) result of a **latent time-invariant** factor  $y \in Y \equiv \{y_1, y_2, \dots\}$ 
  - We interpret **y** as the individual lifestyle: propensity to engage in healthy behaviors
- We propose a novel econometric model to
  - Allocate individuals to lifestyles **y**
  - Measure the importance of lifestyles on health dynamics
- We *jointly estimate* health dynamics and lifestyles using a mixture model:

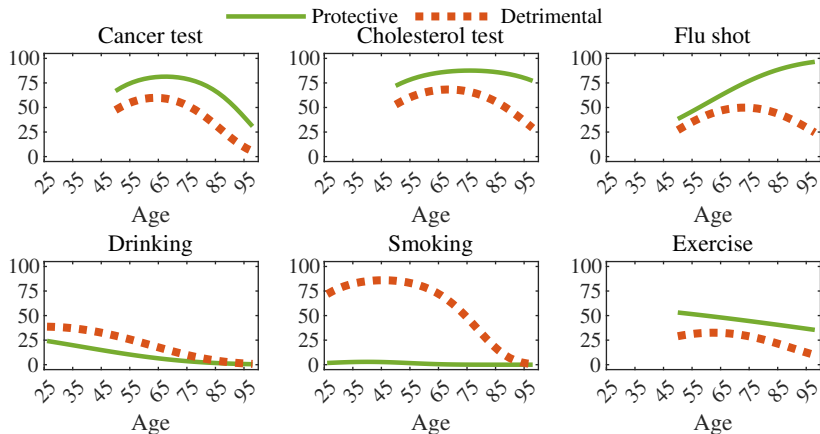
$$\begin{aligned}
 p(\mathbf{z}, \mathbf{h} | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0) &= \sum_{y \in Y} p(\mathbf{z}, \mathbf{h} | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0, y) p(y | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0) \\
 &= \sum_{y \in Y} p(\mathbf{z} | \mathbf{h}, \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0, y) p(\mathbf{h} | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0, y) p(y | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0) \\
 &\simeq \sum_{y \in Y} \underbrace{p(\mathbf{z} | \mathbf{h}, a_0, y)}_{\text{health behavior}} \underbrace{p(\mathbf{h} | \mathbf{s}, \mathbf{e}, a_0, y)}_{\text{health dynamics}} \underbrace{p(y | \mathbf{c}, \mathbf{s}, \mathbf{e}, a_0)}_{\text{lifestyle distribution}}
 \end{aligned}$$



## RESULTS: LIFESTYLES AND HEALTH BEHAVIOR

1. Lifestyles “well” approximated by 2 types: protective and detrimental

### Probability of reporting health behaviors by lifestyle



## RESULTS: LIFESTYLES AND HEALTH DYNAMICS

2. LE at age 50 is 8.6 years larger for **protective** than for **detrimental**

## LE at age 50 across education and lifestyles: males born in 1970s

	All		HSD		HSG		CG		$\Delta$ LE (CG-HSD)		
	%	LE	%	LE	%	LE	%	LE	Data	(a)	(b)
All	100	<b>29.3</b>	100	24.9	100	28.0	100	32.8	7.9	4.7	3.2
PRO	74.4	<b>31.5</b>	44.3	28.5	69.0	30.1	93.6	33.4	4.9		
DET	25.6	<b>22.9</b>	55.7	22.0	31.0	23.3	6.4	23.8	1.9		
$\Delta$	48.8	<b>8.6</b>	-11.4	6.6	37.9	6.8	87.2	9.6	3.0		

(a) Gradient explained by difference in health dynamics across education groups for given lifestyle,  $\Delta_e p(\mathbf{h}|\mathbf{e}, \mathbf{y})$

(b) Gradient explained by difference in lifestyles across education groups for given health dynamics,  $\Delta_e p(\mathbf{y}|\mathbf{e})$

## RESULTS: LIFESTYLES, EDUCATION, AND HEALTH DYNAMICS

## 3. Effect of lifestyle on LE larger for the more educated (3 years)

## LE at age 50 across education and lifestyles: males born in 1970s

	All		HSD		HSG		CG		$\Delta$ LE (CG-HSD)		
	%	LE	%	LE	%	LE	%	LE	Data	(a)	(b)
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(a) Gradient explained by difference in health dynamics across education groups for given lifestyle,  $\Delta_e p(\mathbf{h}|\mathbf{e}, \mathbf{y})$ (b) Gradient explained by difference in lifestyles across education groups for given health dynamics,  $\Delta_e p(\mathbf{y}|\mathbf{e})$

