Education and Health: The Role of Cognitive Ability

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Motivation

- Differences in health and life expectancy across educational groups are striking and pervasive.
- Recent results deriving from natural experiments in education suggest that causal effect of education on health is small or even absent (e.g. Lleras-Muney, 2005; Van Kippersluis et al. 2011; Meghir et al. 2012; Clark and Royer, 2013)
- Suggest an important role for confounding factors, such as discount rates, cognitive and non-cognitive skills (Murasko, 2007; Carneiro et al. 2007)

Motivation (2)

- Established that cognitive ability and some non-cognitive factors such as self-esteem are associated with health outcomes at ages 30-40 (Elias, 2004; Auld and Sidhu, 2005; Murasko, 2007; Carneiro et al. 2007; Kaestner and Collison, 2011)
- Nonetheless, hardly anything is known about how much of the association between education and health is explained by these cognitive and non-cognitive abilities.

Motivation (3)

One notable exception: series of papers by Conti and Heckman (2010), Conti et al. (2010; 2011), and Heckman et al. (2011) in which they:

- estimate a structural equation model modeling the interdependence between education, health, and latent factors capturing cognitive and non-cognitive abilities.
- use the British Cohort Study with self-reported health outcomes measured around age 30
- show that around half of the association is due to the causal effect of education on health outcomes, other half is selection

Our contribution

Disentangle the effects of education and cognitive ability on health outcomes, using a multistate structural equation model

Contribution is twofold:

1. We observe mortality and hospitalization between ages 55 and 75 as objective health indicators
2. Extend structural equation model by Conti et al. (2010) to allow for duration dependent variables (multistate);
time to death, time to hospitalization and time till discharge from hospital

Basic model: educational choice

Assume a probit model for educational choice:
Let $D_i = 1$ if the individual enters secondary education, and 0 otherwise.

$$D_i = \begin{cases} 1 & \text{if } D_i^* \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

Underlying latent utility for education depends on observed characteristics X^D and latent cognitive ability θ.

$$D_i^* = \gamma X_i^D + \alpha_D \theta + \upsilon_D$$

with υ_D independent of X_i^D and θ

Basic model: potential outcomes

Two potential outcomes Y_{i1} and Y_{i0} depending on educational choice, with observed outcome Y_i

$$Y_i = D_i Y_{i1} + (1 - D_i) Y_{i0}$$

Where both Y_{i1} and Y_{i0} depend on exogenous characteristics X^Y and on latent cognitive ability θ.

$$\begin{aligned} Y_{i0} &= \beta_0 X_i^Y + \alpha_0 \theta + \upsilon_0 \\ Y_{i1} &= \beta_1 X_i^Y + \alpha_1 \theta + \upsilon_1 \end{aligned}$$

with (υ_0, υ_1) are independent of X^Y and ability θ.

Basic model: measurements

Measurements for the ability

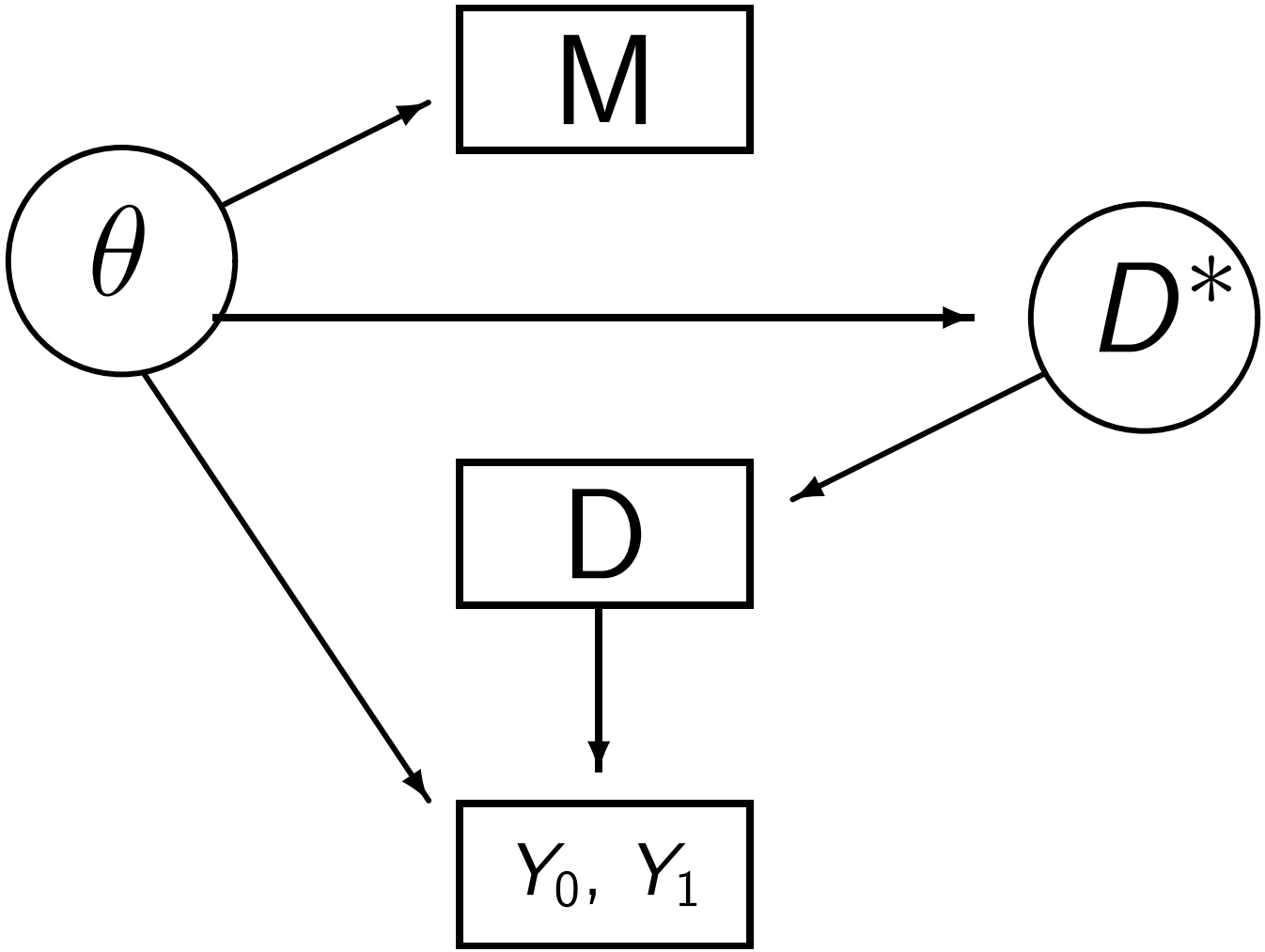
$$\begin{aligned} M_{i,1} &= \delta_1 X_i^M + \alpha_{1,M}\theta + \upsilon_{1,M} \\ &\vdots \\ M_{i,N} &= \delta_N X_i^M + \alpha_{N,M}\theta + \upsilon_{N,M} \end{aligned}$$

with υ_M independent of X_i^M and θ and $\upsilon_M \sim \mathcal{N}(0, \sigma_M^2)$

