Education, cognitive ability and Cause-Specific Mortality: A structural approach

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Motivation

- Education is negatively associated with mortality for most causes of death
- Standard Cox method:
  Interpretation of coefficients difficult in competing risks
  Ignores Cause-specific hazard rates are interdependent
  Does not provide importance of cause
  Education and mortality both depend on cognitive ability
- Proposed solution:
  Focus on months lost due to specific cause of death
  Structural model that derives cognitive ability from IQ-scores
- Using Swedish conscription data 18-63 year

Causal impact of education on mortality

- Recent results deriving from natural experiments and from twin studies in education suggest that causal effect of education on health is small or even absent
- Suggest an important role for confounding factors, such as cognitive ability
- Educational attainment and cognitive ability strongly correlated. Difficult to disentangle.
- Using structural models: models interdependence
  Half of mortality disparity across education levels due to selection of the healthier into higher education (Bijwaard et al. 2015a,b).
- Studies on educational differences in cause-specific mortality ignore endogeneity

Our contribution

Estimate the education-mortality gradient for major causes of death.

Contribution is threefold:

1. Causal effect of education on months-lost due to specific cause
2. Account for endogeneity of education attainment
3. Derive selection effect both on observed and unobserved characteristics (cognitive ability)

Swedish Military examimation Data

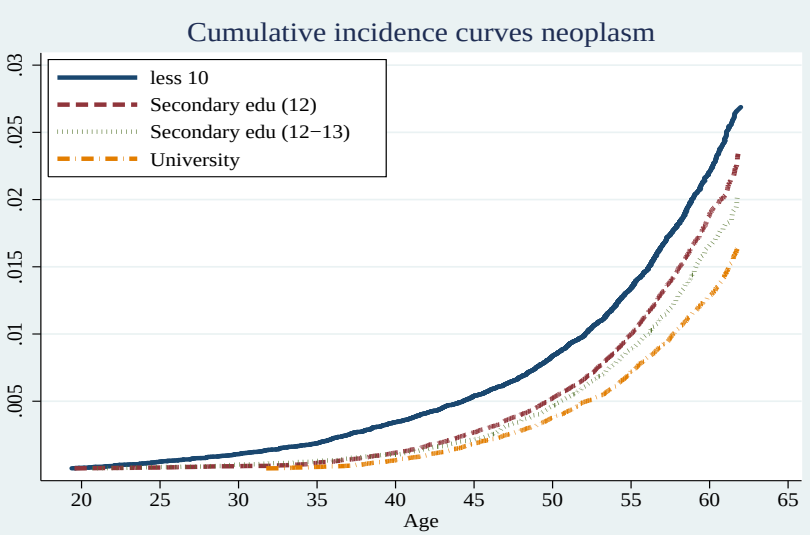
Examinations for military service men born 1951-1960: 446,545 individuals.

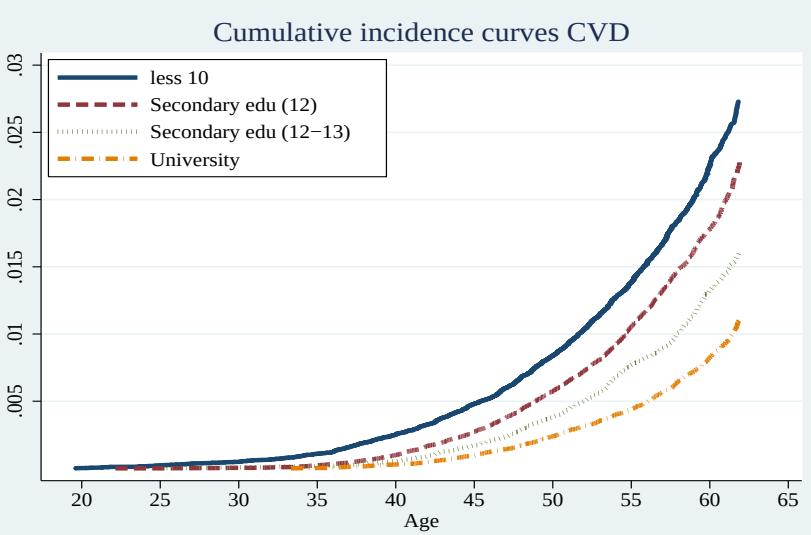
- Linked to parental info: Detailed info on individual demographic and socioeconomic characteristics, including parental SES and education
- Intelligence test: IQ in 9 categories
- Education classified in 4 levels:
  primary education, Secondary education (2 years), Full Secondary education (3 years) and, Higher education
- Linked to death registers:
  Mortality by cause of death, till end 2012.
  neoplasms, CVD, external causes ,and other causes.