## RESULTS: LIFESTYLES, EDUCATION, AND HEALTH DYNAMICS

## 4. Lifestyles explain around 40% of the education gradient of LE

## LE at age 50 across education and lifestyles: males born in 1970s

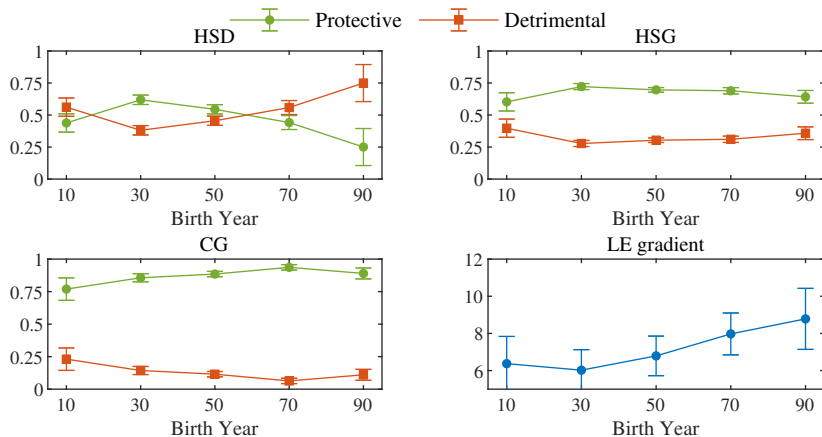
	All		HSD		HSG		CG		$\Delta$ LE (CG-HSD)		
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(a) Gradient explained by difference in health dynamics across education groups for given lifestyle,  $\Delta_e p(\mathbf{h}|\mathbf{e}, y)$ (b) Gradient explained by difference in lifestyles across education groups for given health dynamics,  $\Delta_e p(y|\mathbf{e})$

## RESULTS: CHANGES ACROSS COHORTS

### 5. Education gradient of lifestyles widens over time

#### Probability of lifestyle at age 50 across cohorts. Males



## The Model

# THE MODEL

## Two different stages

- 1 Early life
  - Choice of education and lifestyle
- 2 Life cycle
  - a) **Working age**: standard life-cycle incomplete-markets model of consumption with health and labor market risks
  - b) **Retirement**: as before, but without labor market risks

## Stage 1: Early life



## SET UP

- Teenager/parents in cohort  $c$  make once-and-for-all simultaneous choices of
  - education  $e \in \{HSD, HSG, CG\}$
  - lifestyle  $y \in \{DET, PRO\}$

- They solve  $\max_{e,y} \left\{ V_0^{eyc} - \tau_e - \tau_y \right\}$

- Value  $V_0^{eyc}$  of starting stage 2 with type  $(e, y, c)$

- Cost  $\tau_e$  of education  $e$ :

$$\tau_{HSD} = 0 \quad | \quad \tau_{HSG} \sim N(\mu_{HSG}, \sigma_{HSG}) \quad | \quad \tau_{CG} \sim N(\mu_{CG}, \sigma_{CG})$$

- Cost  $\tau_y$  of lifestyle  $y$ :

$$\tau_{DET} = 0 \quad | \quad \tau_{PRO} \sim N(\mu_{PRO}, \sigma_{PRO})$$

- The choices are independent if  $V_0^{CG,PRO} - V_0^{CG,DET} = V_0^{HSD,PRO} - V_0^{HSD,DET}$

- There are [complementarities](#) between education and lifestyle if:

$$V_0^{CG,PRO} - V_0^{CG,DET} > V_0^{HSD,PRO} - V_0^{HSD,DET}$$

Stage 2: Life cycle

## STATE VARIABLES

- Working agents are heterogeneous with respect to:

### 1 Types

- Education  $e \in \{\text{HSD}, \text{HSG}, \text{CG}\}$
- Lifestyle  $y \in \{\text{DET}, \text{PRO}\}$
- Cohort  $c \in \{1930, 1970\}$

