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

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Motivation

- Differences in health and mortality across educational groups are striking and pervasive (Meara et al. 2008)

- Impact of education differ by disease (Mackenback et al.)
  Some diseases involve complex treatments
  other simple or hardly effective treatment
  Impact of education on cause-specific mortality may differ
Causal impact of education on mortality

- 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. 2013; Clark and Royer, 2013)

- Suggest an important role for confounding factors, such as cognitive ability (Elias, 2004; Auld and Sidhu, 2005; Murasko, 2007; Carneiro et al. 2007; Kaestner and Collison, 2011)

- Educational attainment and cognitive ability strongly correlated. Difficult to disentangle.

- Using structural models:
  About half of health disparities across education levels due to selection of the healthier into higher education (Conti and Heckman 2010; Bijwaard et al. 2015a, 2015b).

- Studies on educational differences in cause-specific mortality ignore endogeneity
Our contribution

Disentangle the effects of education and cognitive ability on years-lost due a specific cause of death using an extension of structural model of Bijwaard et al. (2015a, 2015b)

Contribution is twofold:

1. Causal effect of education on years-lost due to specific cause

2. Decompose the observed years-lost (18-63) difference by education level in treatment effect, educational gain, and selection effect both on observed and unobserved characteristics (cognitive ability)
Swedish Military Conscription Data

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

- **Detailed info on individual demographic and socioeconomic characteristics**, including SES (father and mother at birth) parental education, parental age at birth, birth order and region of birth

- **Intelligence test**: IQ in 9 categories

- **Education** classified in 4 levels:
  - less than 10 years, Secondary education (max 12), Full Secondary education and, university (and PhD)

- **Mortality by cause of death, till end 2013**.
## Descriptive statistics: selected variables

<table>
<thead>
<tr>
<th></th>
<th>less 10</th>
<th>Sec edu (12)</th>
<th>Full Sec edu</th>
<th>university</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>mother ses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>unskilled workers</td>
<td>10%</td>
<td>9%</td>
<td>7%</td>
<td>6%</td>
</tr>
<tr>
<td>Skilled workers</td>
<td>49%</td>
<td>48%</td>
<td>37%</td>
<td>27%</td>
</tr>
<tr>
<td>farmers</td>
<td>19%</td>
<td>15%</td>
<td>14%</td>
<td>11%</td>
</tr>
<tr>
<td>non-manual (low)</td>
<td>14%</td>
<td>19%</td>
<td>30%</td>
<td>39%</td>
</tr>
<tr>
<td>non-manual (intermediate)</td>
<td>2%</td>
<td>2%</td>
<td>5%</td>
<td>8%</td>
</tr>
<tr>
<td>non-manual (high)</td>
<td>1%</td>
<td>1%</td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td><strong>father's education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>less 9 years</td>
<td>66%</td>
<td>59%</td>
<td>46%</td>
<td>34%</td>
</tr>
<tr>
<td>9–10 years</td>
<td>3%</td>
<td>3%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Secondary edu (max 12)</td>
<td>11%</td>
<td>15%</td>
<td>18%</td>
<td>17%</td>
</tr>
<tr>
<td>Secondary edu (13)</td>
<td>5%</td>
<td>8%</td>
<td>11%</td>
<td>15%</td>
</tr>
<tr>
<td>university</td>
<td>3%</td>
<td>4%</td>
<td>10%</td>
<td>21%</td>
</tr>
<tr>
<td>IQ (1–9)</td>
<td>4.0</td>
<td>4.6</td>
<td>5.7</td>
<td>6.5</td>
</tr>
</tbody>
</table>
### Descriptive statistics: distribution cause of death

<table>
<thead>
<tr>
<th></th>
<th>less 10</th>
<th>Sec edu (12)</th>
<th>Full sec edu</th>
<th>university</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># of deaths</strong></td>
<td>8,770</td>
<td>9,451</td>
<td>2,506</td>
<td>3,829</td>
</tr>
<tr>
<td><strong>deaths per 1000</strong></td>
<td>90.8</td>
<td>59.1</td>
<td>45.3</td>
<td>28.4</td>
</tr>
<tr>
<td>neoplasm</td>
<td>18.2</td>
<td>14.0</td>
<td>13.1</td>
<td>10.0</td>
</tr>
<tr>
<td>Cardiovascular diseases</td>
<td>18.4</td>
<td>13.9</td>
<td>10.4</td>
<td>6.3</td>
</tr>
<tr>
<td>External causes</td>
<td>31.5</td>
<td>16.5</td>
<td>11.7</td>
<td>6.8</td>
</tr>
<tr>
<td>Other causes</td>
<td>22.6</td>
<td>14.7</td>
<td>10.1</td>
<td>5.3</td>
</tr>
</tbody>
</table>