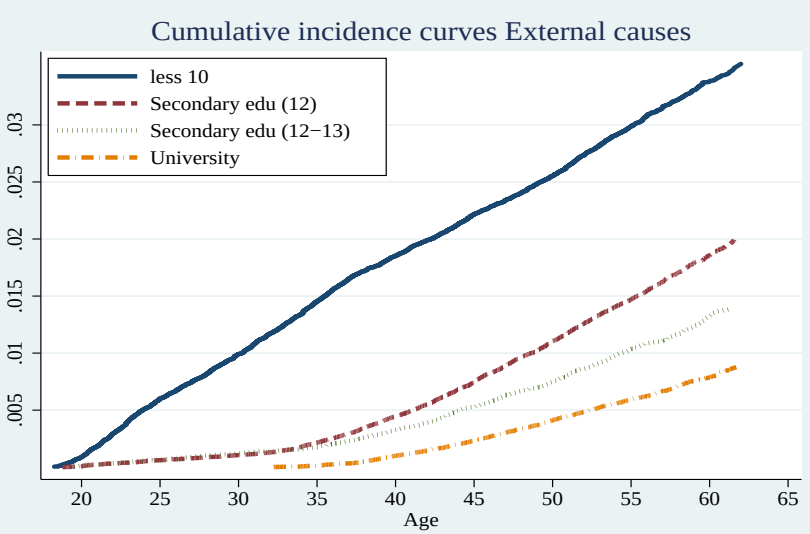
Descriptive statistics: distribution cause of death

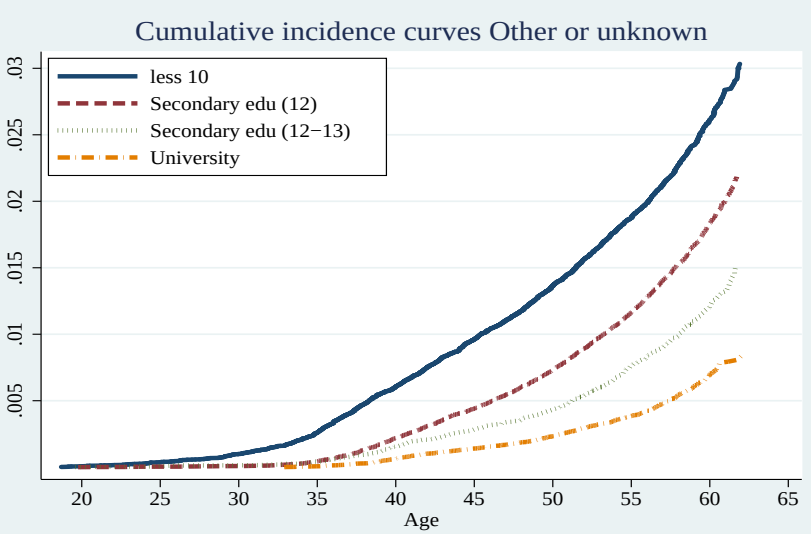
	primary	Sec edu (2yr)	Sec edu (3yr)	Higher
# of deaths	8,770	9,451	2,506	3,829
deaths per 1000	90.8	59.1	45.3	28.4
		causes of death		
neoplasm	18.2	14.0	13.1	10.0
Cardiovascular diseases	18.4	13.9	10.4	6.3
External causes	31.5	16.5	11.7	6.8
Other causes	22.6	14.7	10.1	5.3

Cumulative incidence curves by cause of death and education level









Cox hazard ratios, adjacent education

	Sec edu (2 yr)	Sec edu (3 yrs)	Higher
neoplasm	0.77**	0.88**	0.79**
CVD	0.72**	0.73**	0.63**
external causes	0.51**	0.69**	0.59**
other causes	0.59**	0.64**	0.54**

** $p < 0.01$

Inference in competing risks model

- Cause-specific Cox hazard models, $\lambda_k(t)$
  Difficult interpretation if one covariate appears in several competing hazards and assumes independence of causes of death.
- Cumulative incidence: probability dying from cause k before t

$$F_k(t) = \int_0^t \lambda_k(s) S(s)\, ds$$

  Fine-Gray model sub-distribution hazard also difficult to interpret
- Months lost due a specific cause, (from age 18 till age 63)