### 2 Exogeneous and deterministic state

- Age  $t \in \{25, 27, 29, \dots\}$

### 3 Exogeneous and stochastic states

- Health status  $h_t \in \{h_g, h_b\}$
- Employment status  $l_t \in \{0, 1\}$
- Shock to earnings  $\zeta_t \in \mathbb{R}$

### 4 Endogenous state

- Cash-on-hand  $x_t \in [\underline{x}, \infty)$

## WORKER'S PROBLEM

- Worker's problem can be written as:

$$V_t^{\text{eyc}}(h, \zeta, x) = \max_{c, k'} \left\{ u(c) + \beta \left[ s_t^{\text{ey}}(h) \sum_{h'} \Gamma_t^{\text{ey}}(h'|h) \mathbb{E}[V_{t+1}^{\text{eyc}}(h', \zeta', x')] \right. \right. \\ \left. \left. + (1 - s_t^{\text{ey}}(h)) v_{t+1}(k') \right] \right\}$$

$$\text{s.t. } k' = x - c$$

$$\tilde{x}' = (1 + r) k' + T[l_{t+1}^{\text{ec}}(\varepsilon', h') w_{t+1}^{\text{ec}}(\zeta', \epsilon', h')] - m_{t+1}^{\text{e}}(\xi', h')$$

$$x' = \max\{\tilde{x}', \underline{x}\}$$

$$\text{Flow utility: } u(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma} + b$$

$$\text{Bequest motive: } v_{t+1}(k) = \beta^{T-(t+1)} \theta_1 \frac{(k + \theta_2)^{1-\sigma} - 1}{1 - \sigma}$$

## Calibration

# CALIBRATION

- Life-cycle:
  - External:
    - Parameters related to: demographics, taxes, social security
    - Cohort-specific wages  $w_t^{ec}(\zeta, \epsilon, h)$  and labor force participation  $l_t^{ec}(\epsilon, h)$
    - Cohort-independent health dynamics  $s_t^{ey}(h)$  and  $\Gamma_t^{ey}(h'|h)$
    - Cohort-independent medical spending  $m_t^e(\xi, h)$
  - Internal: SMM to calibrate remaining 4 parameters  $(x, \theta_1, \theta_2, b)$ 
    - Median wealth across age (by education and lifestyles) for the 1930s cohort
    - Value of statistical life
- Early life:
  - Estimate cost parameters by matching the marginal distributions of education and lifestyles for two different cohorts: 1930 and 1970.

# Counterfactuals

## TWO QUESTIONS

- 1 Why is there an education gradient of lifestyles?
- 2 What has been the effect of the rise in the education wage premium on the increase in education gradient of LE?



Question 1: Education gradient of lifestyle

# EDUCATION GRADIENT OF LIFESTYLE

## Mechanisms

- Why higher educated individuals are more likely to be **protective**?

① Income gradient:  $w_t^{ec}(\zeta, \epsilon, h)$  and  $l_t^{ec}(\epsilon, h)$

Higher expected income for the more educated motivates healthier behavior because the value of life increases w/ consumption possibilities

$$V_0^{CG,PRO} - V_0^{CG,DET} > V_0^{HSD,PRO} - V_0^{HSD,DET}$$

② Complementarities in health dynamics:  $s_t^{ey}(h)$  and  $\Gamma_t^{ey}(h|h)$

Gains in life expectancy due to protective health behavior are larger for those with a college education

$$V_0^{CG,PRO} - V_0^{CG,DET} > V_0^{HSD,PRO} - V_0^{HSD,DET}$$

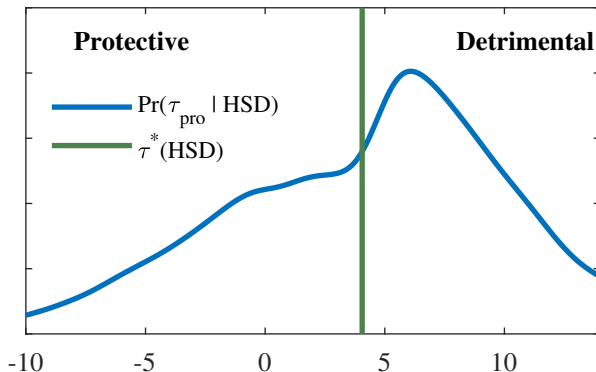
③ Selection:

Given the complementarities between lifestyle and education, individuals facing lower cost of **protective** behavior ( $\tau_{PRO}$ ) are more likely to choose higher education.