θ is assumed to be discrete (3 level)-ability with $\Pr(\theta_l) = p_l$

For identification: $\alpha_{1,M} = 1$ and $\mathrm{E}(\theta) = 0$

Basic model: graphical representation



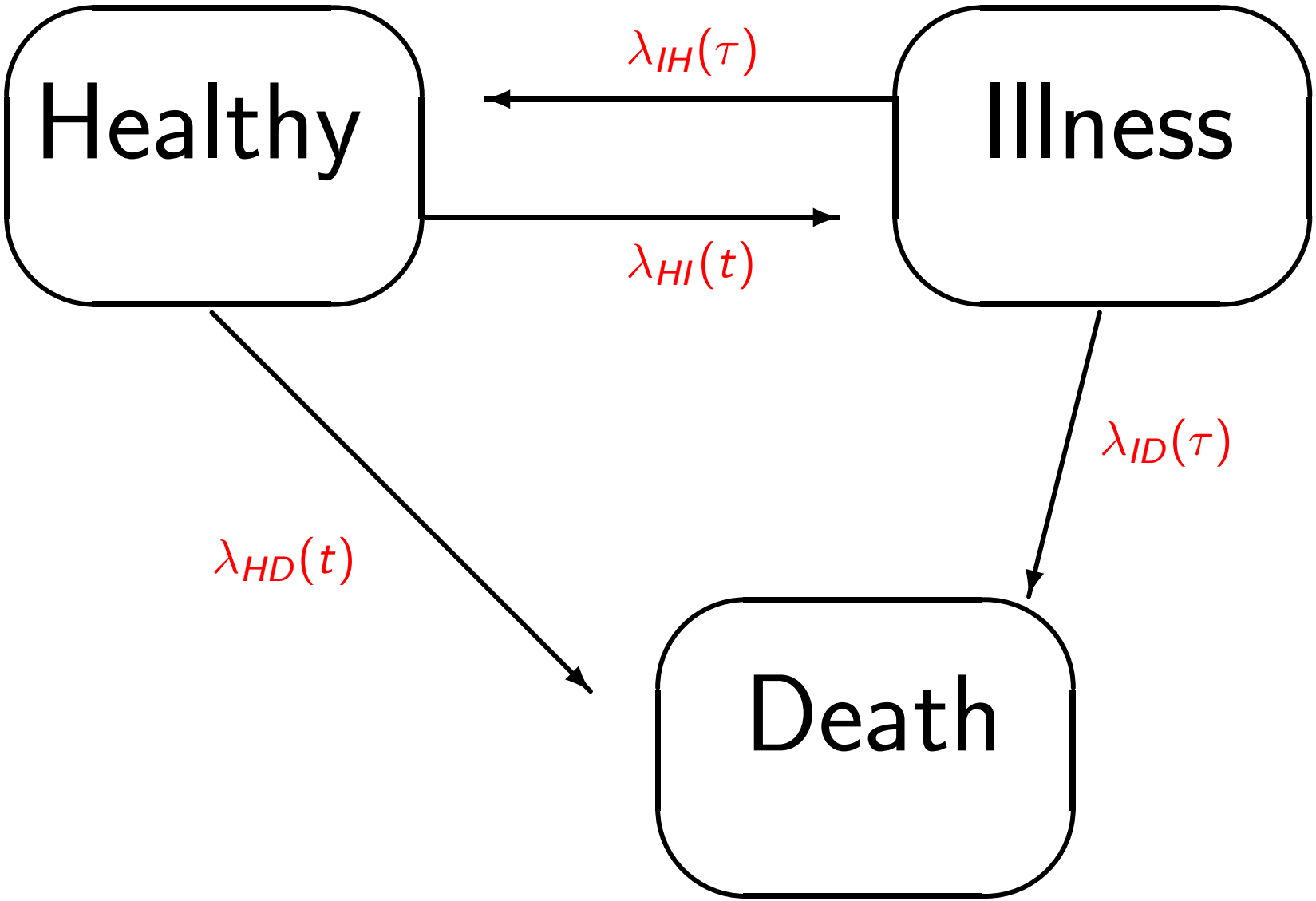
Multistate model

In our case, the outcome (mortality, time to discharge/admission) is a duration, and we have 8 potential hazards $\lambda^{(1)}$ and $\lambda^{(0)}$, with (for each transition) the observed hazard:

$$\lambda(t_i) = \lambda^{(1)}(t_{i1})^{D_i} \cdot \lambda^{(0)}(t_{i0})^{1-D_i}$$

with t_{i1} is the duration for an individual with high education ($D_i = 1$) and t_{i0} is the duration for an individual with low education ($D_i = 0$).