$$L_k(18, 63) = \int_{18}^{63} F_k(s)\, ds$$

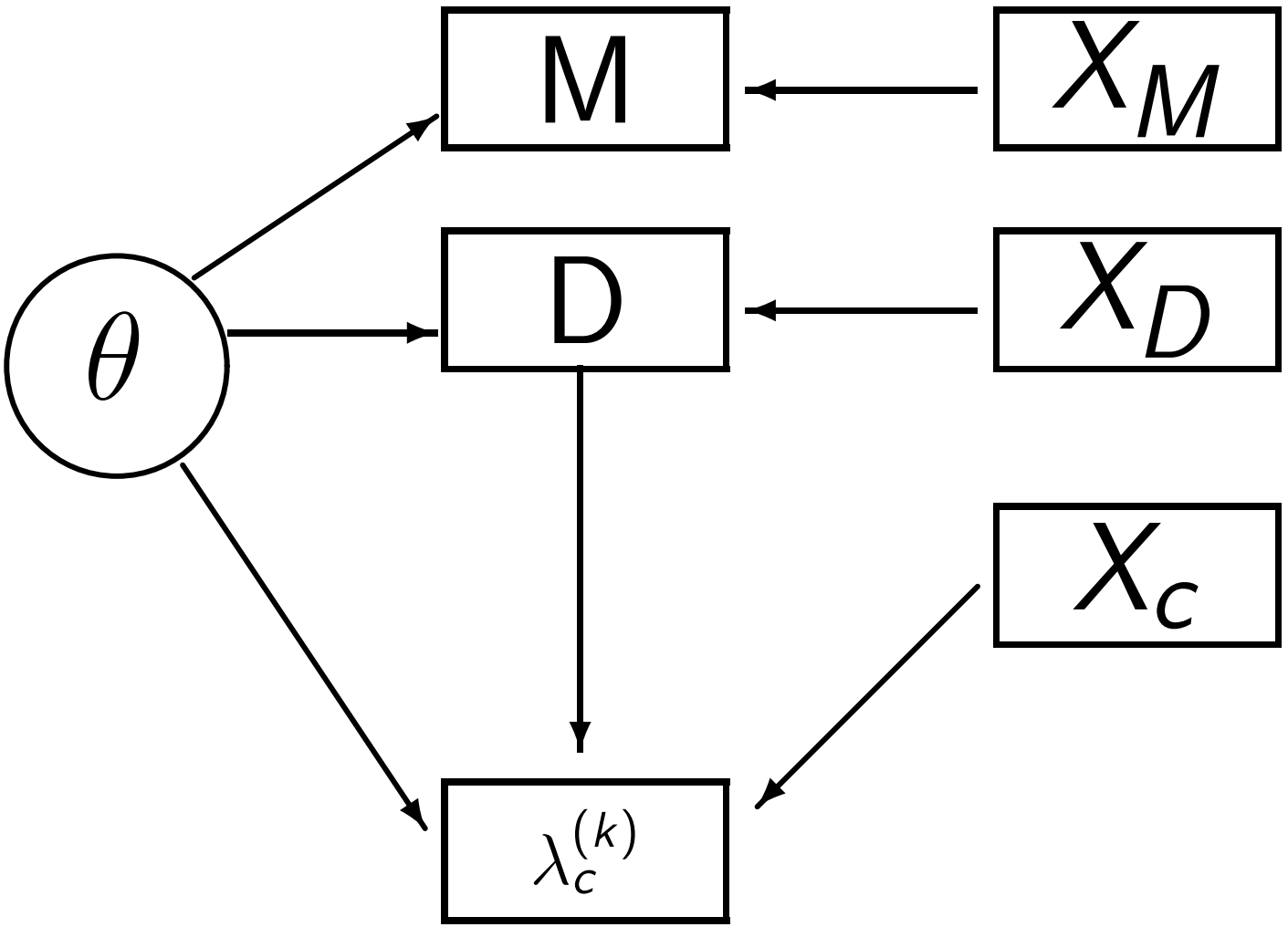
Structural model of education and cause-specific mortality

Extension of structural model of Bijwaard et al. (2015a,b)

Model the interdependence between education and cause-specific mortality, because both are affected by cognitive ability.

1. Educational attainment D
   Ordered probit model depending on observed characteristics and latent cognitive ability, θ
2. Potential cause-specific hazard λ
   Depending on education attained and latent cognitive ability: only observe hazards for observed education.
   Proportional Gompertz with shape and scale depending on education and cause of death
3. Measurement, M
   Measuring (a proxy) of cognitive ability, IQ, depending on observed characteristics and latent cognitive ability

Graphical representation



Gains from improving education

1. Educational gain $G_c(\tau_0, \tau_1)$;
   Average educational difference in months due cause c
   Educational gain (difference) implied by structural model

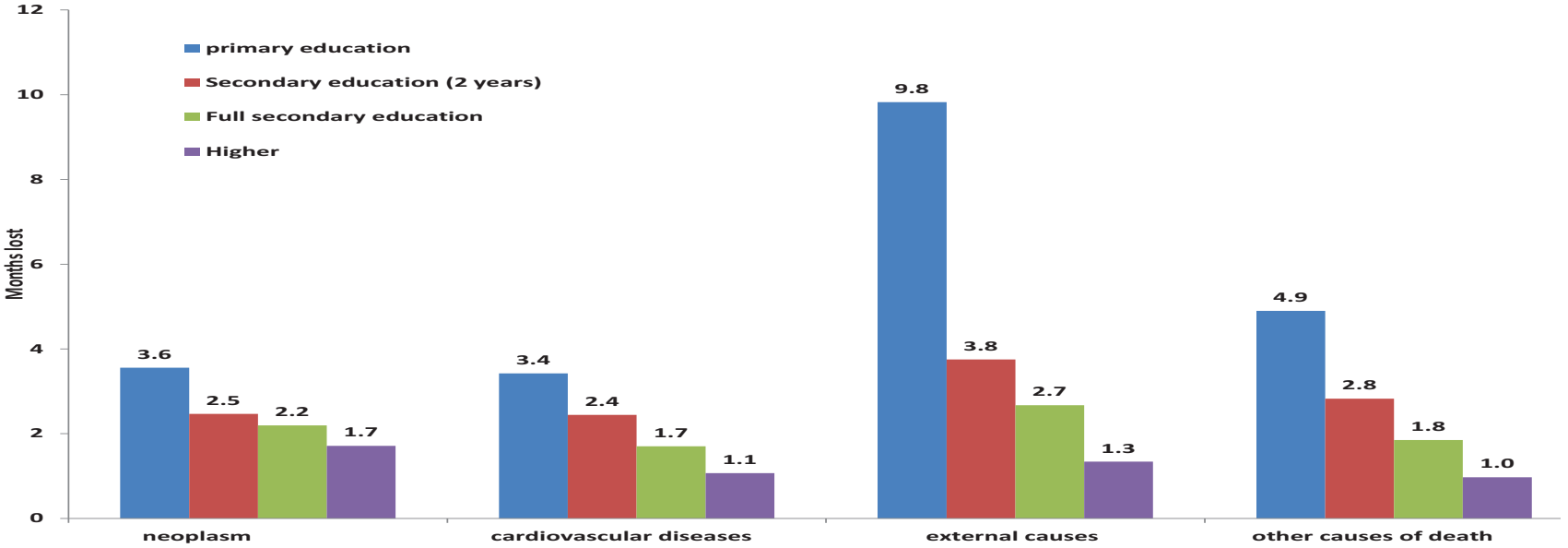
2. Selection effect;
   Effect of selecting education: difference with non-parametric estimate $G_{NP,c}(\tau_0, \tau_1)$
   - selection on observables $G_{NP,c}(\tau_0, \tau_1) - G_{sep,c}(\tau_0, \tau_1)$
     with $G_{sep,c}(\tau_0, \tau_1)$ is the educational gain based on a stratified model (ignoring cognitive ability)
   - selection on cognitive ability $G_{sep,c}(\tau_0, \tau_1) - G_c(\tau_0, \tau_1)$
     difference structural model and stratified model