## EDUCATION GRADIENT OF LIFESTYLE

### Lifestyle Choice for HSD

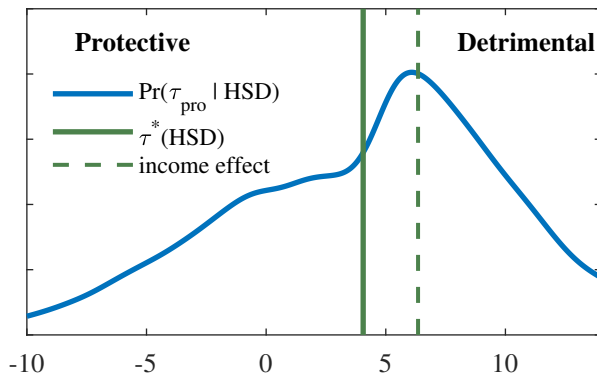
- HSD choose  $y = \text{PRO}$  iff  $\tau_{\text{PRO}} < V_0^{\text{HSD,PRO}} - V_0^{\text{HSD,DET}} \equiv \tau^*(\text{HSD})$



# EDUCATION GRADIENT OF LIFESTYLE

## 1. Income Effect

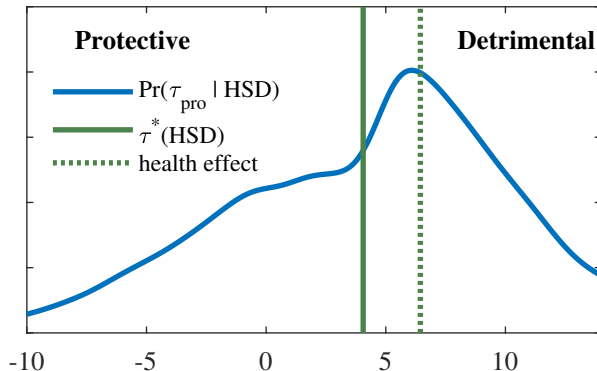
→ If HSD had **same income** as CG: 17pp more of PRO (out of 45pp gap)



# EDUCATION GRADIENT OF LIFESTYLE

## 2. Health Effect

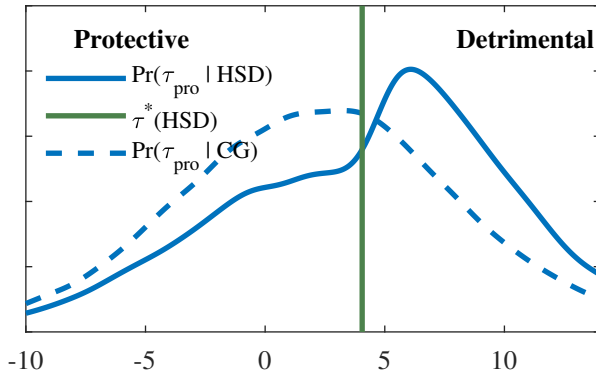
→ If HSD had **same health gain of PRO** as CG: 17pp more of PRO (out of 45pp gap)



## EDUCATION GRADIENT OF LIFESTYLE

### 3. Selection

→ If HSD had same **distribution of  $\tau_{\text{PRO}}$**  as CG: 19pp more of PRO (out of 45pp gap)



## Question 2: Changes over time

# CHANGES OVER TIME

## Mechanisms

- Income effect: Increases in the education wage premium strengthen the complementarity between education and lifestyles,

$$\Delta_c (V_0^{\text{CG},\text{PRO},\text{C}} - V_0^{\text{CG},\text{DET},\text{C}}) > \Delta_c (V_0^{\text{HSD},\text{PRO},\text{C}} - V_0^{\text{HSD},\text{DET},\text{C}})$$