Multistate model: Y_0, Y_1 transition rates



Hazards Multistate model

Assume **Gompertz** proportional hazard from the healthy state:

$$\begin{aligned}\lambda_{HI}^{(k)}(t_i|X,\theta) &= e^{\beta_{kHI0}+a_{kHI}t_i}\exp\left(\beta_{kHI}X_i+\alpha_{kHI}\theta\right)\\ \lambda_{HD}^{(k)}(t_i|X,\theta) &= e^{\beta_{kHD0}+a_{kHD}t_i}\exp\left(\beta_{kHD}X_i+\alpha_{kHD}\theta\right)\end{aligned}$$

and **exponential: piecewise constant hazard** from the illness state

$$\begin{aligned}\lambda_{IH}^{(k)}(\tau_i|X,t_i,\theta) &= e^{\beta_{kIH0}+\sum_j a_{kIH,j}I_j(\tau)}\exp\left(\beta_{kIH}X_i+\alpha_{kIH}\theta\right)\\ \lambda_{ID}^{(k)}(\tau_i|X,t_i,\theta) &= e^{\beta_{kID0}+\sum_j a_{kID,j}I_j(\tau)}\exp\left(\beta_{kID}X_i+\alpha_{kID}\theta\right)\end{aligned}$$

for $k=0,1$ (education), t is age and τ is time in hospital (in days)

Gains from changing school level

Use estimated model to derive effects of changing education:

$$
\begin{aligned}
ATE(t) &= \int\int \mathrm{E}\big[Y_1(t) - Y_0(t) | X = x, \theta\big] \, dF_{X,\theta}(x, f) \\
ATET(t) &= \int\int \mathrm{E}\big[Y_1(t) - Y_0(t) | X = x, \theta, D = 1\big] \, dF_{X,\theta|D=1}(x, f) \\
ATEU(t) &= \int\int \mathrm{E}\big[Y_1(t) - Y_0(t) | X = x, \theta, D = 0\big] \, dF_{X,\theta|D=0}(x, f)
\end{aligned}
$$

with $Y_1(t), Y_0(t)$ many desired outcomes,
e.g. survival, life-expectancy, # of hospitalizations, probability ever in hospital.

Use simulation based on estimated coefficients.

"Brabant" Data and mortality and hospitalization

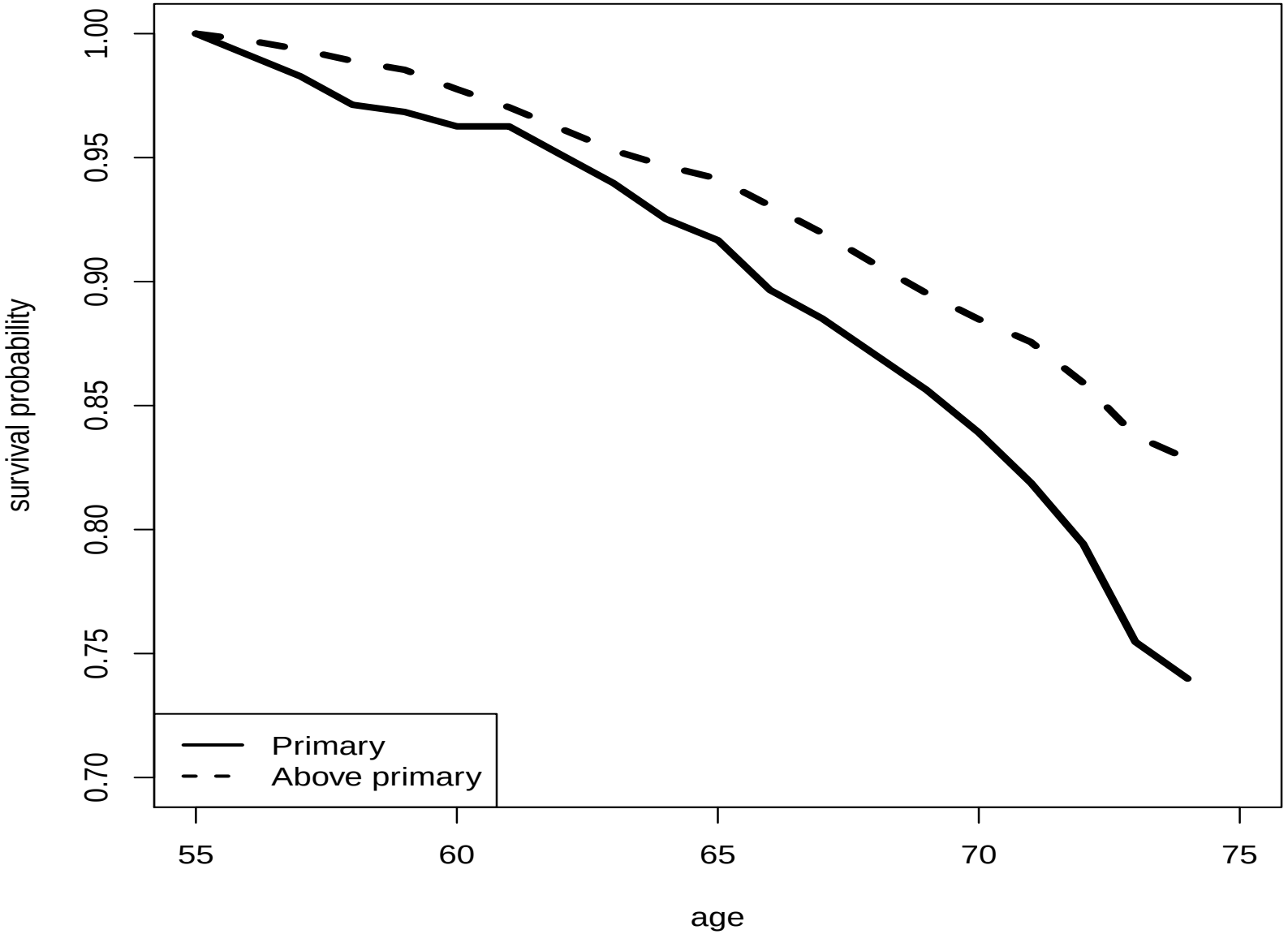
Survey in 1952 among pupils of the sixth grade of primary schools in the Dutch province of Noord-Brabant.