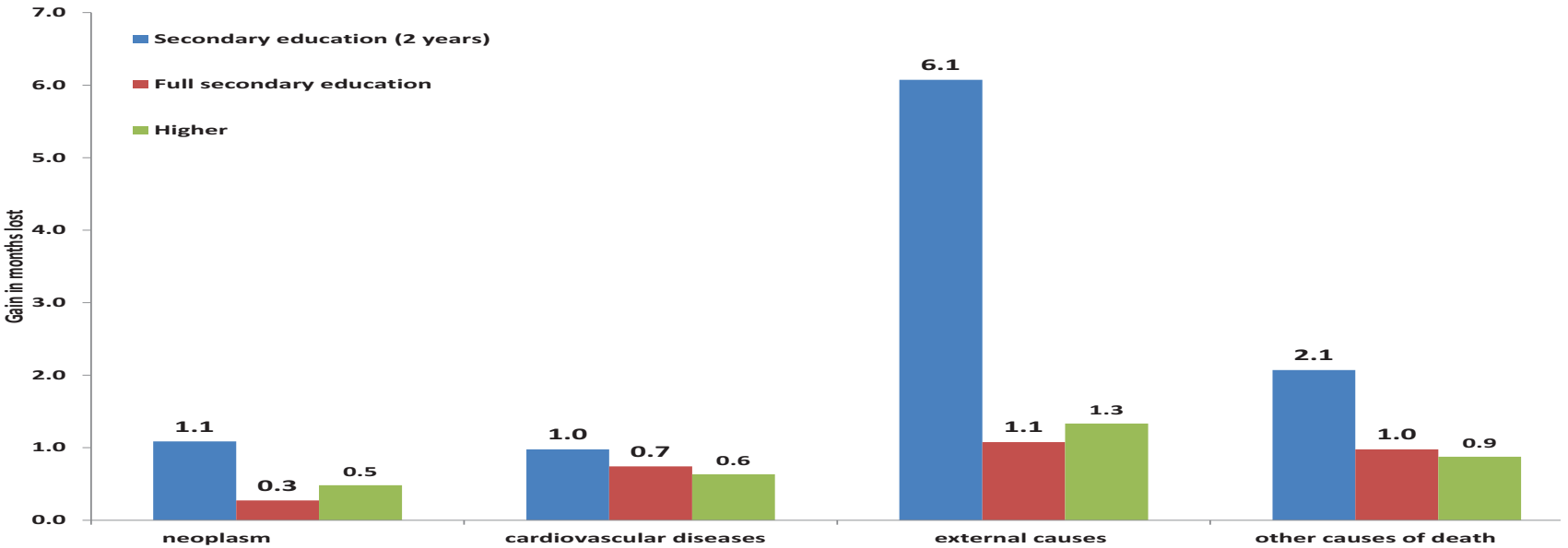
Model estimates of months lost due to specific cause 18-63

Educational gains

1. Non-parametric estimates
   Based on the non-parametric estimate of survival, Kaplan–Meier and cumulative incidence, Aalen–Johansen
2. Structural model
   Gompertz hazard models by education level and cause of death, including observed individual characteristics
   Model accounting for (latent) cognitive ability influencing both education and cause-specific hazards.