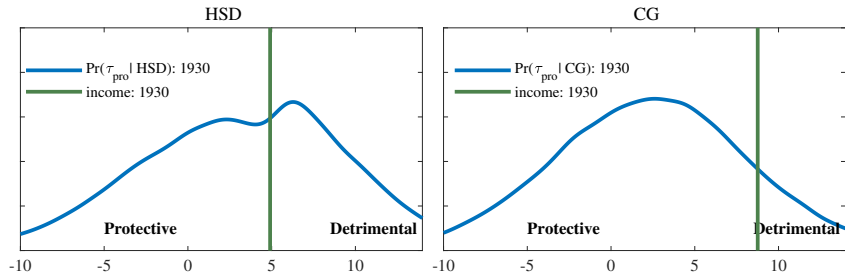
→ This increases the education gradient in  $\Pr[y = \text{PRO} | e]$

- Selection effect: worse pool of individuals in terms  $\tau_{\text{PRO}}$  for both HSD and CG.  
→ Unclear effect on the education gradient



# CHANGES OVER TIME: 1930 VS 1970 COHORTS

1930 cohort

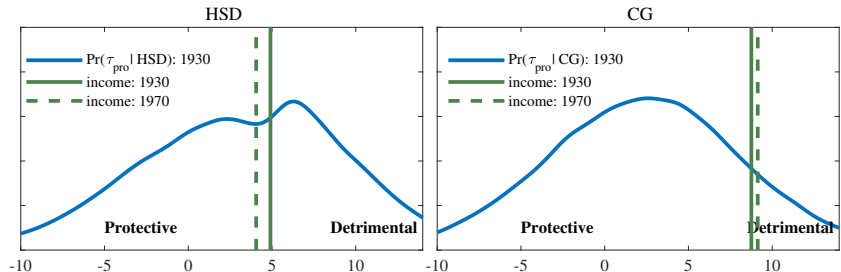


# CHANGES OVER TIME: 1930 VS 1970 COHORTS

## Income effect

$\Pr(\tau_{\text{PRO}} | e)$  as in 1930, education premium widens

- $\Pr(\text{PRO} | \text{HSD})$  declines 5pp
- $\Pr(\text{PRO} | \text{CG})$  increases 1pp
- LE gradient widens 5 months

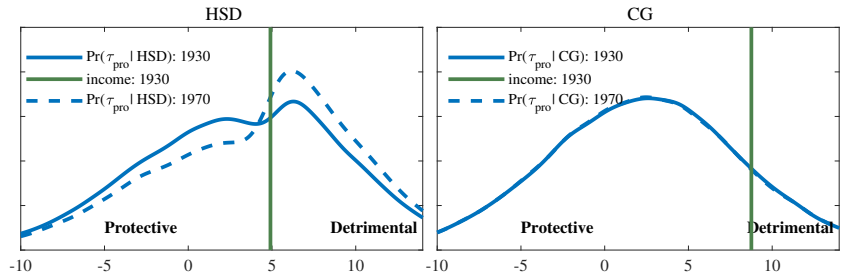


# CHANGES OVER TIME: 1930 VS 1970 COHORTS

## Selection effect

$\Pr(\tau_{\text{PRO}} | e)$  changes and education premium as in 1930

- $\Pr(\text{PRO} | \text{HSD})$  declines 9pp
- $\Pr(\text{PRO} | \text{CG})$  increases 0pp
- LE gradient widens 8 months



## Conclusions

## CONCLUSIONS

- We develop an econometric model to identify latent types in lifestyles
  - ⇒ Differences in lifestyles across education groups account for 40% of the LE gradient (3.1 out of 7.8 years)
- HA model w/ complementarities in edu and health investments
  - ① Education gradient of lifestyles
    - Income and Health advantage explains 15% (⇒ 1.1 years of LE gradient)
    - Selection explains 17% (⇒ 1.5 years)
  - ② 1.9 years increase in education gradient of LE between 1930s and 1970s cohorts
    - Changes in wages explains 50% of the increase
    - 15% explained by changes in wages
    - 5% explained by changes in perceptions
    - 77% explained by changes in selection