*causes of death*
Cumulative incidence curves by cause of death and education level

Cumulative incidence curves neoplasm

Cumulative incidence curves CVD

Cumulative incidence curves External causes

Cumulative incidence curves Other or unknown
Structural model of education and cause-specific mortality

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

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

1. **Education attainment** $D$
   Ordered probit model depending on observed characteristics and latent cognitive ability, $\theta$

2. **Potential cause-specific hazard** $\lambda$
   Depending on education attained and latent cognitive ability: only observe hazards for observed education. 
   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
$\theta$  

$M$  

$D^*$  

$D$  

$\lambda^{(k)}$  

$\lambda$  

$k$  

$\theta$
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

- **Years (months) lost due a specific cause**, (from age 18 till age 63)
  \[
  L_k(18, 63) = \int_{18}^{63} F_k(s) \, ds
  \]
Gains from changing school level

1. **Educational gain** $G_c(\tau_0, \tau_1)$;
   Average educational difference in months due to 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
Educational gains

1. Non-parametric estimates
2. **Stratified models**
   Separate Gompertz hazard models by education level and cause of death, including observed individual characteristics
3. **Structural model**
   Model accounting for (latent) cognitive ability influencing both education and cause-specific hazards.
Non-parametric: Months lost due to specific cause

- Neoplasm
- Cardiovascular diseases
- External causes
- Other causes of death

Education levels:
- Less than 10 years
- Secondary education (max 12 years)
- Full secondary education
- University or PhD
Model estimates of months lost due to specific cause 18-63

1. Non-parametric estimates

2. **Stratified models**
   Separate Gompertz hazard models by education level and cause of death, including observed individual characteristics

3. **Structural model**
   Model accounting for (latent) cognitive ability influencing both education and cause-specific hazards.
Stratified model: Month lost due to specific cause

- neoplasm
- cardiovascular diseases
- external causes
- other causes of death

- less than 10 years
- Secondary education (max 12 years)
- Full secondary education
- University or PhD

- Months lost
Stratified model: Educational gain

- Less than 10 years to Secondary education (max 12 years)
- Secondary education (max 12 years) to Full secondary
- Full secondary to University

Gain in months lost for different neoplasms, cardiovascular diseases, suicide and external causes, and other causes of death.
Model estimates of months lost due to specific cause 18-63

1. Non-parametric estimates

2. Stratified models
   Separate Gompertz hazard models by education level and cause of death, including observed individual characteristics

3. Structural model
   Model accounting for (latent) cognitive ability influencing both education and cause-specific hazards.
Structural model: Months lost due to specific cause

- Neoplasm
- Cardiovascular diseases
- External causes
- Other causes of death

- Less than 10 years
- Secondary education (max 12 years)
- Full secondary education
- University or PhD
Structural model: Educational gain

- Neoplasm
- Cardiovascular diseases
- Suicide and external causes
- Other causes of death

Gain in months lost:
- Less than 10 years to Secondary education (max 12 years)
- Secondary education (max 12 years) to Full secondary
- Full secondary to University
Total selection effect

-1.0  -0.5  0.0  0.5  1.0  1.5

neoplasm cardiovascular diseases Suicide and external causes other causes of death

Gain in months lost

less than 10 years to Secondary education (max 12 years)
Secondary education (max 12 years) to Full secondary
Full secondary to University

Gain in months lost

neoplasm cardiovascular diseases Suicide and external causes other causes of death
Selection on observed characteristics

- neoplasm
- cardiovascular diseases
- Suicide and external causes
- other causes of death

Gain in months lost:
- less than 10 years to Secondary education (max 12 years)
- Secondary education (max 12 years) to Full secondary
- Full secondary to University
Selection on cognitive ability

Gain in months lost

- neoplasm
- cardiovascular diseases
- Suicide and external causes
- other causes of death

less than 10 years to Secondary education (max 12 years)
Secondary education (max 12 years) to Full secondary
Full secondary to University
Summary: Educational gains on cause specific mortality

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

Main empirical results:
- Highest educational gain for **Lowest education** group (< 10 years): 9 mo
- Largest gain due **reduction in external causes**: 1–7 mo
- Small gains for CVD: < 1 month
- Largest **selection effect** lowest 2 groups: 2 mo
- Largest selection effect for external causes
- Positive selection on cognitive ability.
Discussion

- Education, cognitive ability, socio-economic background and health at 18 highly intercorrelated. Our structural model accounts for this.
- Ignoring this leads to overestimate educational gains.
- Still educational improvement beneficial to life expectancy, especially in improving death to external causes.

Limitations

- Other personal traits might affect education non-cognitive skills.
  Educational gain is likely to be upper-bound.
- Only men.