Non-parametric: Months lost and gain 18–63





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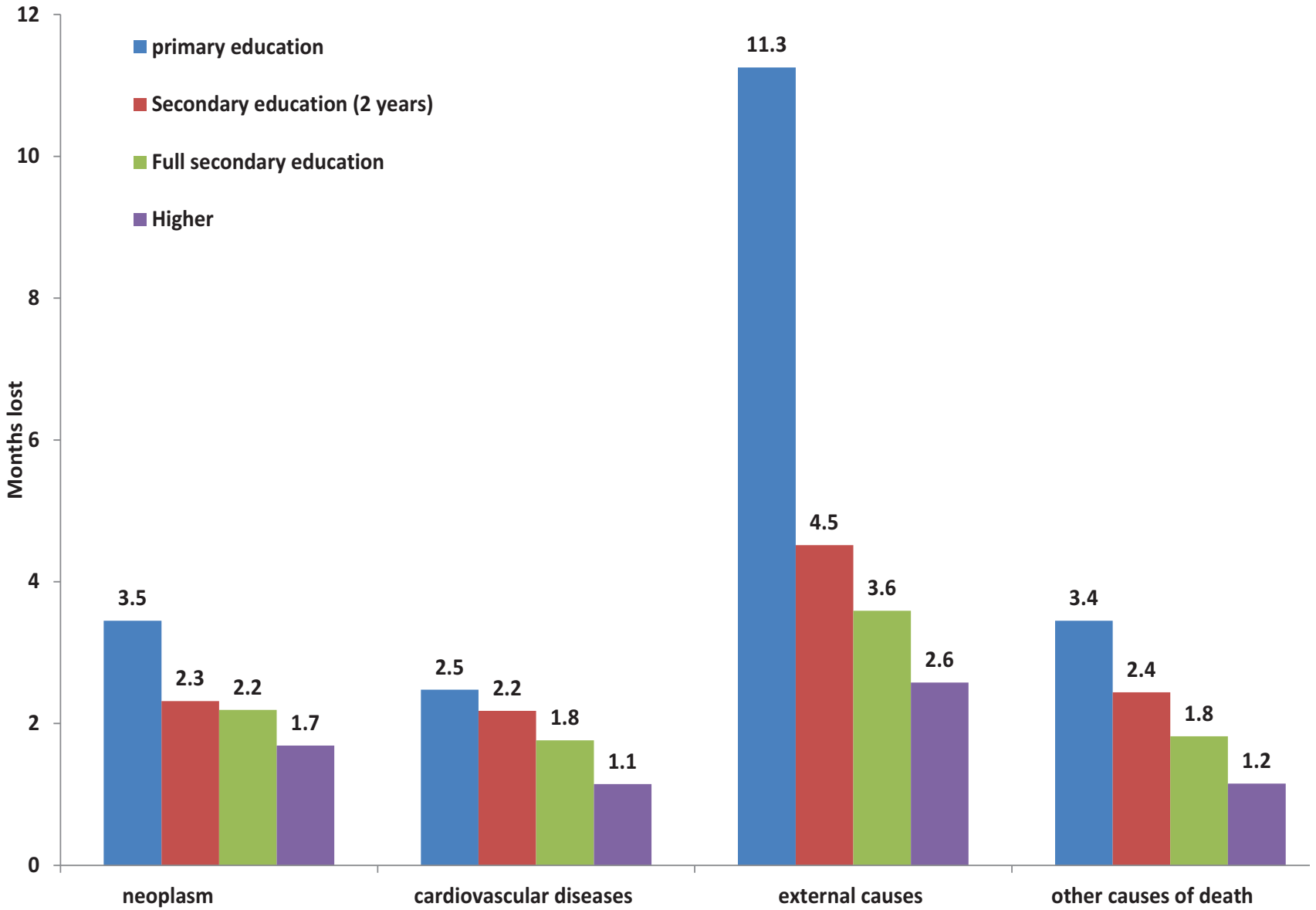