# ECONOMETRIC MODEL

## 1. Health Behavior

- We model the probability of individual  $i$  of reporting the  $m$ 'th behaviour ( $z_{mt} = 1$ ) at time  $t$  as a probit model.
  - There is a latent variable ( $z_{mt}^*$ ) that depends on type ( $y$ ), age ( $a_t$ ), health ( $h_t$ ), and an idiosyncratic shock ( $\epsilon_t$ )

$$z_{mt}^* = \gamma_{0,m,y} + \gamma_{1,m,y}a_t + \gamma_{2,m,y}a_t^2 + \gamma_{3,m,y}h_t + \epsilon_t, \quad \epsilon_t \sim N(0, 1)$$

- Then,

$$\text{Prob}(z_{mt} = 1) = \text{Prob}(z_{mt}^* > 0) = \underbrace{\alpha_m(y, a_t, h_t)}_{\alpha_{mt}}$$

- Considering independence of health behaviour given type, the probability of observing a sequence of health behaviours  $\mathbf{z}$  for an individual across time, is assumed to be given by:

$$p(\mathbf{z}|\mathbf{h}, y) = \prod_{t=1}^T \prod_{m=1}^M \alpha_{mt}^{z_{mt}} (1 - \alpha_{mt})^{1-z_{mt}}$$

# ECONOMETRIC MODEL

## 2. Health Dynamics

- We model the probability of reporting some health  $h' \in \{Good, Bad, Dead\}$  next period as a [multinomial probit model](#)
  - There are latent variables ( $h_{h,h'}^*$ ) that depend on gender ( $g$ ), education ( $e$ ), type ( $y$ ), health ( $h$ ), age ( $a$ ), and an idiosyncratic shock ( $\epsilon_{h'}$ )

$$h_{h,h'}^* = f(a, s, e, y; \beta_{h,h'}) + \epsilon_{h'}$$

with,

$$f(a, g, e, y; \beta_{h'}) = \beta_{0,y,e,g,h,h'} + \beta_{1,y,e,g,h,h'} a$$

Back to Mixture Model

# ECONOMETRIC MODEL

## 3. Weights

- The mixture weights at the initial age (age 25) are modeled as a multinomial probit model:

$$\begin{aligned} y_1^* &= \lambda_{0,s,e,c}^1 + \lambda_{1,s,e}^1 bh + \epsilon_1 \\ &\vdots \\ y_Y^* &= \lambda_{0,s,e,c}^Y + \lambda_{1,s,e}^Y bh + \epsilon_Y, \end{aligned}$$

- We compute weights for future ages using the health transition model:

$$p(y, h_t | s, e, c) = \sum_{h_{t-1}} p(h_t | h_{t-1}, y, s, e) p(y, h_{t-1} | s, e, c)$$

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## HEALTH BEHAVIOUR DATA

## Mean health behavior and 4-year auto-correlation

	Mean					AC	
	HSD	HSG	CG	50-60	70-80	50-60	70-80
Drinking	0.09	0.10	0.07	0.13	0.05	0.53	0.48
Smoking	0.23	0.16	0.07	0.21	0.08	0.81	0.78
Cancer test	0.66	0.76	0.85	0.71	0.77	0.42	0.41
Cholesterol	0.77	0.84	0.89	0.79	0.89	0.37	0.30
Flu shot	0.58	0.62	0.69	0.49	0.77	0.55	0.62
Exercise	0.26	0.39	0.55	0.42	0.38	0.40	0.39

Notes: HRS. HSD: high-school dropout; HSG: high-school graduate; CG: college graduate; 50-60: sub-sample of individuals aged 50 to 60; 70-80: sub-sample of individuals aged 70 to 80. The last two columns show the autocorrelation (AC) of each health behavior with a 4-year lag.

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## HEALTH BEHAVIOUR DATA

## Cross correlation health behaviors

	Drinking	Smoking	Cancer	Cholesterol	Flu shot	Exercise
Drinking	1.00	0.08	-0.02	-0.03	-0.03	0.02
Smoking	0.18	1.00	-0.10	-0.07	-0.06	-0.08
Cancer test	-0.04	-0.13	1.00	0.26	0.19	0.11
Cholesterol	-0.04	-0.11	0.39	1.00	0.24	0.07
Flu shot	-0.05	-0.05	0.23	0.24	1.00	0.02
Exercise	-0.01	-0.14	0.08	0.04	0.02	1.00

Notes: HRS. Upper diagonal: individuals aged 70 to 80. Lower diagonal: individuals aged 50 to 60.

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