- Detailed info on individual intelligence, social background and school achievement ($N = 5,823$)
- Follow-up surveys in 1957, 1983 and 1993 providing labour market behaviour ($N = 2,998$)
- Linkage to administrative records (Stat NL) municipality-, cause of death- and hospital discharge register
  Providing mortality and demographics (1995-2010) and admission and discharge of hospitals, whether it was acute (1995-2005) ($N = 2579$)

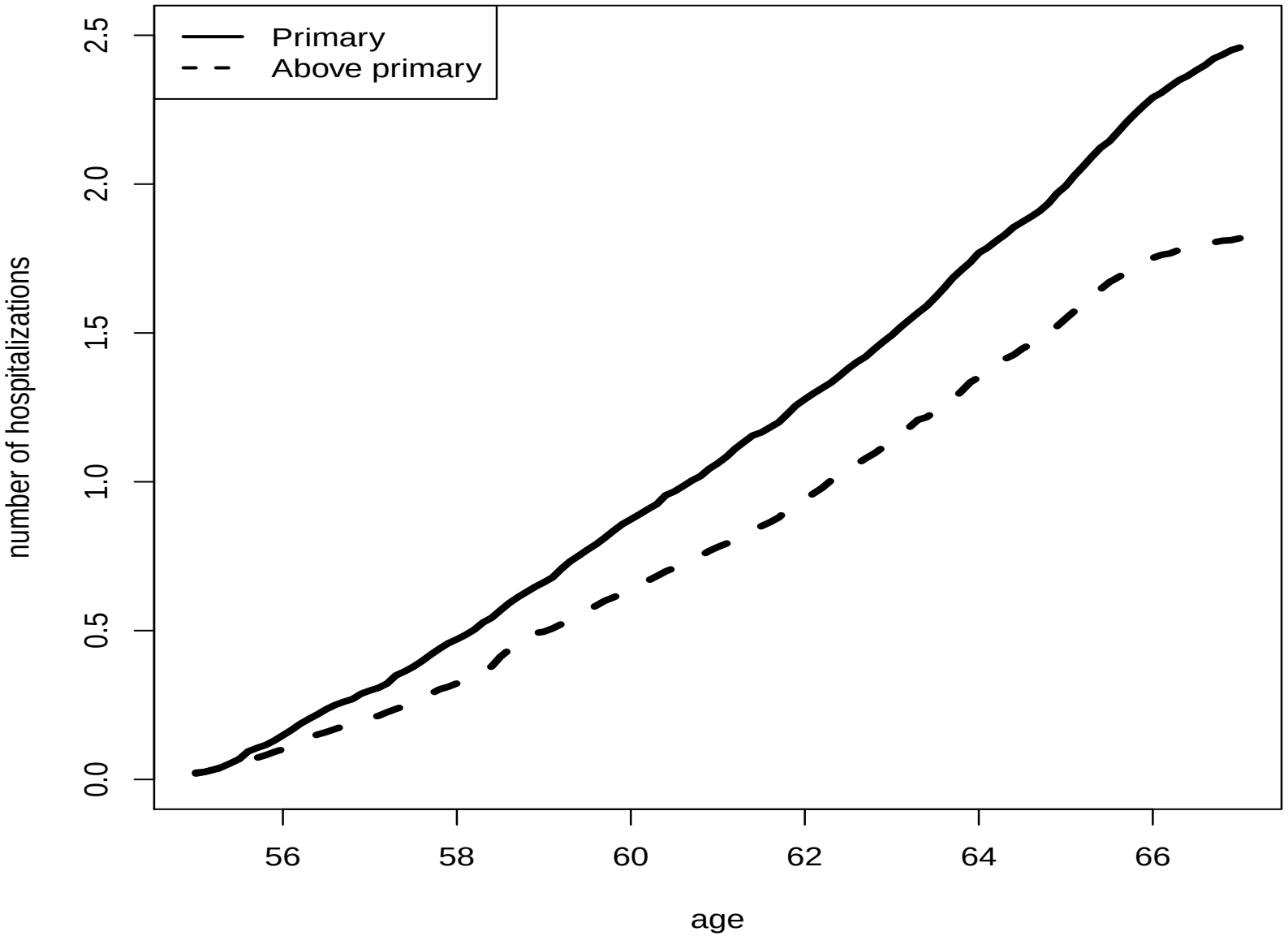
Descriptive statistics

	Low-educated	High-educated
	48%	52 %
Mortality		
died	16%	12%
% died in hospital	23%	18%
Hospitalization		
# hospital stays	2.4	1.8
emergency	25%	25%
length of stay (days)	4.3	4.8
Intelligence		
IQ	95.2	107.6
Male	57%	59 %
Child works	37%	18%

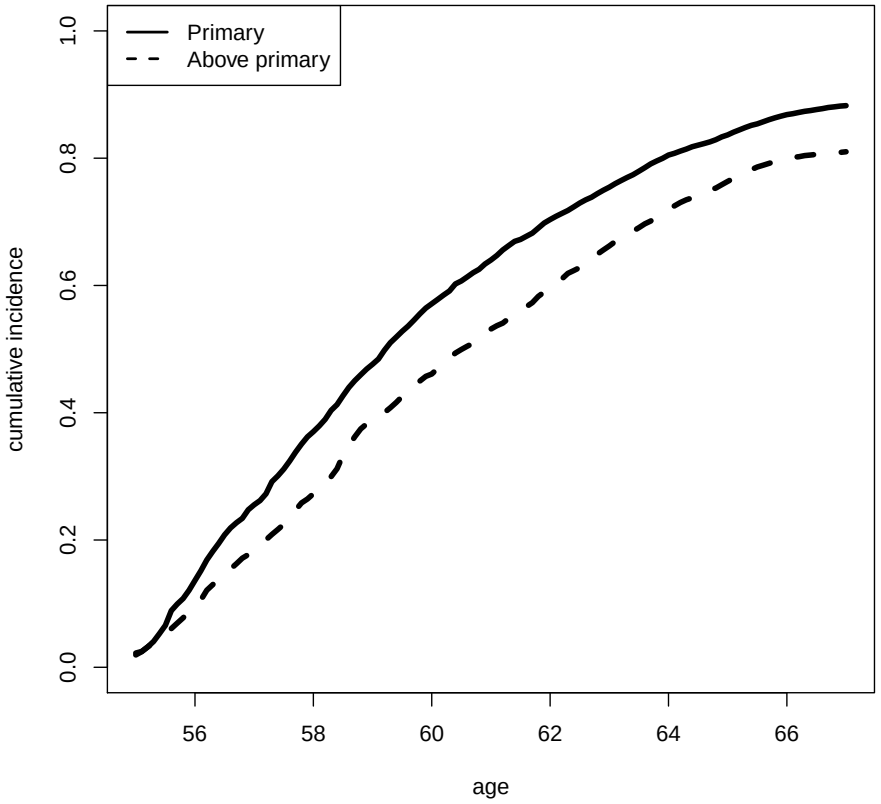
Kaplan-Meier survival, by education level