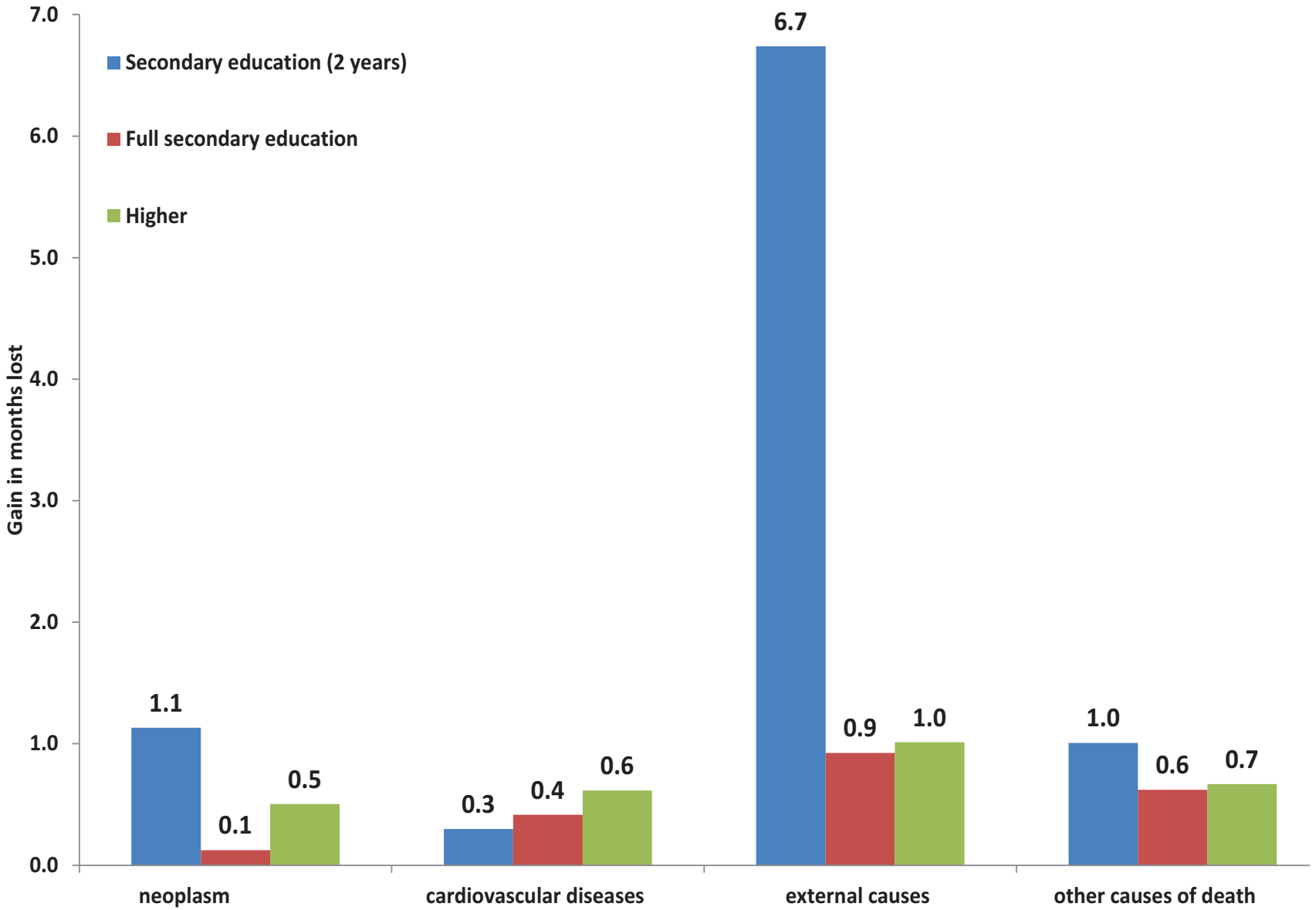
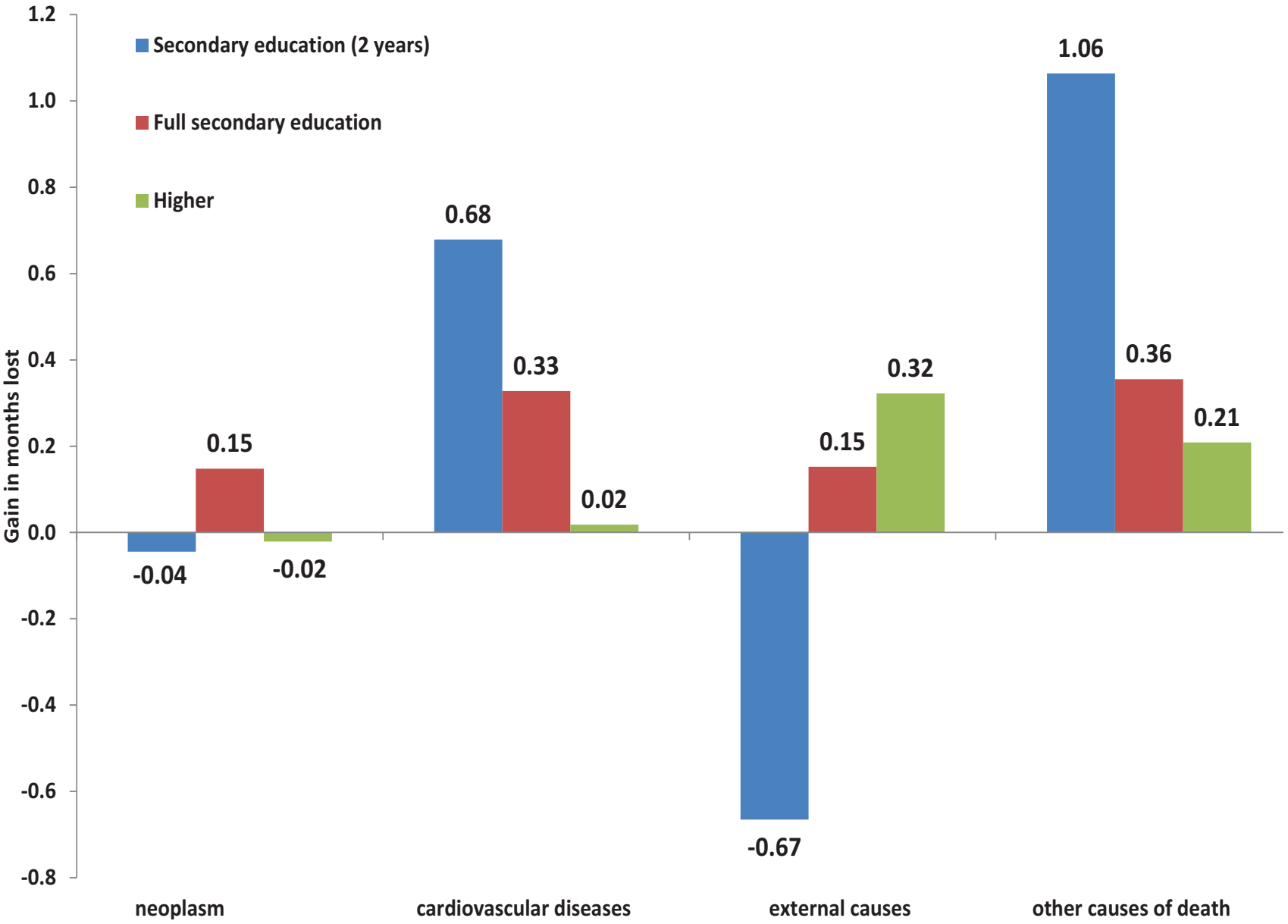
Structural model: Months lost 18–63



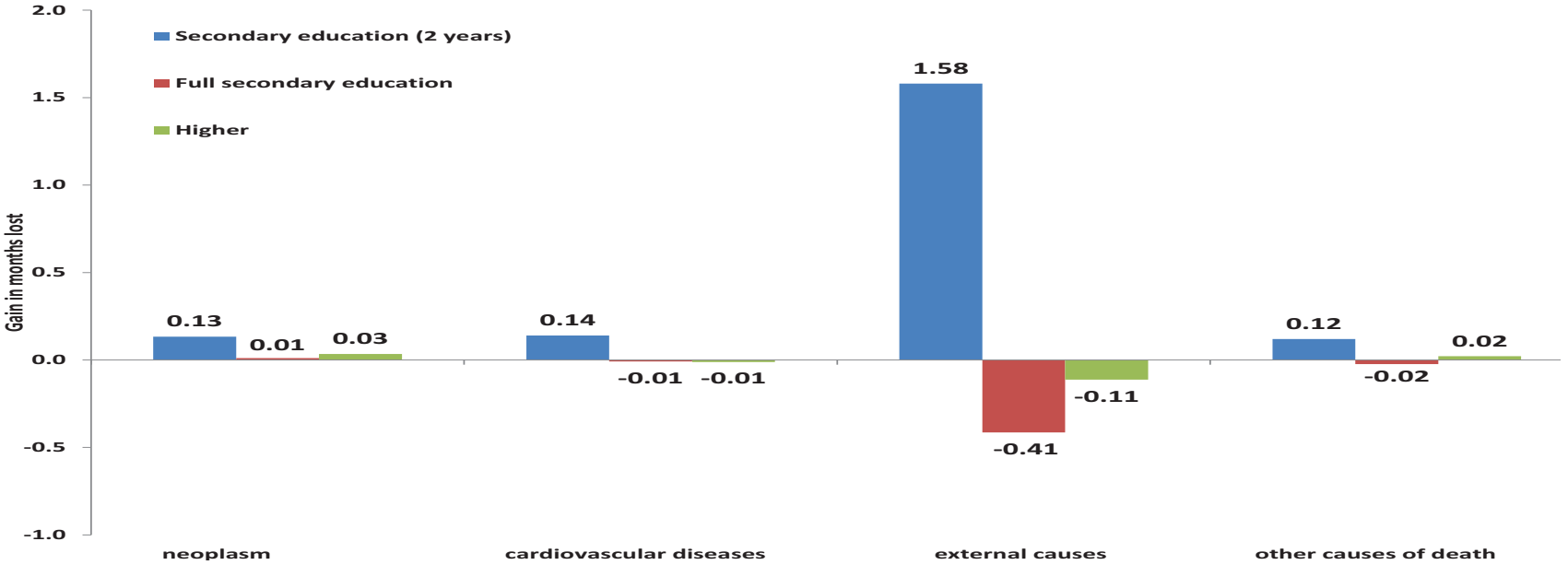
Structural model: educational gain 18–63