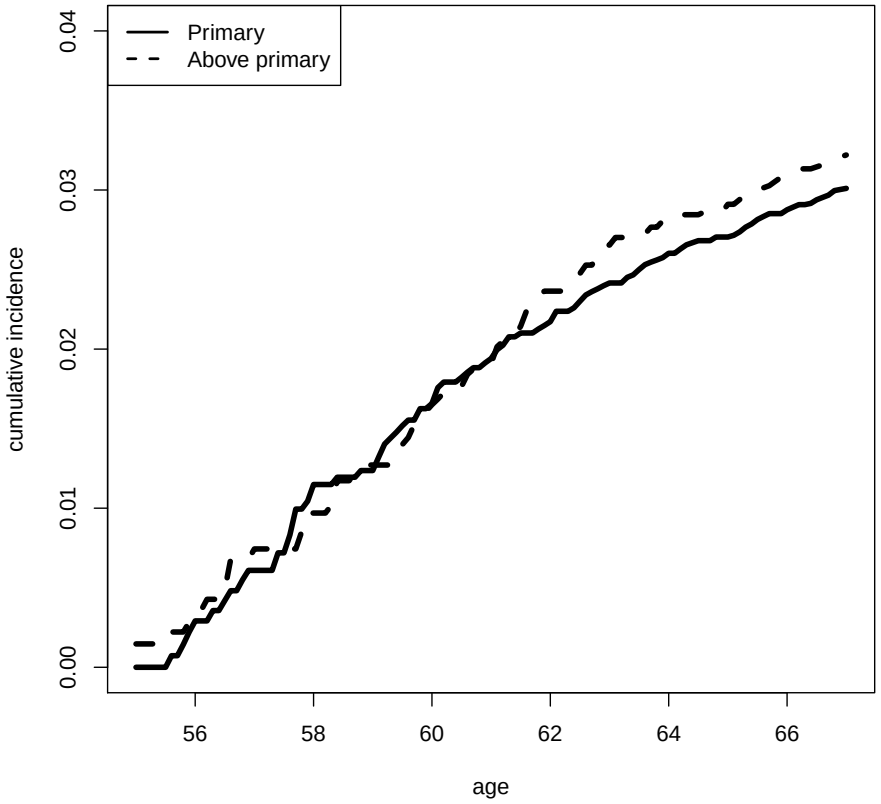
Cumulative Number of hospital visits, by education level



Cumulative incidence from Healthy, by education level

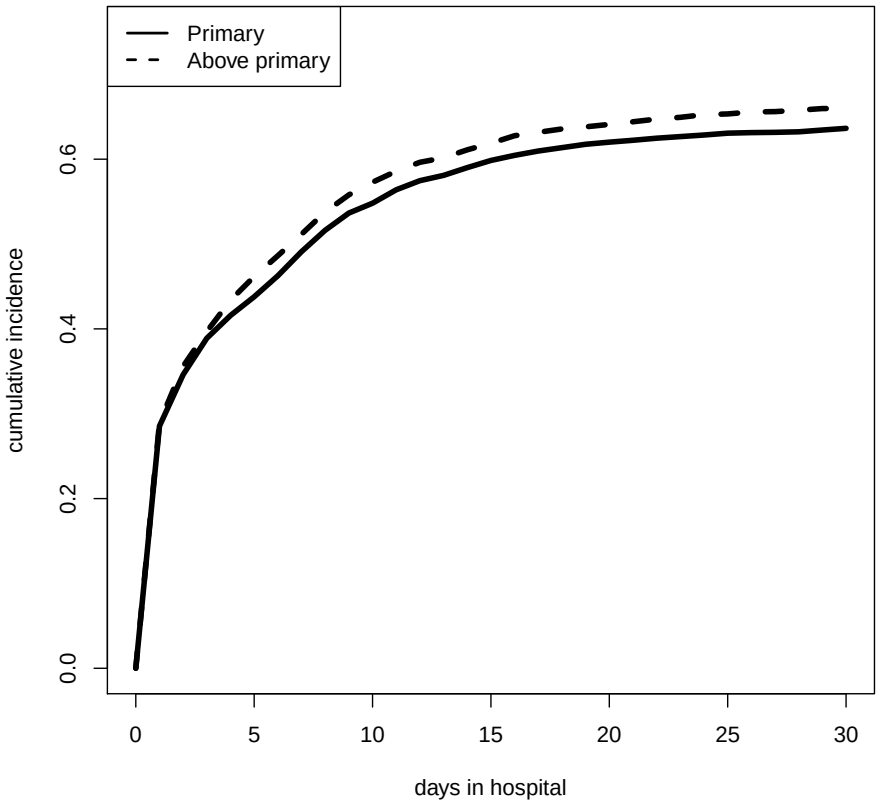


Hospital admission

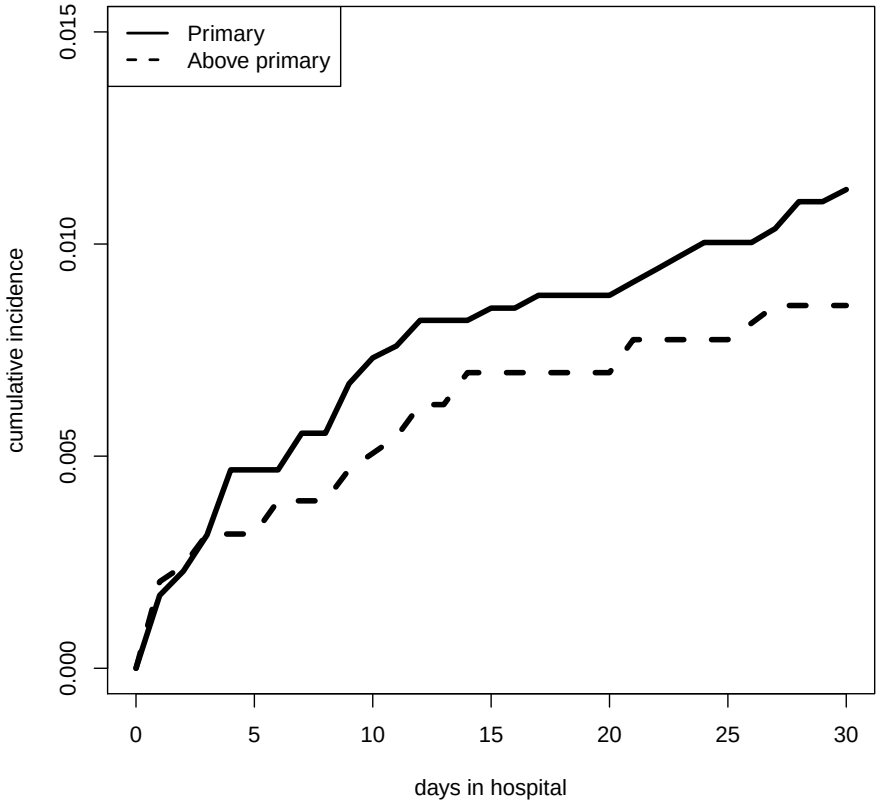


Death

Cumulative incidence from Hospital, by education level



Hospital discharge

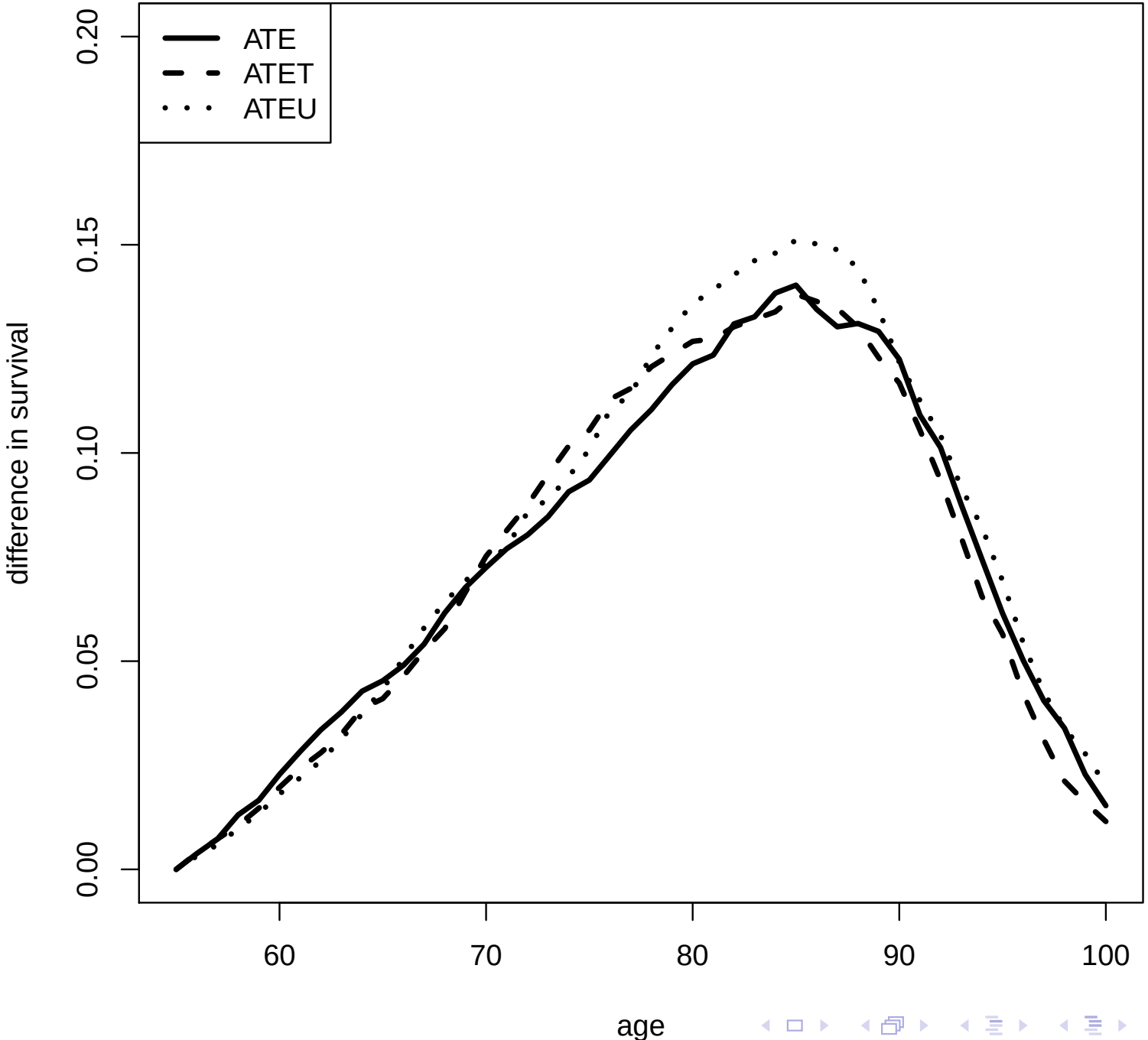


Death

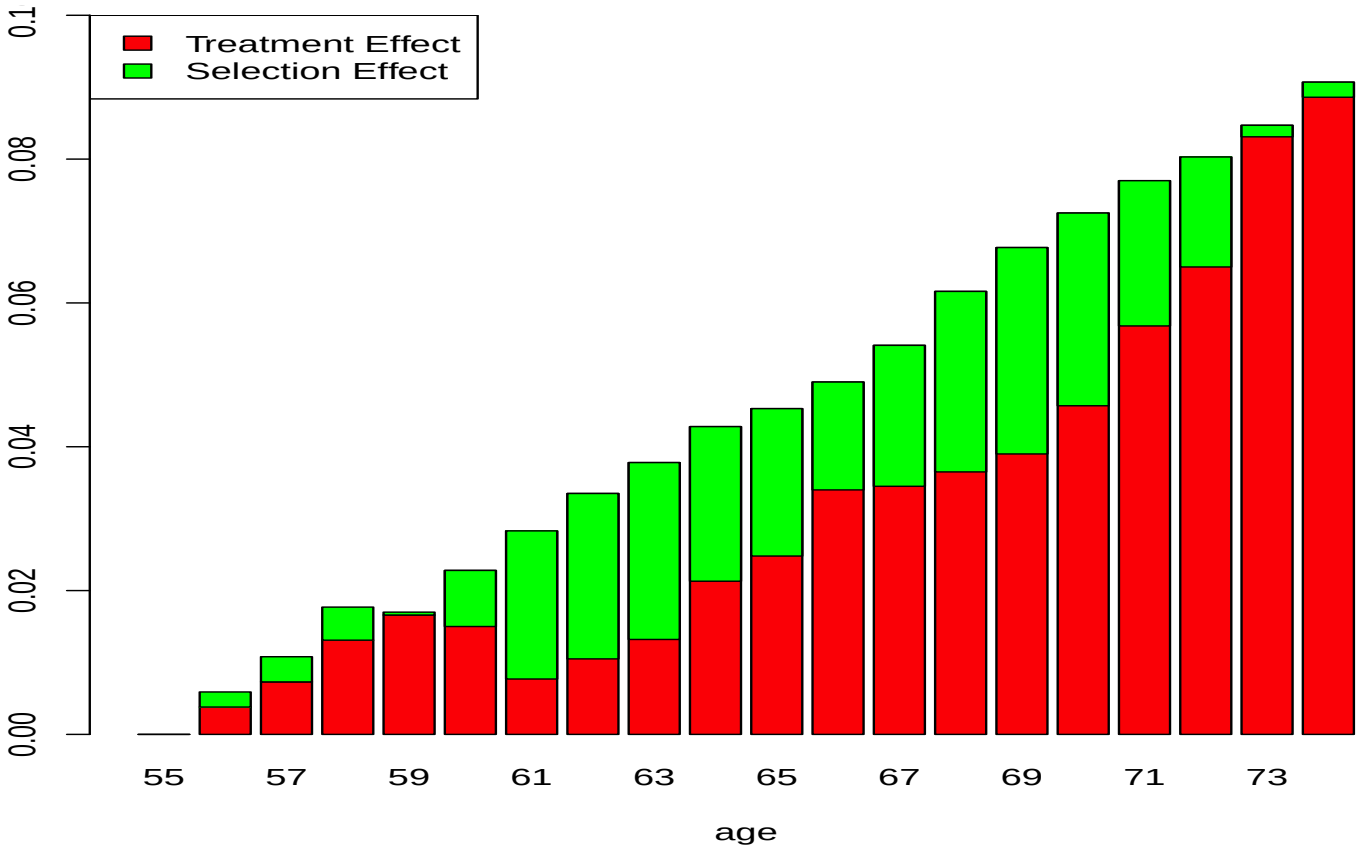
Parameter estimates (selection)

	α	male	workchild	brank5	Prot.	acute
Education	-1.33^*	0.04	-0.21^*	-0.11	0.49^*	–
Hazards						
from healthy						
$\lambda_{HI}^{(0)}$	-6.47^*	0.40^*	-0.19^*	0.53^*	–	–
$\lambda_{HI}^{(1)}$	-5.65^*	0.37^*	-0.08	-0.24^*	–	–
$\lambda_{HD}^{(0)}$	-4.62^*	1.05^*	0.28	0.20	–	–
$\lambda_{HD}^{(1)}$	-4.48^*	0.59^*	-0.02	-0.83^*	–	–
from ill						
$\lambda_{IH}^{(0)}$	-0.12	0.02	-0.21^*	0.04	–	-0.83^*
$\lambda_{IH}^{(1)}$	0.77^*	-0.03	0.11	-0.15	–	-0.67^*
$\lambda_{ID}^{(0)}$	-0.56	0.48	-0.19	-0.02	–	2.05^*
$\lambda_{ID}^{(1)}$	-0.63	0.23	-0.39	-0.30	–	1.01^*
Measurement	1	-0.92	-3.81^*	-3.03^*	5.18^*	–