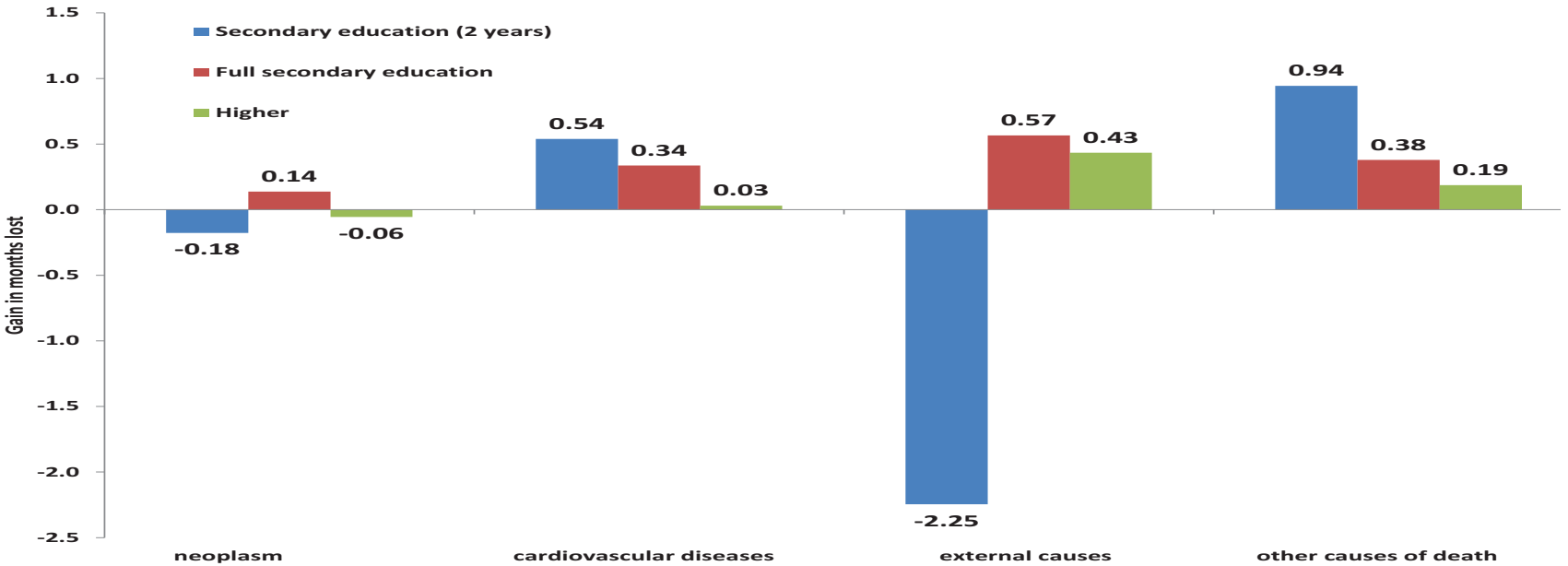


Total selection effect 18–63

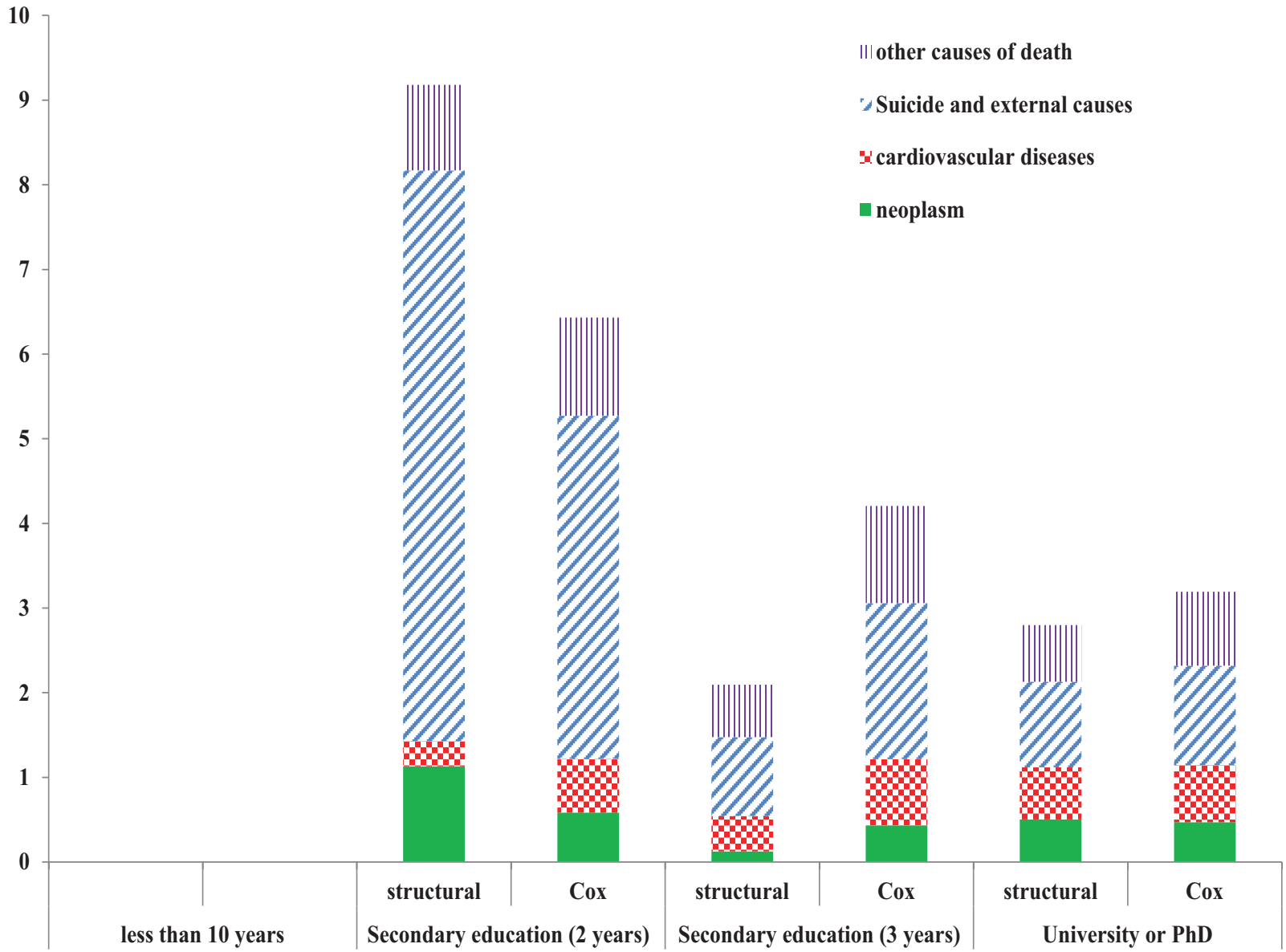


Selection: observed and cognitive ability





Structural model versus Cox models



Summary: Educational gains on cause specific mortality

Developed structural model which accounts for interdependence of education and cause-specific mortality rates.

- educational gain in months lost due to specific cause (accounting for cognitive ability)
- Selection effects: observed and (latent) cognitive ability

Main empirical results: accounting for selection

- Highest educational gain for primary education: 9 mo
- Largest gain due reduction in external causes: 1–7 mo
  small gains for CVD: $<$ 1 month and neoplasms
- Largest selection effect lowest 2 groups: 2 mo
- Largest selection effect for external causes

Discussion

- Months lost better measure than hazard ratios
  Accounts for interdependence between causes and easy to interpret and additive measure
- Structural model accounts for interdependence of education and mortality due to cognitive ability
  Ignoring this leads to underestimate educational gains for low educated and overestimate for higher education

Limitations

- Other personal traits might affect education
  non-cognitive skills
  Educational gain is likely to be upper-bound
- Only men
- short follow up: max age 63