Survival gain for high educated

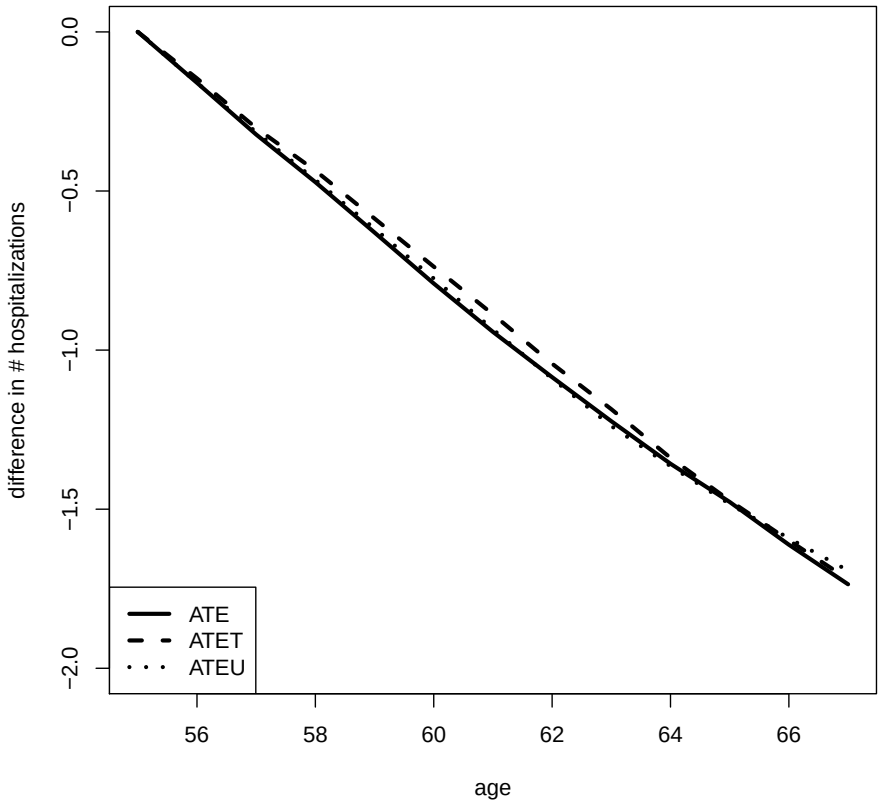


Decomposition

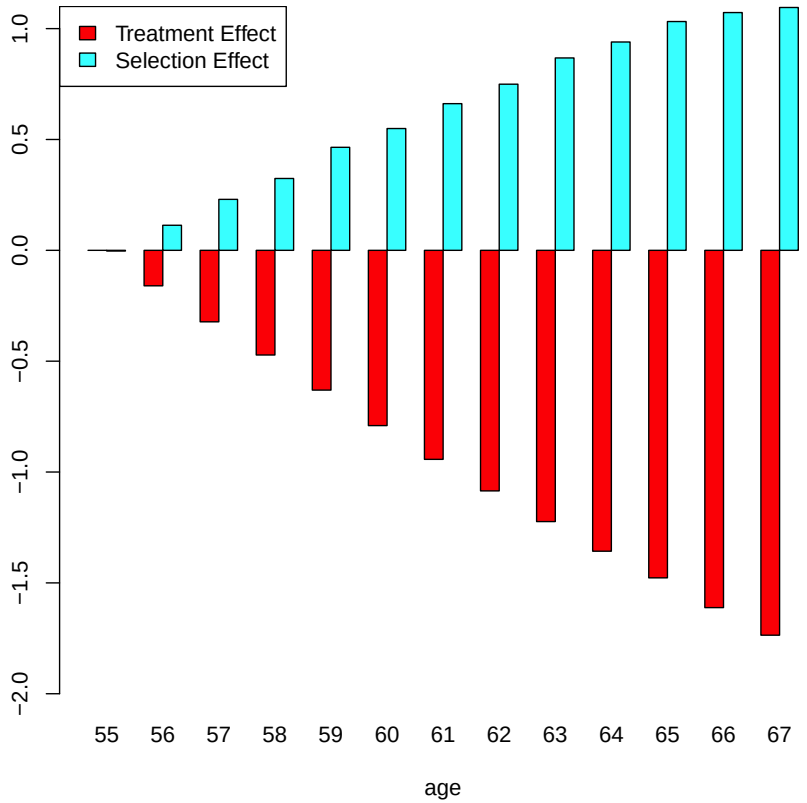


Decomposition of observed difference in Kaplan-Meier survival function in treatment effect and selection effect

Gain in number of hospital visits

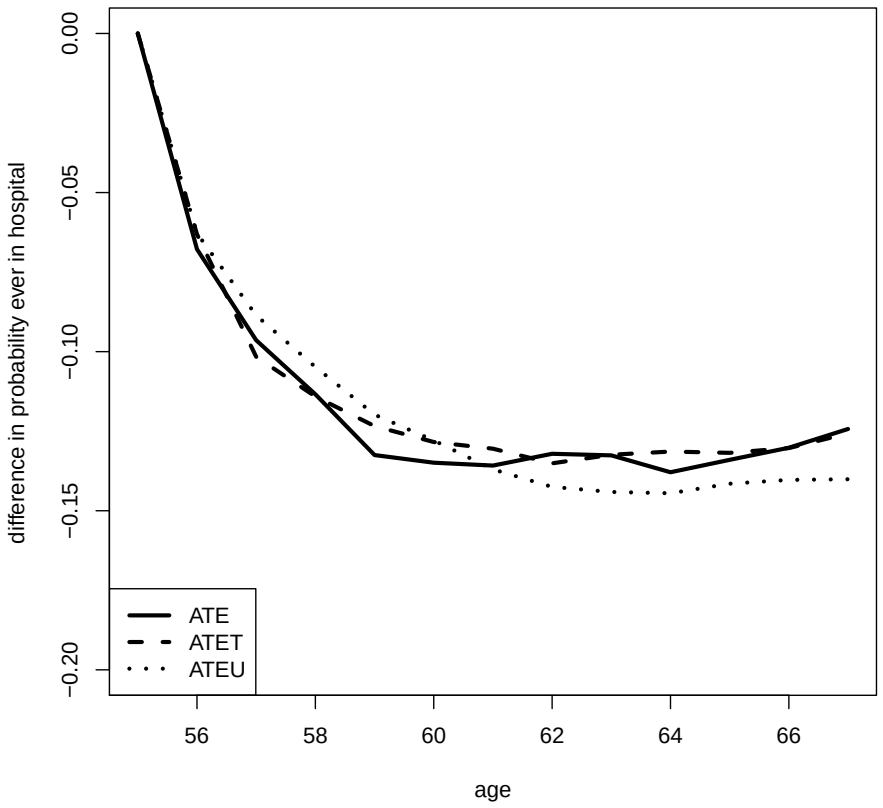


Estimated gain in # visits

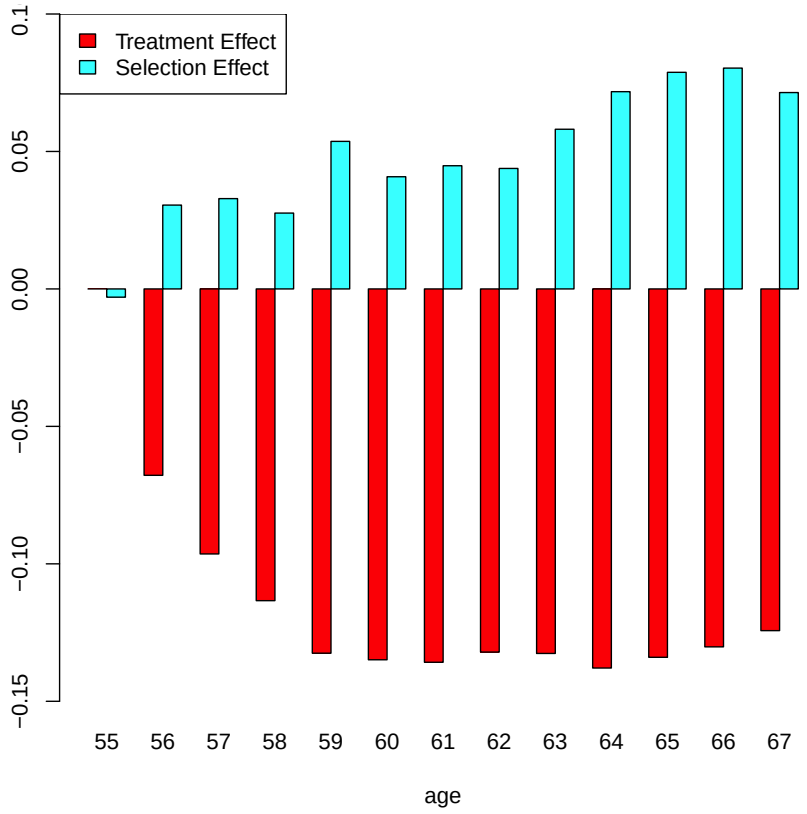


Decomposition

Gain ever in hospital



Estimated gain in probability



Decomposition

Conclusion

- Gain of education
  High educated live longer and are less frequent in hospital
- Latent (cognitive) skills (selection)
  - Survival
    Positive selection, explains up to 50%
  - Ever in hospital/number of hospitalizations
    Negative selection, increases education gain